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**Evaluation and prediction of agonistic behaviour in the domestic dog**

# Evaluation and prediction of agonistic behaviour in the domestic dog

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## Abstract

To date, the strategy in many countries for prevention of danger originating from dogs, has been a) to ban certain breeds which are supposed to be more aggressive than others, and b) to apply a variety of temperament tests to dogs of all breeds, with the aim of detecting those with elevated aggressiveness. There is some scientific literature in this field, but empirical hypothesis testing is still scarce.

The first part of this thesis examines whether "dangerous dogs" can be reliably distinguished from "normal" dogs. In a formal test of aggressive and unacceptable social behaviour, designed to predict aggressive behaviour later in the dog's life, six distinct sets of releasers for aggression were identified (Groups A-F), and a further three in a supplementary test conducted in-home (Groups G-I). Breed, age, sex, and previous training were found to influence the quality and quantity of the behaviour shown in the individual subtests. Responses to Group D (dogs) were associated with previous history of biting dogs; responses to Groups B (threats from humans) and E (play) were associated with previous history of biting people. Both might therefore be predictive of future risk of biting.

In addition to aggressive responses, an ethogram was used to characterise the dogs' behaviour; the majority appeared to display aggressive behaviour motivated by a stressful state and/or uncertainty.

In the second part, the behavioural development of four litters of Rhodesian Ridgebacks was recorded in weeks four to eight of life, focussing on behaviour shown in dyadic interactions with siblings. When the same dogs were tested as adults, puppy behaviour proved not to be a predictor for any behaviour patterns shown in conflict situations. Biases in the test, and the implications of the results for keeping and breeding dogs, and for prevention of danger arising from dogs, are discussed.

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Front page: Mother and son in agonistic interaction. With friendly permission from the artist, Dorothea Heinrich, Hamburg

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## Literature review

## 1.1 Rationale

Aggressive behaviour is a part of the domestic dog's social behaviour and belongs to its normal behavioural repertoire (Bradshaw & Nott, 1995). The literature on canine aggression reveals a huge gap between what is knowledge supported by scientific study, and what is "folk psychology" among the dog-owning, dog-using and "dog-expert" community. The statement made by Rooney (1999) about the play behaviour of dogs can equally be applied to their aggressive behaviour: "Literature is vast but suffers from a deficiency of empirical hypothesis testing and an abundance of unsubstantial claims which have, in some cases, been raised to theorem". This gives cause for concern, as canine aggression and its prevention have recently become a topic of public interest due to fatal incidents with humans in some European countries. This introduction to the thesis collects what scientific data currently exists on dog aggression. Several common assumptions on the why and when of dog aggression and the question of whether dog bites can be predicted in advance shall also be addressed.

### 1.1.1 Why study dog behaviour?

#### 1.1.1.1 The domestic dog

The domestic dog, *Canis lupus familiaris L.*, has lived with man for at least 15,000 years, as archaeological findings show (Davis & Valla, 1978). It is supposed to originate from the grey wolf, *Canis lupus* (Clutton-Brock, 1995). Recent mitochondrial DNA analysis estimates the start of the dog's domestication as long ago as 135,000 years (Vilá et al., 1997). The how of domestication is unclear and cannot sufficiently be determined from archaeological findings. Clutton-Brock (1995) speaks of "early dogs" when she refers to the dog-like skeletons in ancient graves from around 14-13,000 BC, buried together with humans in a way that led to the assumption that those animals have been more than just "dinner on the journey to paradise". From then on, it seems appropriate to assume, the close association between dogs and humans, which is still undiminished nowadays, built up gradually.

Dogs have been a source of food as well as a means of hunting food, and also for protecting it later on, once other wild animals had been domesticated and turned into livestock. Dogs have been the object of some kinds of worship, and have been equipped with human attributes in myths and legends. Distinct breeding is supposed to have started around 3-4,000 years ago (Clutton-Brock, 1995). Greyhound-type dogs seem to be the most ancient of the foundation types, leading to the assumption that hunting indeed was one of the first tasks the dog had to fulfil. The Romans gave detailed descriptions of their types of dogs and their respective functions. Hunting dogs, guard dogs, sheep dogs and lap dogs are described, with their phenotypes and desirable behavioural traits (Forster & Heffner, 1968, cited in Clutton-Brock, 1995). Our modern molossoid type dogs, for example, very probably came from the region of Molossus (part of Epirus) and were used to hunt large prey. They were, compared to other breeds of that time, heavier dogs with a broad, short muzzle used to hold and fix the prey (see details in Fleig, 1983; Weisse, 1990; Räber, 2001). According to Gordon (1973) and Schulte (1988) such dogs were also used during war (as weapon-carriers, and for scaring off enemies).

Today about 400 different breeds exist (Clutton-Brock, 1995). Specialisation in function has resulted in many individual phenotypes. In former days selective breeding was done by looking for those dogs that did their job best. Even today dogs are bred and trained to be used to guard people and livestock, to hunt, to work in the military, police and customs services and, more recently, to aid people with a range of physical disabilities. From around 1860, when the first dog show happened in England, another element came into focus: pedigrees were developed and an internationally fixed phenotype became the standard for any individual breed. Breed is here defined as a subdivision of domestic animals from one individual species. Animals from one subdivision differ from those in other subdivisions in genetically fixed morphological or behavioural traits (Herre & Röhrs, 1990).

1.1.1.2 The dog-human relationship

In the past dogs had to fulfil certain functions for humans, as already said, but today dog keeping is not so much determined by those functions, apart from the lap dog. For the dog owning community the dog has now developed into a pure companion animal (a pet). In the UK about 7.3 million dogs live in 26 % of households and are mainly kept as pets (Robinson, 1995; Rooney, 1999). In Germany about 5.1 million dogs live in 15 % of households (IVH, 2002). Here also the majority are kept as pets. In the USA between 52.9 and 58.2 million pet dogs reside in 35 % of households (Overall, 2001).

Pet dogs do fulfil functions. Dogs are used as a surrogate for human needs (attachment, love, status etc.) and share human life in nearly every facet. Dogs can bring great pleasure to their owners, and dog-ownership is supposed to be associated with a wide range of physical and psycho-social benefits (Friedmann, 1995). Different theoretical models exist to explain those benefits.

Wilson & Netting (1987) developed a developmental-psychological theory that included the complete history of pet ownership and looked at the individual wellbeing of the owner.

Collis & McNicholas (1998) state in their social-support theory that pets provide support in acutely stressful situations. This is further developed in their buffering-hypothesis, with pets functioning as a buffer against critical and stressful events.

Bergler (2000) summarises the different theories in his theory of balance: humans value their social relations by evaluating their costs and benefits and thus decide to keep a relationship, invest in it or let it go. An important factor in the decision process is the individual discrepancy between expectations and reality. Bergler sees parallels in humans undergoing a social relationship with another human or a pet. Bryant (1985) identified dogs as part of the social support system for families and Rogers et al. (1993) described dogs as a social lubricant for old people, helping to relieve loneliness.

### 1.1.2 Why study the social and aggressive behaviour of the dog?

When the relationship between owner and dog is not successful, this is mostly due to the dog and its behaviour not fitting with the owner's expectations. This can lead to dogs being surrendered or euthanised. Valid data about how many dogs are involved each year are sparse. Anderson & Forster (1995) cite 15-20 million animals euthanised in humane shelters each year in the USA, and speculate that the majority of these animals had been brought there due to behavioural problems in general. Overall (1997) says that 30 % of the owners who come with their dogs to her behavioural clinic have already considered euthanasia.

The data mentioned above, although scanty, indicate a significant welfare concern, and it seems necessary to go deeper into the field of human-dog relationships, not least to evaluate the equally shared mutual benefits for both sides. The dog's highly social nature facilitates the ease with which the dog became the earliest and still the most important companion animal. Humans feel at ease with the social and communication behaviours of dogs. There is a tendency to claim that it is easy to deduce what the dog means by a certain behaviour and so no specialised knowledge is necessary to keep dogs, as this basic knowledge is not only widely available but originates from common sense. On the other hand incidents involving dogs, and the data above, tell another story of how well man really knows his best friend.

The huge amount of popular dog literature has only a minor scientific basis. Many statements on dog behaviour, dog handling or dog training are told and retold for many years without analysing or questioning their scientific or even pseudo-scientific background. Scientific examination of the dog's social and aggressive behaviour should make an important contribution towards improving the dog-human relationship.

1.1.2.1 Problems in the dog-human relationship

It is not exactly known what proportion of the dog population does not fulfil their owners' expectations. What can be estimated from official statistics, media reports and from data published by behaviour counsellors is that aggressive behaviour in dogs causes the most problems in the dog-human relationship. The aggressive dog has been an increasing object of public and political interest to scientists as well as human doctors and veterinarians. The last official German statistic (Deutscher Städtetag, 1997) lists roughly 4,500 incidents with dogs per year for the time-span 1991-1996. In Switzerland somewhere between 200 and 1000 out of 100,000 citizens get bitten by a dog each year (Bundesamt für Veterinärwesen, 2000). In the Netherlands 50,000 people per year have to be treated in hospital after having been bitten by a dog (Netto & Planta, 1997). Between 0.5 and 4.7 million people are bitten by dogs each year in the USA, with 10-16 fatalities (Landsberg et al., 1997; Overall, 2001). This makes canine aggression a health problem as well as a public danger.

Estimates of the proportion of dog bites that are directed against owner(s) or other family members vary between 25 and 85 % (Kizer, 1979; Podberscek & Blackshaw, 1991; Askew, 1996, Horisberger, 2002). If intraspecific (dog-dog) aggression and aggression against other animals are also included, many owners must be in the position of requiring help to improve their dog's behaviour; many dogs may otherwise be euthanized.

Canine aggression is the most common behavioural problem in dogs seen at behavioural practices (Overall, 1997; Landsberg et al., 1997): among all behavioural problems complained of by owners, aggressive behaviour varies between 30 % and 62 % (Lund et al., 1996; Blackshaw, 1988; Mertens & Dodman, 1996; APBC, 2003). Other problems mentioned are separation problems, fearful and phobic behaviours to auditory and visual stimuli, attention-seeking behaviour, house training problems, training problems, stereotypic behaviours, coprophagia, pica, and inappropriate chasing behaviour (APBC, 2003).

1.1.2.2 What is a "dangerous dog"?

"Danger" is defined as being the probability of suffering, liability to suffer, injury or loss of life, and "dangerous" means "with any likelihood of causing danger to somebody or something". It can thus be said, that any dog could become dangerous to humans, other dogs or other animals, just as a result of normal dog-like behaviour e.g. jumping at people, biting or hunting (BTK, 2000). In this thesis however, "dangerous dog" will be used in the sense as it is used in the media (Dressler, 1999): dogs that have bitten humans or other dogs, or where people are suspicious that any such dog, or a dog of particular breed, might bite and injure.

Dog aggression is a hugely emotive issue in the media. The "dangerous dog" became a very popular phrase in Germany in 2000 after two fatal incidents. An old woman was killed by a Rottweiler bitch in the spring and a six year old boy was killed in the summer by an American Staffordshire Terrier and its female Pitbull Terrier companion. But the "dangerous dog" was not a new invention in the year 2000. In the media it has become a topic every now and then and, as Podberscek (1994) and Dressler (1999) showed, reports follow a wavelike trend – once public interest is raised, reports on incidents with "dangerous dogs" increase disproportionately to reality. Media reports influence politics and vice versa. Certain breeds have been of public interest whereas others for which incidents were also reported, got no special treatment in the news.

When one looks at dog-bite or dog-incident statistics, the numbers seem approximately stable over a long period until the end of the 1990s (Sacks et al., 2000; Overall, 2001). The statistic "Deutscher Städtetag" from 1997 even states that overall numbers have noticeably decreased when compared to the statistic five years earlier (Deutscher Städtetag, 1992, 1997). The German state of Hamburg lists a slight increase for the years 1998 and 1999 and a distinct decrease for the year 2000; the same trend as for the state of Brandenburg (Von der Schulenburg, 2000; Land Brandenburg, 2000; Bürgerschaft der Freien und Hansestadt Hamburg, 2001).
In summer 2000 all German states brought in new "Dangerous Dogs Acts" (DDA). All but one DDA listed certain breeds that were supposed to be dangerous due to inherited elevated aggression levels. Authorities claim that reductions in dog-related incidents are the result of these strictly enforced new DDAs.

The German statistics on incidents with dogs do not allow a distinction to be made between two opposing interpretations of the problem: that certain breeds are "highly dangerous" or that there is no such thing as a "dangerous dog breed". What makes the German data on dog-bites/dog-incidents so equivocal? First of all they cover only those incidents that are reported to the authorities. Bites within the family, although they may have caused serious injuries, are rarely listed as police etc. will not be involved. Some of the earlier data, i.e. from the late nineties back, do not differentiate whether the dog bit or merely caused injury by jumping up. The identification of the breed is also a big issue. For breed-specific legislation to be effective data is needed, saying that certain breeds are over-proportionally involved in incidents. The correct naming of the breed of every single dog can definitely be questioned in the statistics. Often people with no dog-experience, be they police officers, medical personnel, city officials or the victim itself, identify these dogs.

Beaver et al. (2001) criticise the American dog-bite statistics with similar arguments: "dog statistics are not really statistics and they do not give an accurate picture of dogs that bite". Gaining this "accurate picture" is, according to Beaver et al., one of the prerequisites for protection from "dangerous dogs".

Thus far it can be stated that the "dangerous dog breed" probably does not exist in scientific reality. It exists in people's minds, mainly influenced by the media. The question remains, how great is the chance that any individual dog may cause danger to somebody or something. The following sections look at the dog's social behaviour, and aggression, and examine how, or indeed if ever, future aggression can be predicted. Substantiation of the hypothesis that there are certain breeds that are more dangerous than others is also discussed.

## 1.2 Social behaviour

### 1.2.1 What is social behaviour?

Social means living in groups, irrespective of group size. In nature group sizes can vary between two and over a thousand animals (Krebs & Davies, 1996). Social behaviour is the sum of all behaviours aimed at a partner (usually of the same species) which is capable of interacting/communicating, or those behaviours that are triggered by such an interacting partner in an individual animal. The main components of social behaviour are co-operation and competition. These can include agonistic behaviour (including aggression), epimeletic- and et-epimeletic-, dominance- and submissive-, sexual- and play behaviour (Gattermann, 1993). All those behaviours are aimed at keeping the group (of whatever size) together to the benefit of some or all of the group members (Immelmann et al., 1996).

Social behaviour can be detected in nearly every species, as usually some contact is necessary for reproduction at least. There are a few truly solitary animals e.g. marine sponges, but there is consensus to classify mammal species as solitary that reduce their contact with conspecifics to the minimum necessary for fertilisation and some primary care of the brood. Primarily solitary mammals. include e.g tiger (*Panthera tigris*), hamster (*Cricetus cricetus)* or glutton (*Gulo gulo*) (Immelmann et al., 1996).

Lundberg (1988) differentiates two types of social groups. Non-anonymous-groups: attached social partners which know and recognise each other individually form a group. The group thus represents a network of different partnerships. Anonymous-groups: members of the group do not know each other individually and thus one individual is not generally attached to another specific individual but only to the group. Triggers to keep the group together are of a supra-individual nature: for example, common group pheromones, typical phenotype or a special territory.

Scott & Fuller (1965) define a social relationship as a regular and predictable behaviour occurring between two or more individuals. The relationship consists of both the observable behaviour and a system of rules, which may or may not correspond to the actual behaviour. Members of an individual group are attached to each other with "attachment", expressed as one individual either approaching and staying next to another individual or not leaving when approached itself (Bowlby, 1982). Anonymous and non-anonymous structures and individual partnerships can overlap and complement one another. During evolution, selection has favoured individuals that have strategies in their repertoire which maximise the individual's genetic input into the next generation's gene-pool (termed as "fitness"; Dawkins, 1976). The crucial point is finding the optimal compromise between survival of the adult and the costs of reproduction.

Living in groups can have advantages and disadvantages. One advantage can be a subjective or objective increase in an individual's safety. One disadvantage can be the fact that rivals for resources stay close by. So anywhere where species have developed the habit of living in bigger or smaller groups, it can be presumed that the gains of social life outweigh the costs for the individual animal, especially when looking at the individual's fitness.

### 1.2.2 Social behaviour of the dog

Dogs are highly social animals and this was taken advantage of by humans in the process of domestication. The modern wolf is a highly social animal as well, but what is not known is, whether the wolf today displays the same social behaviour as the common ancestor of today's wolf and today's dog. What can be said is that there are many similarities between dog and wolf social behaviour, but also differences (Bradshaw & Nott, 1995; Feddersen-Petersen, 1992), including the possibility of new signals arising during domestication. Feddersen-Petersen, looking at the play behaviour of wolves and standard poodles, describes a certain behaviour unique in the Poodle: stamping ("Trampeln") was shown when one poodle wanted to activate another one into play interaction. Poodles that were socialised with wolves showed stamping without hesitation to wolves, but the wolves reacted fearfully and with flight – even though they were fully socialised to the Poodles.

When looking at Canids in general, three types of social organisation can be found, all non-anonymous types of group structure. In type I two animals form a temporary bond during breeding season. Permanent bonds of two individuals, sometimes with the young staying until the next breeding season starts, form type II social systems. The lay public more commonly knows the type III social system: the pack, which consists of more than two related (or unrelated) individuals living together for longer than from one breeding period to the next. The wolf can be seen to live in all three types of social groups, depending on ecological and geographical modalities and abundance of resources and/or enemies. Bradshaw & Nott (1995) therefore speculate that differences in the social repertoire in different dog breeds may have a genetic background, due to former existing variations inherited from the wolf.

Dogs do not only live in intra-specific social groups but also in inter-specific ones. For today's dog it can be assumed that the majority live in a social relationship with humans. This makes studies of the social behaviour of dogs even more difficult, as the observer quite often is a member of exactly that system he or she is looking at. Thus it is necessary to piece together the whole picture from studies that are aimed at particular aspects of social behaviour (Bradshaw & Nott, 1995).

Possible approaches include: looking at wolf behaviour under different conditions (natural, semi-natural etc.), looking at feral and so-called pariah dogs, and looking at dogs from different breeds and living under different conditions with man. Another approach is to begin with single behaviour patterns ("behaviours") forming the ethogram of these animals and from there on try to develop the picture deeper, i.e. into the social structure. As ethograms of domesticated animals and their wild conspecifics differ, it is not advisable to simply compare them as a means to judge and assess certain behaviours shown by a member of the domesticated form in a certain context. In an attempt to solve this problem, Leyhausen (1982) coined the phrase " ethological profile of a species " (=Ethologische Kennzeichnung einer Art). He said that one has to look at the domesticated species in their own right, as well as comparing between wild and domesticated forms, giving every species its own ethological profile. This approach also allows for differences in the social behaviour of different breeds (ethological profile of a breed) as assumed by Bradshaw & Nott (1995).

Quite a lot is known now in detail about the social behaviour of dogs, although scientists still do not have the complete picture. Pioneers in the studies of dog behaviour were, among others, Scott & Fuller (1965). They concentrated on the development of dog behaviour (behavioural ontogeny) and especially at the ontogeny of social behaviour. We know now, that about 80 % of all recorded behaviours in the wolf and the different dog breeds, so far examined, develop within the first eight weeks of a pup's life (Feddersen-Petersen, 1994a).

1.2.2.1 Development of social behaviour in the dog

Scott & Fuller (1965) defined the different phases of behavioural ontogeny in the dog, and so far none of the subsequent studies have successfully challenged the general framework of behavioural ontogeny built up by them. Upon finishing their third week of life puppies reach the so-called socialisation period and start to learn the main components of their social behavioural repertoire. They have now reached a point in development where it becomes possible to start more differentiated communication with the living and non-living environment. Scott et al. (1974) described this period as a "critical period for the formation of primary social relationships or social attachments".

Pups of that early age are still not very fearful, a crucial prerequisite for a pup to become easily socialised and habituated to whatever living and non-living environment is presented in this period. According to Fox & Stelzner (1966) the ability to experience fear starts around week four to five. Before that age puppies will react to aversive stimuli, e.g. with vocal signals of pain or any other sign of distress, but that aversive stimulus will have no durable effect on subsequent behaviours. After the fifth week the ability to experience fear grows and when the socialisation period is finished at around 12-14 weeks of age, puppies have gained a picture of the world they are supposed to live in for the next ten and so years. From then on the animal will tend to withdraw from something new and strange, and presumably experience fear, rather than approach and make contact. In this connection Zimen (1990) spoke of two genetically independent motivational systems in the dog: the motivation to make social approaches to strangers, and the motivation to flee from novel stimuli.

By then, puppies have formed a primary social attachment to their parents and littermates and also regard certain members of other species as pack-members. They have learned the rules that apply to the social group and have trained themselves in the relevant communication systems. Another sensitive period (heightened sensitivity to fear-arousing stimuli) has also been suggested at around the sixth month of age (Woolpy & Ginsberg, 1967; Mech, 1970; Fox, 1971a). Development of social behaviour and the learning of rules applying to the social system is not finished with the end of the socialisation period. But what can be stated is that from that time on the young dog is capable of participating in the struggle to determine which individual will have the highest fitness. Both co-operation and competition apply here. Every single social behaviour is presumably aimed at one or the other, with the overall goal being to heighten one's own fitness.

1.2.2.2 Form and function of social behaviour in the dog

Effective communication is essential for the formation and maintenance of social relationships (Bradshaw & Nott, 1995). It can be stated that any single social behaviour, even when it comes to behaviour like the act of copulation, or the licking to stimulate urination in pups by the bitch, conveys information. A sender signals specific information to a receiver, thus altering the receiver's behaviour. The mother's licking to start urination is part of forming the relationship between her and her pups. The act of copulation can be relevant to maintain a social relationship and can also be a signal to a third party for altering another social relationship. Communication, which is intended by the sender, can be distinguished from passive transfer of information, which is unintentional or not the primary purpose of the behaviour. During evolution, some passively transferred information has become intended signals in their own right (Bradshaw & Nott, 1995).

Many behaviours forming the ethogram of a species or a breed can vary in the information they transmit, according to who uses them, when and how. A good example is the jumping of puppies at the mouth/throat area of a conspecific. Young puppies start to do it in the phase they are weaned by the bitch. The predominant addressee is the bitch itself but the same behaviour pattern can be shown against other adult members of the pack as well. This behaviour (pups jump with their snout and front paws, usually against the corners of the other's mouth) triggers a certain behaviour in the adult: the adult will vomit whatever it has in its stomach to feed the pups. Later on, when pre-digested food is no longer necessary, this behaviour (jumping at) changes its intended information for the receiver. It becomes a greeting signal with friendly as well as submissive properties and can be used as a means for de-escalation in an upcoming conflict.

A review of communication in the dog is given by Bradshaw & Nott (1995). Differences from the modern wolf are apparent, for example when it comes to auditory communication; for example, dogs rely more on barking in individual situations than do other Canids. In visual communication also, domestication has produced changes. Dogs that strongly resemble the wolf in their phenotype have more or less all the expressive possibilities a wolf has. Dogs with definite phenotypic changes in face or body have restricted possibilities for varying their signalling, compared to the wolf. Feddersen-Petersen (1992) looked at the numbers of different faces certain breeds could show. She found more than 90 possible different faces in the European wolf and less than 15 in the Dogue de Bordeaux, for example. Goodwin et al. (1997) showed that the further the domestic dog has diverged from the appearance of the wolf, the more elements of lupine body-language have been lost. They suggest that if this process has affected the development of the brain and nervous system as well, the most physically paedomorphic dogs should only reveal infantile wolf behaviour patterns. In their paper from 1997 they give some examples to back up this idea.

Bradshaw & Lea (1992) say that domestication has, in many breeds, enhanced the tendency to show subordinate behaviour patterns, rather than the complete behavioural repertoire that could have been inherited from the wolf. The changes the dog underwent when being domesticated from the wolf seem to be a crucial point when looking at the dog's social behaviour today. Earlier investigators have claimed that those changes can be explained in terms of alteration of the thresholds of stimuli that release them, rather than in the form of the behaviours themselves (Scott, 1950).

Feddersen-Petersen (1992), on the other hand, states that too much emphasis can be put on the neoteny of modern dogs compared to the wolf. Rather she emphasises that today's dogs should be given an individual ethological profile and looked at in the own right, especially in their social relationship with man. Neoteny, according to Coppinger & Coppinger (2001), is a heterochronic process whereby dogs have developed various dog shapes and behaviours by retaining wolf juvenile shapes and care-soliciting behaviours longer into adulthood. Coppinger & Coppinger distinguish neoteny from paedomorphism with the latter being a result, a truncation of development, where the animal becomes reproductive in an ancestor's juvenile stage. According to them neither hypothesis (neoteny - and paedomorphism theory) has been proven scientifically. They propose that it is more likely that modern dog characteristics are inherited from other dogs during breeding after the first wolves have been domesticated.

#### 1.2.2.3 Social hierarchy – the "worship of dominance"

As stated already, the main function of any social behaviour is to format and maintain the social relationship to the benefit of each member of the group. As dogs live in non-anonymous groups and are capable of living in / adapting to groups of different sizes, it is necessary to examine their social hierarchy more closely. Hardly any other behavioural term is as much misused in the lay literature on dogs than the term "dominance". E.g. Tabel stated in 1998 that the Alpha-wolf (the "boss") reigns with draconian hardness and brutality over his pack. He furthers stated that the social hierarchy of the dog needs pressure as a general mechanism, and that the rank of every pack member has to be achieved through fighting. He concludes that humans have to transfer this system of pressure and fight into the man-dog relationship, otherwise humans will not be able to train their dogs perfectly and will not be able to play the alpha role with their dog at all. Tabel's conclusion is still a hypothesis although one that is widely accepted among the "dog-expert community". However, this human behaviour (trying to gain rank through pressure and fighting) may be one important reason why dogs bite their owners, as science gives a different picture of how wolves and dogs organise their social group and build up a hierarchy.

Lockwood (1979) and van Hoof & Wensing (1987) concluded from their observations of wolf packs that neither the direction nor the frequency of aggressive threats or attacks were reliable indicators of dominance relationships in wolf packs. The question of "how much aggression is necessary to format and maintain dominance" will be discussed in detail later on. Here the dominance-concept as such shall be addressed.

Dominance is an attribute of the pattern of repeated, agonistic interactions between two individuals, characterised by a consistent outcome in favour of the same dyad member and a default yielding response of its opponent, rather than escalation. The status of the consistent winner is dominant and that of the loser subordinate. Dominance status refers to dyads while dominance rank, high or low, refers to the position in a hierarchy which is the sum of dyadic relationships, and thus depends on group composition. Dominance is a relative measure and not an absolute property of individuals (Drews, 1993).

Lundberg (1987) speaks of "individual dominance" but means the same as Drews: dominance is not seen as an inherited trait of an individual animal but one that has to be gained in dyadic interaction. Lundberg gives examples of different ways to measure dominance in a dyad, and subsequently bigger groups, with observers looking at the quality and quantity of submissive and/or dominant behaviours. Lundberg states, that for some species it can be more effective, in order to get a clear picture of relations and status, to concentrate on the submissive behaviours, as these do stand out more. In some species the dominant individual behaves rather "normally" apart from occasional rank-showing behaviours, whereas the subordinate individual more frequently and more overtly shows its subordinate status and behaves carefully not to offend the dominant individual (Gattermann, 1993).

This can, without oversimplifying too much, apply to both wolves and dogs (see review by Serpell & Jagoe, 1995). In wolves and dogs, neither the dominant nor the subordinate partner in the dyad shows its respective status-related behaviour overtly every time. In connection with status related behaviour the before mentioned cost-benefit-relations also apply. It makes no sense to show, who one is or might want to be, when nobody is interested or at least looking. And it makes no sense either to insist or stand up for one's status when the situation and possible outcome does not justify the costs. It can be assumed that here differences exist between humans and dogs: humans will identify different situations as "hierarchy-important", and thus invest energy and costs, than dogs will, and vice versa. Misunderstanding in communication may result, subsequently leading to "accidents" (e.g. the dog showing agonistic behaviour towards the human). This point will be discussed in detail later.

Hierarchy-systems of different degrees of permanence are usually classified as follows. A grade-1-dominance-system is a hierarchy in which a strong unidirectional dominance-subordinate-relation exists. Once established it will proceed as long as no major events occur, such as loss of strength due to old age. The "peck-order" of chicken is often used as an example for such a dominance-system. Grade-2-dominance-systems show bi-directional dominance-subordinate-relations that can change according to seasonal, territorial or other temporary influences. They even depend on the individual's day to day behaviour in connection to any possible stressor (Lundberg, 1987). Wolves and dogs appear to adopt Grade-2-dominance-systems (see Serpell & Jagoe, 1995).

Hierarchies are difficult to identify in wolves living in a type I social system (Mech, 1970). This is easier when looking at type II social systems, and hierarchies are most clearly to be seen in type III social systems. In the wolf there is consensus that two separate hierarchy-systems (female and male) exist, with the males overall being dominant over the females (Schenkel, 1967; Mech, 1970; Okarma, 1997). According to Bradshaw & Nott (1995) dominance relationships among female wolves should be characterised as "dominance asserting", while those among males and between males and subordinate females should better be described as "dominance acknowledging". It is problematic and might be dangerous to simply transfer wolf-type hierarchies into the man-dog relationship. Here there is definitely a deficit in reliable and significant research.

Drews (1993) refers to "repeated agonistic interactions" that form the hierarchy. The terms "agonistic" and "aggression" have already been widely used in this text without definition. This is a phenomenon often seen in dog literature in general. Certain terms are used without explicit definition and have become a sort of loosely defined common language with the dangerous possibility that any two people using the same term do not mean the same thing. The term aggression can be used to describe behaviour reflecting a mixture of emotion and action (Abrantes, 1997) or strictly as a term for certain visible behaviours e.g. biting, that are used in conflicts over resources (Eibl-Eibesfeldt, 1987), or some combination of these. One aim of the following sections is therefore to try to arrive at useable definitions for terms like "aggression" or "agonistic".

## 1.3 Aggressive behaviour

### 1.3.1 Aggressive behaviour in general

There are two Latin words that might be possible roots for the term "aggression". "Aggredi" stands for "approaching someone, attacking someone". "Ad gressum" could in an applied sense mean "to seek confrontation with someone". Apart from that, it is difficult to find one single, plain and valid definition for the term "aggression" in the literature.

Gattermann (1993) defines "aggressive behaviour" as "attacking behaviour" against conspecifics which is aimed at expelling, conquering, wounding or killing an opponent in a conflict. Aggressive behaviour is used in competition over resources. It comprises movement (e.g. approach), signalling (e.g. threats) and physical interaction (e.g. ritualised or serious fights). Gattermann differentiates between aggressive (offensive) behaviour and defensive behaviour, with individual single behaviours like biting or certain threats occurring in both. Although this differentiation would imply some emotional involvement - the offensive (i.e. self assured and furious) biter vs. the defensive (i.e. fearful) biter) - this author does not go deeper into the subject and does not mention emotions as such.

Abrantes (1997) calls "aggression" a drive - purposeful energy - which is aroused by meeting with a conspecific and while competing over vital resources.
Archer (1976) differentiates between attack behaviour (aggression as such) and fear behaviour, but just makes some passing comments on threatening behaviour, which is defined by him as "describing the symbolic expression of the intent to fight". He states that aggression as such is a "vague, imprecise and inclusive term, which can refer either

to an interpretation of intent, or to a state of mind, or to a hypothetical motivational system, or can simply be a description to indicate forcefulness".

Scientists have tried to propose some simple and uniformly applicable theories about why and when individuals react with aggression. "Aggressiveness" labels the level of such individual's readiness to react with aggression. An "aggression-drive" has been proposed that starts aggressive behaviour under certain conditions. In some of these "classic theories on aggressiveness" the animal or human is portrayed as a passive victim of its own drive-activated aggression, rather than being actively responsible for its own actions. The most famous of those classic theories is probably the "blocked-drive-hypothesis" by Lorenz (1964). Its basis was the "drive to destroy" as defined by Freud (1950). According to Lorenz the "drive to destroy" is inert and can be blocked. If blocking continues over too long a period and the drive is not been activated in its due time, it can erupt on its own, possibly as a kind of vacuum activity.

Another older theory is the frustration-aggression-model developed by Dollard et al. (1939). They also proposed an aggression-drive but conceived it as being slightly more variable than in the theory later constructed by Lorenz. According to Dollard et al. humans and animals react quite passively with aggression to any frustrating situation. Scott (1960) stated that aggression is solely a reaction to an adequate signal (reaction-hypothesis) that has impact on the aggression-drive. Again he saw his protagonists as more or less passive victims of their inborn drives, although these drives were to some extent subject to learning. Bandura & Walthers (1963) on the other hand thought that an individual's aggressiveness is solely determined through processes of conditioning, using different positive and negative reinforcers.

Today all these "plain and simple" theories or hypotheses on the why and when of aggression have been proved irrelevant and more or less false. The "single aggression-drive" has been abandoned in favour of the notion that aggressive behaviour in any given situation can arise out of various motivational states created by different emotions.

Emotions consist of patterns of physiological responses and species typical behaviour, produced by particular external and/or internal stimuli; in humans these are accompanied by positive or negative feelings, i.e. fear, happiness, anger etc. (Carlson,

2001). Emotions also describe a reflective perception of actual stimulation, drive or even motivation that need a certain degree of consciousness and as such are not equally displayed in all animals (Gattermann, 1993). So up to now no consensus exists as to whether emotions like "anger" or "happiness" actually exist in animals, or are exclusively human, whereas the emotion of fear is recognised as existing in mammals of all kinds, and birds and reptiles also. Panksepp (1998) speaks of different emotional systems (fear-system, seeking-system etc.) in the brain, "which generate an animal's egocentric sense of well-being with regard to the most important natural dimensions of life, offering solutions to survival problems". In this sense Rolls (1999) speaks of emotions as states elicited by rewards and punishers A reward is anything the animal will work for; a punisher is anything the animal will work to escape or avoid, thus creating a motivational state leading to a certain behaviour being displayed. The most straightforward definition of "motivation" would be "incitement for action". Gattermann (1993) speaks of motivation as readiness to show a certain behaviour, appropriate to a given situation. Thus, according to its appraisal of a situation and its individual behavioural (and genetic) predisposition, an animal might use aggression as one possibility among a number of strategies to gain or hold its well-being.
The following sections will now give a detailed overview on current knowledge on the why and when of aggression.



1.3.1.1 "Aggressive terminology" as used in this paper

Aggression is used in this thesis as a synonym for aggressive behaviour and as such has no emotional or ethical connotations. Pure predatory behaviour will be differentiated from aggression and discussed separately. This definition follows Archer (1976) and sees aggression as a synonym for attack. Aggressive behaviours are certain behaviours from an ethogram, either species- or breed-specific, that are used against a conspecific or any other opponent, with the aim of wounding, expelling, killing or conquering in a conflict over resources (Gattermann, 1993). In the literature on animal behavioural counselling (e.g. Lindsay, 2000) quite often a differentiation is made between "defensive aggression (emotion: fear)" and "offensive aggression (emotion: rage)", thus classifying aggression by motivational labels; in addition contextual labels (e.g.

maternal aggression) are used (Lindsay, 2000). This problem will be explored further, emphasising dogs, in a later section, but it can be stated here that such an approach has its pitfalls although it might be useful if any behavioural therapy for prevention and control has to be based on a causal explanation. It is quite difficult to precisely deduce an animal's actual emotional and motivational state, as animals might even use signals to cheat an opponent. Whether animals do or do not use honest signals has been discussed extensively and cheating is supposed to occur, although rarely (Preuschoft & van Schaik, 2000). Another problem is that such catchphrases as "defensive aggression" can lead to too broad and generalised diagnoses and treatment protocols.

Aggressive communication (aggressive communication behaviour) is a separate term and summarises all behaviours used as threats against an opponent without any physical damage being involved, although physical contact may occur. Behaviour which prevents a conflict from escalating (submissive behaviour) also belongs within aggressive communication; this term as such does not imply any special emotional foundation (Feddersen-Petersen, 1995).

Offensive behaviours are directed against another organism with the intention of attack or threat, in contrast to defensive behaviours, which are used to promote withdrawal from an opponent (e.g. flight) or are used as signals to calm the opponent down (Feddersen-Petersen, 1995). Again the terms as such imply no emotional condition.

The term agonistic behaviour is collectively used for any behaviours directed against, or as a reaction to, conspecifics or any other opponent as a component of, or an answer, to threat, attack or just disturbance. Agonistic behaviour has both offensive and defensive elements. Thus it can be used to gain/keep distance in space and time from the opponent (Gattermann, 1993).

Antagonistic behaviour is a synonym for offensive behaviour which is directed against an opponent (Gattermann, 1993; Immelmann et al., 1996).

Dominance is an attribute of the pattern of repeated, agonistic interactions within a dyad, where both members of the dyad come to recognise each other's relative position and eventually alter their responses towards one another, from symmetrical to asymmetrical behaviour. A Dominance relationship develops between two animals in which an asymmetry in the outcome of repeated agonistic interactions can be measured: one of the animals (the dominant one) consistently wins interactions over resources at the expense of the other (the subordinate one). Although aggressive behaviours may have played a role in establishing the relationship, they need not necessarily be displayed by the dominant partner every time. Rather, it is an attribute of the dominant partner that it shows aggressive behaviours quite seldom, whereas the subordinate frequently performs submissive behaviour towards the winner (Drews, 1993; Gattermann, 1993; Immelmann et al., 1996).

Resources are the items necessary for maintaining/increasing the individual's fitness. Included are not only food and water but also all other subjects/objects an animal might be motivated to gain or hold; physical or social commodities that guarantee or increase the individual's fitness e.g. territory or a partner for reproduction (Dawkins, 1976; Gattermann, 1993). The intactness of one's own body can be regarded as one of the most important resources for any individual. Resource-holding potential (RHP) is an attribute intrinsic to an animal which characterises its ability to gain/hold control over a resource (Maynard-Smith, 1982). "Intrinsic" here incorporates a mixture of inborn and acquired traits. Inborn traits can be strength of muscles or height. Acquired traits can be former experiences, leading to knowledge about the possible outcomes of a conflict about resources i.e. prediction of cost/benefit.

Fear is a negative emotional state that develops/occurs when an individual actually detects danger or just anticipates danger (a dangerous situation) with the anticipated dangerous situation/event not or not yet present. In both German and English languages, fear and anxiety are clearly differentiated. A fearful individual is in an actual dangerous situation and can start adequate actions to control, change or flee that situation. An anxious individual experiences danger without being able to recognise any immediate dangerous situation. Thus the scope of action is much more limited than when fearful (Gattermann, 1993).

1.3.1.2 Evolution of aggressive behaviour and aggressive communication

Darwin's (1859) theory of natural selection was, after initial resistance, quickly adopted. The early ethologists of the 20th century, e.g. Tinbergen, von Frisch and Lorenz (Lorenz, 1964), developed from there on their theory of "group selection". Reproduction was the goal to be achieved by any individual with the general wellbeing of the species as such being the main target. This was further set out e.g. by Wynne-Edwards (1962), who stated that any behaviour of an individual, and especially the social behaviours, was aimed at keeping the population at an appropriate level for its ecological commodities, so that the species as such can survive.

Reports of infanticide, e.g. in lions or langurs, gave rise to doubts about the theory of group-selection. Today a selection-model on the basis of the individual's genes, not the species or even individual as such, is widely accepted. Dawkins (1976) coined the phrase of the "selfish gene". It is in the "interest" of individual genes to perpetuate. The individual is conceived as a means whereby genes are transported into the next generation. Following this theory, infanticide in lions can be seen as "normal behaviour happening in an individual situation" but is not pathological behaviour as was thought earlier (Pusey & Packer, 1992).

Besides the selfish gene and the different fitness models as presented by Dawkins, another theory of evolution, the "theory of games" (Maynard-Smith, 1982) has had a major impact on today's picture of the development of species and individual groups of behaviours. Maynard-Smith's central concept was that of "evolutionary stable strategies (ESS)". An ESS is defined as a behavioural strategy which, if most members of a population adopt it, cannot be bettered by an alternative strategy. Costs and benefits for showing any such individual behaviour in an ESS lie in an optimal relation to one another for the majority of the population's members.

One major criticism of the Dawkins selfish-gene-theory in its simplest form was the fact that it did not easily explain altruistic behaviours, which can be observed in nature. The theory of games could explain this phenomenon and thus fit it into the theory of selfish genes. E.g. especially for social animals it can be worthwhile to help a group member, e.g. in rearing its offspring instead of having one's own offspring, either because that other offspring shares a certain percentage of one's own genes (i.e. kin selection as described by Hamilton (1964)), and having one's own offspring could be too costly and thus be a potential threat to one's own fitness, or because the altruistic behaviour may be reciprocated later.

So far it can be stated that any behaviour shown by an individual aims at increasing its fitness, or at least holding it stable. Behaviours that have been developed very widely throughout the animal kingdom must share this feature (serving to increase fitness) to a large extent, and can be regarded as elements of different ESS for an individual species in a particular ecosystem. This can definitely be stated for aggressive behaviour.

Archer (1976) sees the first stage, in the development of an "attack and fear-avoidance system", occurring because animals had to counteract stimuli in their environment that were capable of producing physical damage. Some forms of escape and avoidance responses to noxious stimuli are shown from Protozoa onwards, with the selective advantage being obvious. The alternative to fleeing the noxious stimulus would be the opposite strategy: remaining and removing the noxious stimulus from the vicinity. Aggressive responses (i.e. attacking the noxious stimulus) would have evolved predominantly where the noxious stimulus could easily be removed and/or where flight would have placed the animal in a suboptimal environment. In parallel, more sophisticated sensory equipment for the detection of noxious stimuli developed and the "hardware" to process these inputs (i.e. the brain). The next stage of evolution was the capacity to react to noxious stimuli in advance rather than waiting for actual damage to happen before taking action (Archer, 1976). Thus the so-called Fight-Flight-system developed. Parallel to the development of more sophisticated detection and processing systems, further physiological systems evolved, enabling the organism to react appropriately in either way (fight or flight), e.g. the physiological reaction of stress (Gray, 1987).

Aggressive behaviour is one possible means to heighten an individual's fitness, used in a conflict over resources – but it can be a very costly one and as such can also endanger fitness. Thus especially well-armoured species, e.g. many canids, have evolved systems to assess a rival's strength before an actual fight - aggressive communication behaviour.

Maynard-Smith (1982) spoke about information being transferred during animal contests and set out four major points:

1.It is common for an animal to use a range of actions during a contest; these actions can plausibly arranged on a scale of increasing aggressiveness.

2. Information is present in these acts, in the sense that there is a correlation between the act now performed and the next act by the same individual.

3. Information is received, in the sense that there is a correlation between the act now performed by one individual, and the next act performed by its opponent.

4. A common pattern is for the contest to start with acts at a low level on the scale of aggression, and gradually escalate, as each animal matches any increase in aggression by its opponent. Such contests may or may not end in physical contact.

Threatening behaviour and its counterpart, signalling of defeat and/or submission, probably developed and subsequently evolved rather by chance (learning by doing/experiencing) (Krebs & Davis, 1996). Participants in a contest that were able to estimate actions of the opponent beforehand, had a higher chance to perpetuate their genes. If one opponent (the sender) always bares its teeth before biting, the other opponent (the receiver) knowing this signal, has a chance to react before the actual damage occurs. Teeth-baring has become a reliable signal for biting, presumably because it is an honest signal, since the size and sharpness of the teeth are revealed to the opponent. If a sender finds that teeth-baring leads many opponents to retreat, it will perform this behaviour first in a conflict, as it might spare the much higher costs of an actual bite.

It can be stated that conflicts, be they with conspecifics or others, usually develop over resources. Each individual needs certain resources to increase its fitness – quite often at the same time as its neighbour. Performing costly behaviour, like attack, without a clear estimate of the chances of gaining something valuable, would overall tend to threaten the individual's own fitness. Aggressive communication enables opponents in a conflict to get information about the other's RHP in comparison to its own, thus being able to weigh its chances of success. Strategies which involve the assessment of a rival's strength and, if possible, motivation prior to a contest will tend to minimise injury and are therefore likely to be more successful than simple strategies as "always attack or always flee" (Bradshaw, 1996). For example, territory-holders tend to win in contests against intruders; the motivation to hold the territory is higher in the holder (the territory has a higher value) as the holder has already expended time and energy in gaining information about the content of the territory.

Many signals are thought to have evolved from rather coincidental behaviour, as stated above, that gave some information about the sender's motivation. In the long run some signals vanished and others were ritualised and became an ESS. This happened in more or less solitary living species as well as in social species. However for social animals a greater variety and a stronger ritualisation of signals would seem necessary, i.e. be more important than for more solitary animals. For certain species, e.g. deer (*Capreolus capreolus*), conflicts with rivals most possibly happen around the breeding season. At other times of the year conflicts are far less likely and thus, as possible situations for fight are restricted, only a simple repertoire of aggressive behaviours and aggressive communication might be necessary.

With social living animals this will be quite different. At any time during a day a rival to certain resources lives close by – and has to, since at other times during the day it might be beneficial to collaborate with this rival as a hunting companion or guard. So in species with a long-term co-operative social structure, such as the wolf, complex dominance/submission signals have evolved. Together with complex signals for threat, avoidance or de-escalation (sometimes overlapping with signals for dominance/ submission) they regulate, and largely prevent, aggressive interactions within the group (Bradshaw, 1996).

Submissive signals can be conceived as "distance-reduction" signals. They allow individuals to come/stay closer to one another than territory or individual distance (personal space) would allow otherwise. The term "submissive" refers to such signals displayed by highly social animals like the wolf (Zimen, 1981) and implies a certain hierarchical structure. But in facultatively social animals like domestic cats, distance-reducing signals can also be detected, although they neither correspond to the submissive signals of the wolf nor indicate the existence of a hierarchy (Bradshaw, 1996).

According to Clutton-Brock (1995) the biological process of domestication resembles natural evolution: the parent animals become reproductively isolated from the wild population and constitute a small founder-group, or deme, that will at first be very inbred and will subsequently undergo a process of genetic drift. Over successive generations the domestic "species" will multiply in numbers and will be genetically changed by "natural selection" in response to factors in the new, human environment. The term natural selection has been put into inverted commas to show that here exactly lies a problem: it is to be questioned whether, for a domesticated species, selective breeding by man, once it has begun, can also be called "natural selection". Here, game theory and the selfish gene as an explanation for certain behaviours and motivations of animals collide with human intervention.

No concrete data exist so far to solve the problem. As stated earlier already in section 1.2.2, the whole picture has to be pieced together from studies that are aimed at particular aspects of behaviour. One way would be to give domesticated species an ethological profile and make comparisons: if wild and domesticated animals show the same behaviours in analogous situation, the same underlying motivations, e.g. in connection with RHP, could safely be assumed. Problems arise here due to the fact that for some domesticated animals the wild ancestor no longer exists. But then there is a possibility to study domesticated animals that have lived under natural conditions for quite some time, as has happened with feral horses, and look at their behaviour.

Questions such as what are the driving forces behind any behaviour shown, and what happens if an animal cannot show a certain behaviour it would like to show according to its emotional condition, are also important in the area of animal welfare, and have been quite extensively looked at. Buchholtz (1993) and Tschantz (1993) have incorporated principles of game-theory and the selfish gene in their own theories on the estimation of the welfare-status of an animal. Tschantz's concept of the "satisfaction of needs" and Buchholtz's concept of "action readiness" show that such evolutionary concepts as "RHP" and "motivation for action due to the need to pass on one's genes" could be applied to domesticated and even companion animals. So it is reasonable to assume, even for companion animals, that conflicts develop over resources and that cost-benefit estimates participate in the decision whether to attack or flee or communicate.

To further complete the picture on aggressive behaviour and aggressive communication in domesticated and especially companion animals it will be necessary to look more closely at the genetics of aggression.

1.3.1.3 Genetics of aggressive behaviour

Genes do not directly code for any special character or behavioural trait like "aggressiveness" as such. Nevertheless genes do influence the physiological basis of and thus canalise behaviour. For simple structured animals like protozoa, that do not show many different or sophisticated learning processes, it is quite easy to relate certain behaviours to certain genes (Kung et al., 1975). The more complex an individual is, and the more learning can be observed, the more problems arise. The historic discussion on "nature vs. nurture" is still running. It was Tinbergen (1963) who stated that behaviour is in one sense 100% of each, both inherited and learned.

Aggression as such does not represent a single functional behaviour system or functional cycle, like e.g. reproduction or foraging behaviour. Rather, aggression is displayed as a means to reach goals of many kinds (see section 1.3.1.2), be that reproduction or feeding. Thus it seems unlikely that one or just a few single genes might play a (the) crucial role for aggression to be shown by any individual animal.

On the other hand, examination of families or lines within a species under selective breeding, can show that some behavioural differences within higher species are to some extent due to genetic differences (Alcock, 1996).

Most of this research in mammals has been undertaken with mice, due to their short reproductive cycle (three months) and the ease with which they can be kept in laboratories. For example, Saudou et al. (1994) showed that male mice with a knock-out gene for the neurotransmitter serotonin showed increased aggression in experimental settings compared to mice without that knock-out gene. Nelson et al. (1995) could show the same for a knock-out gene for another enzyme that plays an important role in neurotransmission (neuronal nitric oxide synthase). Both enzyme and neurotransmitter are relatively ubiquitous in the brain; these authors and their successors so far have not managed to show that these chemical structures play a crucial role as the generator for aggressiveness. The problem with such studies is the fact that increased aggressiveness is just one feature that can be easily monitored when the metabolism of the brain is somewhat broadly changed. Other behavioural systems may be equally affected but may be less easy to measure.

Certain behaviour patterns can be predicted to be largely inherited in any species, those that have to function/work on their first performance, as soon as the relevant triggering stimuli occur. For example, if a female from a rather solitary living species had to learn the whole range of maternal behaviour (including attacking someone threatening her offspring) just through trial and error, this would reduce the number of surviving offspring, at least of the first litter, immensely. The same can be said for altricial young: if they could not react to a radical drop in their surrounding temperature at once with, for example, a species-typical sound to attract their mother's attention, they could die very fast. Inborn behaviours also include fixed action patterns like reflexive reaction of defence or offence to a noxious stimulus which has activated nociceptors (see section 1.3.1.2) – the fixed action pattern to elevate one's foot when stepping on a nail probably occurs automatically. Experience (training, see next section) could eventually alter even such reactions, at least to a certain extent.

Benus & Röndigs (1996) found differences in maternal care when looking at different inbred strains of mice. The more aggressive short-attack-latency mice (SAL) showed significantly higher rates of maternal behaviour than the less aggressive long-attack-latency mice (LAL), and also did so in cross-fostering settings. LAL mice proved to be more easily influenced by external factors for any behaviour in their repertoire (Benus et al., 1987). Benus & Röndigs (1996) showed that SAL and LAL mice followed different maternal patterns, behaviourally and physiologically. These patterns led to marked differences in the early experience of genetically aggressive and non-aggressive mice. The authors concluded that the question still remains unanswered as to which behaviours are actually coded for by the genes that contribute to the phenotypic behavioural differences between those strains.

Van Oortmerssen & Bakker (1981) stated that the successfulness of the artificial selection for SAL and LAL mice proved that variation in aggression partly stems from genetic variation. From reciprocal crosses they suggested a significant role of the Y-chromosome in the development of aggression, in interaction with autosomes that regulate the adult plasma testosterone level (van Oortmerssen et al., 1992). Benus & Röndigs (1997) showed in cross-fostering experiments that SAL-pups became more aggressive mice even when reared by LAL-mothers. The interesting finding was that SAL and LAL mice did not differ greatly in latency to attack at a subadult age. The authors concluded that there is a genetically based difference in the maturation process. They could also show that SAL and LAL mice generally have different coping strategies with stressful events and in behavioural flexibility in general.

This had been detected already by van Oortmerssen & Busser (1989): aggressive active copers with routine-like behaviour were particularly successful as residents within stable demes; non-aggressive passive copers with flexible behaviour had a higher fitness under migratory conditions. Analogous differences in coping strategies could be seen between active-coping pigs and passive-coping pigs (Hessing et. al, 1994). From their findings Benus & Röndigs (1997) concluded that the postnatal maternal environment should hardly influence the behavioural profiles of SAL and LAL mice. In a further experiment Benus & Henkelmann (1998) could show that litter composition as such had a pronounced influence on the development of aggression and coping. Males from all-male litters exhibited a faster maturation of attack latency scores and had, as adults, a more active coping style than males from single-male litters.

As these examples show there is no unambiguous answer to the question "nature or nurture" – even when inbreeding experiments show, for example, that SAL-genes produce SAL mice under a variety of conditions. Behaviours that play a fundamental role in ensuring the individual's fitness, including aggression, are unlikely to be coded by one single gene.

When evidence for the heredity of aggressiveness is looked at, the heredity of fearfulness should be looked at as well. The connection between flight and fight has already been discussed. Genetic variation in the ability to experience fear can be predicted from evolutionary considerations and has been proven by selective breeding in rats and mice (Broadhurst, 1975; Archer, 1976; Gray, 1987). Broadhurst carried out cross-fostering experiments for his reactive (= more fearful) and non-reactive (= less fearful) rats and could show that these traits, as in SAL and LAL mice, were to a large extent genetically determined. Here some pre- and postnatal environmental influences had to be considered as well, and the "nature-part" did not account for all of the observed variation. What if those fearful and non-fearful animals are tested in situations that might evoke attack? Benus and her various colleagues actually looked at fear behaviour in their SAL and LAL mice in an open field test and could show that the more aggressive mice (SAL) scored lower for fear behaviour.

The chance that these differences in high and low aggressiveness and fearfulness are due to mutations occurring during inbreeding is less than the chance that some already existing traits from the genome were differentially emphasised. So it can be summarised that there are inherited traits for features like aggressiveness or fearfulness in animals. To what extent those traits influence each other and the behavioural repertoire of the respective animal, and how much input is given by the environment, is not clear so far.

#### 1.3.1.4 Learning of aggression

The "nurture-part" of the ongoing discussion will now be addressed: can aggression or aggressiveness be learned? Liebermann (2000) defines learning as a change in an organism's capacity for behaviour due to particular kinds of experience, i.e. an individual adaptation of the behaviour according to the specific environment.

Although the „hardware" of learning is defined in the genes, an animal's aptitude for learning is the result of both - genetic make up and early experience (Immelmann et al.,1996). The ability to learn has a great advantage to pure heritability: Learned information has a greater variability and offers more chances of adaptation to a changing environment. Thus learning has progressively been developed as a tool for survival by higher organisms during phylogenesis.

Squire & Kandel (1999) stated that the basic principles for learning at the neuronal and biochemical levels illustrate phylogenetically old mechanisms. Certain second-messenger-systems, that are important in creating long-term-potentiation (LTP) in synapses work already in bacteria, here involved in feeding-mechanisms (detecting "hunger").
In order to understand the „learning of aggression", some learning principles have to be defined.

Habituation is a form of learning in which the probability of a response to a stimulus decreases with repeated presentation of that stimulus, when the stimulus has no great impact on the individual's perceived fitness. Habituations can easily be disinhibited if situations change, as this would mean a change of the stimulus' information-properties (Liebermann, 2000).
Sensitisation is the opposite of habituation. Here a behavioural reaction is increased when the organism is repeatedly exposed to a signal/stimulus. Sensitisation occurs quickly when signals have an imminent meaning for the individual's fitness and to unlearn them is more problematic than in the case of habituation. Neither of these forms of learning are regarded as associative learning.

Classical conditioning is the name for the process of associative learning where a formerly neutral signal (conditioned stimulus) precedes and becomes a predictor of an already established signal (unconditioned stimulus) and releases a certain behavioural reaction (then called a conditioned reflex) even in the absence of the unconditioned stimulus.
Pavlov's experiments with dogs set the foundation for research on that part of learning biology in the early 20$^{th}$ century (Pavlov, 1927). Experiments to elucidate the principles of classical conditioning have been undertaken since with many different species – from marine snails to humans – and the results are quite uniform, though species-typical (for a review see Liebermann, 2000). The process of classical conditioning involves two signals that become associated. The behavioural output is usually some reflex-like action/reaction that is not under active, conscious control by the organism, e.g. salivation, that starts reflexively as soon as something palatable and food-like is within the mouth or is smelled or seen. This is an inherited stimulus-reflex-connection, which will increase the fitness of any organism that possesses it. Any behaviour that carries

this attribute can be classically conditioned. These can be either internal reactions e.g. the physiological stress reaction, or reflex-like reactions of fast orientation towards or away from a noxious stimulus. Fast orientation towards a noxious stimulus can happen, according to the species typical behavioural repertoire, e.g. in the form of biting.

Instrumental conditioning is the process of associative learning where a formerly neutral signal becomes associated with a certain, controlled behaviour shown by the organism. The association formation is facilitated by an "important event" following the behavioural response to the signal, thus resulting in a change in the probability of the response (Liebermann, 2000). In other words, in instrumental conditioning an animal learns something about the consequences of its own behaviour. When an animal discovers that a certain behaviour is connected to a certain positive outcome in association with a certain signal (environmental situation), this behaviour will be shown more often subsequently. The opposite happens with negative experiences connected to certain behaviours. The terms positive or negative outcome relate to the organism's perceived fitness.

In instrumental conditioning the association-formation between a signal and a behaviour is due to reinforcement. Reinforcers are stimuli which, if their occurrence, termination or omission is made contingent upon the making of a response, alter the probability of the future emission of that response (Gray, 1987; Rolls, 1999, Liebermann, 2000). When a Stimulus increases the probability of emission of a response in the future, it will be called a "positive reinforcer". When a stimulus decreases the probability of emission of a response in the future, it will be called a "negative reinforcer". This definition follows Rolls' (1999) idea that "positive reinforcers" are anything appetitive, predicting an increase of fitness (or at least a stable state) in the broadest sense. "Negative reinforcers" are aversive signals (e.g. pain) predicting a decrease of the individual's state of fitness. Rolls (2005) further differentiates between "punisher" (decreasing the probability of an action to be emitted in the future) and "negative reinforcer" as such (stimulus increasing the probability of the emission of a response that causes the negative stimulus to be omitted) but gives no substantial reasons to do so beyond a slight semiotic difference. An animal cannot not act or behave as long as its alive. If it abandons some action that was followed by an aversive stimulus it can only do so in favor of another action. This action could in itself be an action that caused the aversive stimulus to vanish. So the differentiation that the punisher happens before the action to be decreased and the negative reinforcer happens afterwards, when the animal shows another more acceptable action, is a thin borderline.

Instrumental reinforcing stimuli are thought to produce certain mental states in an individual (emotions) (Rolls, 1999, 2005) and thus work as a sort of motivating force. Some of those stimuli are unlearned (= primary reinforcers). Usually such reinforcers are directly connected to the individual's fitness in that they resemble or are closely connected to resources. Pain would be such a primary reinforcer. Pain is an important signal bearing the information that the resource "intact own body" is endangered. Pain as such can be regarded as aversive (a negative reinforcer) whereas the omission of pain has positive reinforcing properties. Food or water can have either a positive reinforcing property (an animal associates the presentation of food with showing a certain behaviour as e.g. lever pressing in a Skinner box) or negative reinforcing properties (an animal associates the omission of food with showing a certain behaviour). The reinforcing property, either negative or positive, is not inherent in the reinforcer as such. It depends on the whole situation the animal is set in while being instrumentally conditioned. This includes former experience of the same or a similar setting.

In the case of threatening behaviour, the departure of the opponent when threatened acts as a reinforcer to the threatening interactor, and thus the threatening behaviour might increase in quality and quantity in subsequent analogous situations. A pain-eliciting injury gained in a fight with a certain opponent can act as a negative reinforcer, which will influence the strategy adopted in a subsequent conflict with that individual.

Hollis (1984) showed that she could classically condition aggressive behaviours in a fish species. The unconditioned stimulus for those fish was the sight of a male conspecific. Hollis could condition attack behaviour reliably to another optical signal (a light). From an evolutionary perspective this made no sense: why was it possible to be conditioned to a cost-intensive behaviour with no actual benefits to gain? In further trials Hollis could show, that there were advantages to fitness in this feature. Fish that had been "prepared" by the light were much more likely to win an ensuing fight with a conspecific. The important point here is that this training did not include an overall increase in aggressiveness in the fish.

Culler (1938) stated that foresight proves to possess high survival-value, and conditioning is the means by which foresight (not used in the sense of awareness of the future) is achieved. Others who demonstrated that aggression could be classically conditioned in animals included Vernon & Ulrich (1966), Creer et al. (1966) and Lyon & Ozolins (1970).

Kudryavtseva et al. (2000) studied aggressive behaviour in adult male mice with consecutive experience of victories in agonistic dyads. They showed that quality and quantity of aggression changed over 20 days. Mice with just few victory-experiences showed much more attacking behaviour, whereas mice with a more victory-experiences showed more threatening behaviour and especially aggressive grooming (an imposing-threatening behaviour where the winning mouse "sits" on the other, grooming its neck vigorously while the other freezes). When attacks were shown by mice with substantial experience of winning, they had an increased latency. The authors also found that the behaviour of one partner in social interaction depended on the behaviour of the other.

There was a positive correlation between less attacking behaviour in mice with substantial experience of winning, and submissive behaviours shown very rapidly by partners with substantial experience of defeats. Mice with no or just a few experiences of winning showed full attacking behaviour even when the other mouse displayed full submission. Prolonged experience of agonistic interactions resulted in the winning mice learning a better behavioural strategy. Kudryavtseva et al. concluded that victories in agonistic dyadic interactions function as a reinforcer to the animal's readiness with which it will engage in an aggressive encounter the next time the relevant stimulus is present. Again, as in Hollis (1984), no general increase in aggressiveness as such could be seen. During subsequent aggressive encounters the mice changed their strategies from pure and fast attack to threats – i.e. showing concern for their own fitness. However, in some mice it was observed that repeated experience of aggression was accompanied either by the development of such pathological states as long lasting non-adaptive affective aggression, or anxiety.

Aggression can be instrumentally reinforced either through non-aggression-related reinforcers (e.g. food, water; Reynolds et al., 1963; Azrin & Hutchinson, 1967) or through the outcome of the attack itself, as shown above and by Azrin et al. (1965a).

Lagerspetz (1964) showed that mice would even run over an electric grid for the possibility of approaching and attacking a conspecific. Here mice from an aggressive strain or those with recent fighting experience crossed the grid faster. Tellegen et al. (1969) could maze-train mice, with the positive reinforcer being the possibility to attack another mouse. Aggressive behaviour could be reinforced negatively by shock. Azrin (1970) and Roberts & Blase (1971) showed that attacks could decrease in a certain experimental setting, as a function of the intensity of contingent shocks.

In summary, aggressive behaviour and aggressive communication are subject to classical and instrumental conditioning, and many elements of a conflict can either become a feature of an aggression-inducing signal or function as a positive or negative reinforcer. Thus it is now necessary to look at the motivational background for aggressive behaviour or aggressive communication. What triggers aggression and thereby allows such learning processes to happen?

#### 1.3.1.5 The motivational background of aggression: fear, frustration and stress

As already shown in section 1.3.1.3, the ability to show aggressive behaviour is genetically determined: genes code for the hardware (muscles, bones, tendons etc.) that enable the organism to show a behaviour e.g. biting (open mouth, directing head towards certain object, closing mouth around object etc.). What is only to some extent (with unknown dimensions) genetically determined is why, when and where the above mentioned behaviours (open mouth etc.) are shown and what they are directed at.

Archer (1976) summarises certain basic situations that are capable of evoking agonistic behaviour: either aggression (attack), aggressive communication, avoidance or flight. He clearly distinguishes those basic situations from conditioned fear or attack behaviour, although conditioning can influence any one of them. The situations will be described separately in the following paragraphs; in nature they can overlap and sum up.

<u>Pain</u> has been shown to induce aggressive behaviour in experiments. Here electric shocks or heat are usually used as pain-inducing stimuli. Ulrich & Azrin (1962) and

Azrin et al. (1965b) showed that pain elicited aggressive (attack-) behaviour in rats or squirrel monkeys. Other species used were hamsters, cats, snakes, turtles, chickens (reviewed by Ulrich, 1966) or gerbils (Boice & Pickering, 1973). Aggressive behaviour was usually displayed against a conspecific or an inanimate object. Archer (1976) stated that shock can, of course, also elicit pure fear behaviour like avoidance or flight.

Intrusion into individual distance or "personal space", not necessarily by a conspecific or even another animal, is likely to elicit aggressive behaviour (Archer, 1976). Individual distance, as the simplest form of defended area, might be the precursor of other forms of defendable resources. Attack is encouraged rather than flight if the surroundings are familiar (Marler, 1956), but flight can occur as well.

Territory intrusion/something novel: two characteristics are important factors influencing the probability of aggression: the attacker is familiar with the surroundings and the intruder resembles a novel stimulus or shows certain aggression-eliciting features like the red breast of robins (Lack, 1939) or certain odours in male mice (Mugford & Novell, 1971). More recent research favours unfamiliarity with the intruding conspecific as facilitating attack (Southwick, 1967). This is strengthened by the observation of waning in aggressive responses due to repeated presentation of the intruder over consecutive days (Peeke et al., 1971). This was interpreted as a process of habituation, enabling neighbouring animals to reduce mutual stress.
The probability of aggression increases with increasing novelty of the unfamiliar object and decreases with decreasing familiarity of the area (Archer, 1976).
Since one of the classical fear-evoking situations for any organism is the presentation of something novel in the familiar environment, Archer supposed that species-typical responses to particular, fear- or aggression–inducing, stimuli, have evolved from that more general situation.

An unfamiliar situation or place can elicit aggression or fear behaviour in the animal entering or approaching it. Animals, which had hitherto been familiar with each other and had not showed aggression without relevant stimuli like pain, showed increased aggressive behaviour against each other just due to being placed in a new environment (Willis, 1966; Archer, 1969; Archer, 1976).

A familiar object in an unfamiliar place can elicit aggressive behaviour (Peeke & Veno, 1973), especially when paired with pain (Galef, 1970).

Frustration, i.e. omission or reduction of something expected, particularly a reward, can evoke either aggression or fear behaviour (Gallup, 1965; Archer, 1974; Archer, 1976). Thwarting is a special form of frustration, where an animal is prevented by a physical barrier from completing a previously reinforced response (Berkowitz, 1962; Duncan & Wood-Gush, 1971; Haskell et al., 1999). Duncan & Wood-Gush also observed fear behaviour in animals being thwarted.

Another trigger for frustration is a low reinforcement schedule. Delay between initiation and completion of an instigated response sequence is a form of frustration likely to evoke aggression (Archer, 1976). Knutson (1970) and Cole & Parker (1971) demonstrated this phenomenon in pigeons, and Hutchinson et al. (1968) in squirrel monkeys. Usually the animals had been trained on a high-ratio fixed-ratio reinforcement schedule. Most of the attacks against either another animal or inanimate model (even the animal's own reflection) occurred during the post-reinforcement pauses. Archer (1976) describes variations in aggressive response due to species, sex and the nature of the reinforcement. Azrin (1961) stated that post-reinforcement pauses in high ratio schedules also have a sort of "aversive nature". Archer (1976) further concluded that such frustration can lead to both aggressive and fear behaviour.

Davis & Khalsa (1971) demonstrated that male, but not female, rats showed an increase of aggressive behaviour during morphine withdrawal, which can be conceived of as a form of frustration. From Marshall & Weistock's (1971) report of an increase in induced jumping in mice, it can be concluded that fear behaviour is also evoked during morphine withdrawal.

A partial overlap between the conditions that can produce fear and aggression behaviour and those that can produce displacement and irrelevant activities can be seen (Archer, 1976). Macfarland (1966) proposed an attention-switching hypothesis. Displacement activities occur particularly readily in frustrating situations, and take the form of behaviour which is common in the animal's repertoire. There are no features in general that are common to the other mentioned situations evoking both fear and aggression

behaviour (e.g. pain, novelty etc.). Novel stimuli or situations can evoke approach and exploration, typically after fear behaviour has waned. Aggressive behaviour may overlap with exploration, usually when the novelty is less pronounced (Banks, 1962; Bateson, 1964). Aggression- or fear-inducing stimuli can overlap, but the noxious stimulus must neither be too severe to induce aggressive behaviour nor should it be introduced too gradually (Galef, 1970; Legrand & Fielder, 1973). The same applies to frustration and pain (Hayes et al. (1969).
Archer (1976) assumes that animals maintain a continuous complex representation of expectancies based on: a) the total sum of experiences; b) precise spatial representation of particular habitually used areas of the environment; c) temporal representation of the expected outcome of a particular sequence of previously rewarded response. Such expectation models are then continually compared with incoming information. Any large discrepancy will initiate a motor command to show aggression or fear behaviour. This model can even be applied to pain-induced aggressive behaviour (Crosby & Cahoon, 1973; Hutchinson et al., 1971; Archer, 1976).

Archer (1976) states that the common factor in all previously listed situations evoking aggressive or fear behaviour is that they produce a discrepancy from the animal's expectation model or model of its environment. He assumes that any perceived discrepancy will first activate a sort of "orienting response" towards the respective stimulus and then, if the discrepancy proves to be sufficiently large, will activate either aggressive or fear behaviour. Archer gives a detailed diagrammatic representation of this, shown in Figure 1.1.

Looking at this model of discrepancy from an evolutionary perspective, the first stage in the development of the flight-fight system probably occurred because animals had to counteract stimuli in their environment that were capable of producing physical damage. Pain-induced aggressive behaviour would therefore represent the simplest form of aggression. Nociceptors would be the first more advanced sensory equipment necessary to detect any discrepancy between what is there and what is expected. During evolution animals then developed the neurosensory equipment to react to potential rather than to actually noxious events, which would be, it its simplest form, a response to any major change in the immediate environment. Archer (1976) suggests that the different forms of aggression and fear behaviour listed above involve a similar type of comparison process, though not necessarily the same types of neuronal structures.

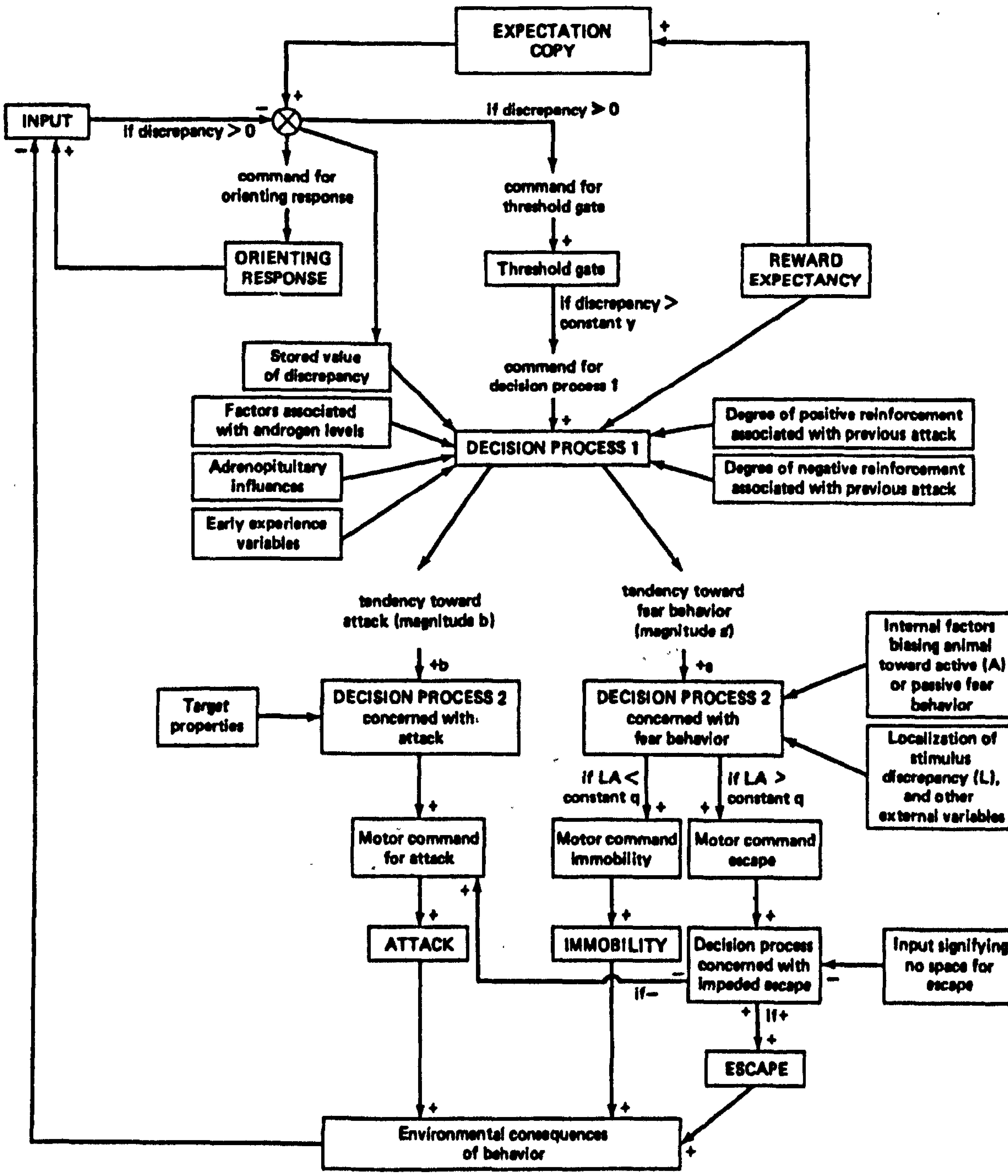



Figure 1.1) Diagrammatic representations of factors, influencing the occurrence of aggression and fear behaviour (from Archer, 1976). After a discrepancy from expectation is detected and verified via orienting response, the above mentioned fear or aggressive behaviour eliciting situations, together with some internal states mentioned in later sections, converge in the decision process 1. From here the relays for either fear or aggression behaviour are set and further modified by decision process 2.

The decision whether aggression and/or fear behaviour is shown, is further influenced by properties of the attacker, or the situation. For example, just the physical prevention of escape may itself be sufficient to evoke aggressive behaviour (Hediger, 1950). Aggressive behaviour is not necessarily directed at the evoking stimulus, it can be directed to a nearby stimulus that has characteristics suitable for attack, e.g. another animal (Lagerspetz, 1964; Wolfe et al., 1971; Poole, 1973). Here Ulrich (1966) showed, that the occurrence of such redirected aggression decreased with increasing distance between animals.
Archer (1976) calls this kind of aggressive behaviour "displacement of aggression" and suggests that it is elicited mainly by frustration. Berkowitz (1969) considers that the more the attacked stimulus resembles the frustrating stimulus, the more likely it is to be attacked. Other important properties of an aggression evoking stimulus are its size and movement: the larger the target of either fear or aggressive behaviour, the more likely fear behaviour will be shown; a moving stimulus will more easily evoke aggressive than fear behaviour (Archer, 1976).

Archer (1976) thought it plausible to assume that the effects of pain, novelty and frustration operate on a common mechanism at some point in the system. This could, according to him, just be on the output side, or, according to Gray (1987) consist of some common property in evoking certain emotional states. For example, Gray conceived the state of fear as qualitatively equivalent to frustration. Hinde (1970) suggested a similarity between different situations evoking aggressive behaviour, leading to analogous physiological states, and Gray (1987) suggested the same for fear behaviour as a behavioural output.
Hebb (1946) gave early support for Archer's model of discrepancy, with his statement that emotions such as fear and anger do not arise from a particular set of stimulus properties, e.g. novelty. They rather arise from the discrepancy between what is expected or has frequently been experienced by the animal and what is actually happening.

This idea of discrepancy between what is happening and what is expected causing stress, thus leading to emotions such as frustration or fear, has been further developed by Spruijt et al. (2001). Motivational states have an organising effect on associative networks in the brain and thus guarantee that only relevant associations been retrieved and relevant possible actions been activated. Stressful conditions can be counteracted by the perspective of successful coping or can be partly compensated by other rewarding events.

Rolls (1999) describes emotions as internal responses elicited by reinforcing signals. Different reinforcement contingencies produce different emotions – not in a vacuum but in a brain that already has, due to heritage or learning, some expectations of stimuli to come and their respective reinforcement contingency in individual situations. According to Rolls the stimulus that produces the emotional state does not have to be shown to be a reinforcer when producing such state – it simply has to be capable of being shown to have reinforcing properties.
Rolls summarises three main functions of emotions: 1) they elicit autonomic and endocrine responses that are usually adaptive; 2) they lead to flexibility of behavioural responses to reinforcing stimuli, the elicited emotion enabling the organism both to obtain a reward or avoid a punishment; 3) they thus elicit motivation for action.

From the above it has been concluded that the main underlying emotions to evoke both fearful and aggressive behaviour are fear and frustration. Following Archer (1976), Melzack & Wall (1996) and Rolls (1999), pain is able to elicit either of these emotions. All three (pain itself, fear, and frustration) are able to start the physiological stress reaction in vertebrates (Gray, 1987).

Another emotion that has been mentioned as arising through expectation discrepancy, is anger (Hebb, 1946). According to Panksepp (1998), anger starts the physiological stress reaction and is elicited through frustrating events ("when the availability of desired resources diminishes"). Panksepp also states, that many cognitive aspects of anger are undoubtedly unique to humans. According to Gray (1987) the very limited physiological differences between fear and anger have only been detected in experiments that involved humans and can be described better as a more general distinction between states of activity and passivity. Since both emotions, anger and fear, are apparently elicited by the same stimuli and lead to roughly the same physiological (and thus measurable) stress reactions, from here on the term fear will be used for both.

In human psychology the term "stress" can refer to an emotional state, but here it will be used in the biological sense: the organism is physiologically and/or psychologically challenged and certain physiological reactions to counteract that challenge are activated (Gattermann, 1993). These physiological reactions are summarised in the next section.

1.3.1.6 Neurophysiology of aggression, hormonal influences and the stress reaction

No single area or nucleus in the brain catalyses aggressive behaviour. Aggressive and fear behaviour are elicited by a number of different brain structures that form a network. The most important role is played by certain parts of the brain's limbic system, predominantly the amygdala, which is greatly involved in the creation of emotions. The amygdala is important for "learning fear" and has direct projections to activate the vagus and sympathetic branch of the autonomous nervous system, thus being important in starting the physiological stress reaction (summarised by Overall, 2001).

Distinctions among neural pathways for aggression have been effectively made by the careful psychobehavioural analysis of aggressive sequences evoked by direct electrical stimulation of the brain (ESB) (Panksepp, 1998). Holst (1957) was among the first experimenters who tried to elicit aggressive behaviour via electric stimulation of certain brain regions. Attack or flight could both be activated via stimulation of the hypothalamus, another part of the brain belonging to the limbic system. It was interesting that stimulation of the same area could evoke either behavioural output (flight or fight), depending on the strength of the electric current. Flynn (1967) mentioned two different forms of aggression he could evoke via ESB: predatory aggression (biting as one element of predatory behaviour, so-called "silent biting" as it happens very fast and without any preceding behaviour) and rage-like aggression. Later he and his colleagues (Flynn et al., 1970) described that ESB of the anterior hypothalamus elicited aggressive behaviour, that of the medial hypothalamus flight behaviour, and that of the lateral parts predatory behaviour. Siegel & Brutus (1990) have further refined Flynn et al.'s findings. They saw more aggressive behaviour when stimulating the ventrolateral and medial hypothalamus, whereas predatory behaviour was elicited by stimulation of the dorsolateral part. Stimulation of the ventromedial and posterolateral hypothalamus could especially influence the attack latency. Complete destruction of the ventromedial hypothalamus could produce permanently aggressive rats and cats (Overall, 2001).

It was thought for some time that animals, although performing the behaviour, did not experience emotions during ESB. However, analogous experiments with humans could show that emotions such as fear were aroused during ESB (Mark et al., 1972).

The Amygdala and hypothalamus interact in the elicitation of emotions and the processing of aggressive or fear behaviour. If the connection between both areas is cut or partially blocked, a decrease in quality and quantity of aggressive behaviour can be monitored. The basolateral part of the amygdala is activated when aggressive behaviours are shown, the corticomedial part is active during flight or withdrawal (Adamec, 1991; Koolhaas et al., 1990).

It has to be kept in mind, that the results of experiments about which brain area initiates which behaviour should not be automatically generalised to all mammalian species. Rather, the evolutionary history, actual species typical behaviour and ecological demands of the species have to be taken into account when interpreting such neurophysiological results.

Apart from just considering different regions in the brain, it is also important to consider neurotransmitter systems that might influence the creation of emotions and the respective behavioural output. Neurotransmitters primarily involved in the emotion of fear and the elicitation of fear and aggressive behaviour are serotonin (5-HT), dopamine, noradrenaline, gamma amino butyric acid (GABA) and excitatory amino acids such as glutamate. Receptors for these neurotransmitters can be found throughout the brain and can mount up in certain small areas of the brain, e.g. in parts belonging to the limbic system.

Noradrenergic arousal from the locus coeruleus or serotonergic arousal from the raphe cell group (both again parts of the limbic system) have been proposed as basic substrates for fear and anxiety (Redmond & Huang, 1979; Graeff et al., 1980). The problem is, that none of these, or other models that try to explain the neurophysiology of fear in connection with just one or at least two neurotransmitter systems, have proved to be ultimately and exclusively right (Panksepp, 1998).

In humans a central serotonergic deficit has been associated with impulsiveness and aggressive behaviour (Linnoila & Virkkunen, 1992; Cleare & Bond, 1994). Impulsiveness (i.e. impulsive aggression) is a term from human psychology which is associated with irritability, frustration and impulsive action (Cocarro, 1992). Moyer (1987) differentiates impulsive aggression from instrumental aggression, which has been learned and has no strong emotional component. Hollander & Rosen (2000) link impulsiveness in humans to such disorders as impulsive aggression, pyromania, pathological gambling or sexual impulsions. The serotonergic system is involved in a variety of mood disorders, including anxiety or impulsive violence (Mayford et al., 1995). As already mentioned, Saudou at al. (1994) were able to show that mice lacking a certain serotonin receptor ($5\text{-}HT_{1B}$) reacted with increased aggression towards an intruder. This receptor seems to play a critical role in aggressive behaviour. It is present in the amygdala and the central grey area, and plays a role, to some extent, not only in the fear and aggressive behaviour of an animal, but also influences the readiness with which an animal will react fearfully (Mayford et al., 1995).

GABA, as the main inhibiting neurotransmitter in the brain, can suppress fear (Miczek et al., 1995). Glutamate, as the brain's most prolific excitatory neurotransmitter, can non-specifically heighten an animal's ability to express fear, and mediates the learning of fear. Glutamate is thought to be the neurotransmitter that directly conveys the signal of fear through the neuroaxis (Panksepp, 1998), and is thought to be the key transmitter to evoke the unconditioned response for fear (Eckersdorf et al., 1996).

As fear does not ultimately elicit aggressive behaviour every time (see earlier sections of this chapter), there is no direct connection between any one of these neurotransmitters and an individual behavioural output, e.g. biting. Previous experience of aggressive encounters also modifies the effects of neurotransmitters. E.g. Diazepam, a GABA agonist, has different effects on aggressive and fear behaviour expressed by mice with different experiences of aggression (Kudryavtseva & Bondar 2002). Kudryavtseva (2000) showed that chronic experience of aggression in mice is accompanied by activation of the dopaminergic system in the winners. The repeated experience of victories also changed the pharmacological response of opiate receptors. They became more sensitive, as did some serotonin receptors (5-$HT_{1A}$, 5-$HT_{2A}$). The losers of such repeated aggressive dyadic interactions expressed changes in the serotonergic and noradrenergic system in different parts of the brain. As a consequence there were significant differences between winning and losing mice in emotional expression, movement activity, investigative activity, communicative ability, alcohol consumption and some physiological aspects, e.g. stress reactions. Differences between winners and losers are even apparent in their m-RNA levels (Filipenko et al., 2001, 2002).

These few examples of experiments in the vast field of neurobiology and neurochemistry illustrate the difficulties experimenters face when they try to interpret their results. Experience in aggressive encounters, either as winner or loser, influences the neurotransmitter systems with, for example, an impact on memory formation. But those influences are not linear; comparing winners and losers, the same neurotransmitter system can be influenced in different ways and in different parts of the brain. The construction of any biological rules on the neurophysiology of aggression, that might, for example, increase the possibility of finding "the perfect drug against aggression", is still some way ahead.

Sex hormones also influence aggressive behaviour. Males, which are often used for studies of aggression, typically show qualitatively and quantitatively stronger aggression than females, due to the influence of androgens (Gray, 1987). Both amygdala and hypothalamus have receptors for both androgen and estrogen/progesterone. High levels of aggression can typically be seen, in both rodent and primate societies, when levels of circulating testosterone in males are high. Castration of adult male mice decreases aggressive behaviour, and injection of testosterone restores the aggression level. Female mice did not react with increased aggression when injected with testosterone (Gray, 1987).

Van de Poll et al. (1982) could show that castrated adult rats reacted with increased aggression if allowed to win their fights and with decreased aggression if they lost. Again neither of these effects was seen in female rats treated the same way. As ovarian hormones have been shown to have little direct effect on aggressive behaviour, Gray (1987) ironically sums up that the requirements for high levels of aggression are a high level of testosterone, a male brain and success in agonistic encounters.

Aggression in females appears to be variable between species, and to be related to social structure. According to Gray & Buffery (1971), no sex difference in fearfulness should be found in a species where the formation of hierarchies plays little part in social life.

Again the influence of androgen on aggressive behaviour should not be considered in isolation. E.g. Bevan et al. (1960) showed that experience of victories or defeats had a greater influence on later aggressive behaviour in mice than androgen levels did. Swanson (1973) showed that nonreceptive female hamsters and gerbils showed as much tendency to attack one another as did males, if territory borders were violated.

Gonadotropic hormones e.g. luteinizing hormone (LH), can influence quality and quantity of aggressive behaviour as well. LH has more influence on aggressive behaviour in starlings than testosterone does (Matthewson, 1961). In many species females show a form of territorial aggression, restricted to the period of infant protection, influenced by the hormone prolactin (Moyer, 1987).

The hormones of the pituitary-adrenocortical axis are also supposed to influence aggressive behaviour. High levels of the adrenocorticotropic hormone (ACTH) reduce aggressiveness and low levels cause an increase in aggressiveness, independently from any androgenic influence; e.g. Dexamethasone treatment (which lowers ACTH level) raised aggressiveness in mice (Candland & Leshner, 1974). Again this rule cannot apply generally to every mammal species. The influence of ACTH level on aggressiveness differs according to the species tested and the stimulus used to evoke aggressive behaviour (Brain & Evans, 1973). ACTH also has an impact on fear behaviour, and it is supposed that ACTH blocks aggressive behaviour by increasing the display of fear behaviour (Archer, 1976).

Another hormone released from the hypothalamus, TSH (thyroid stimulating hormone) acts upon the thyroid gland and influences the release of the thyroid hormones T3 and T4, which have multiple functions in the organism. They play important roles in growth and maturation. T3 very broadly increases the organism's oxygen turnover; T3, especially, acts on other hormones e.g. insulin, somatotropin hormone or adrenalin. It could be shown that strains of mice, differing in their reactivity to novel/noxious stimuli, also differed in their thyroid function. The "reactive", i.e. more fearful mice, had a less active thyroid than the "nonreactive", i.e. less fearful mice. This difference is supposed to be due to different sensitivity of the thyroid gland, not necessarily to differences in the gland tissue itself (Broadhurst, 1975). In cats increased aggressiveness is described as a component of hyperthyroidism (Meric, 1989)

1.3.1.7 Aggression and clinical diseases

Many examples in human psychology connect certain clinical illnesses with increased aggressiveness, the story of Phineas Gage (told by Damasio, 1996) being just one of the more commonly known. As a synopsis from the previous sections it can be stated that any physiological or psychological trauma with impact on nervous tissue in the brain or on other hormonal systems outside the brain can potentially influence the organism's emotional state, thus influencing motivation for action in specific situations. Traumata can range from acute or chronic pain to organic malfunction, e.g. liver or kidney problems. Epileptic fits can be accompanied by aggressive behaviour, especially when the neuronal discharge is located in the limbic system (limbic epilepsy) (Reisner, 1991). Feline ischaemic encephalopathy may lead to increased aggression in cats, if the cerebral ischaemic necrosis, due to thrombosis in the middle cerebral artery, is manifested in the temporal lobe (Bernstein & Fiske, 1986). Pentürk & Yalcin (2003) found hypocholesterolaemia associated with dogs showing dominance aggression. Juhr et al. (2003) found that dogs with a history of dangerous biting had higher circulating concentrations of zinc than a non- biting control group.

1.3.1.8 Predatory behaviour

Biting and subsequently killing another animal are also behavioural elements of predatory behaviour. Thus the term "predatory aggression" is widely used in the literature.
Moyer (1968) considered predation (predatory biting) to be a form of aggression, whereas Archer (1976) differentiates such behaviours that are concerned with the acquisition of food from true aggression, due to differences in underlying motivation. Gray (1987) classifies predatory aggression as essentially approach behaviour of the same kind as food-seeking or water-seeking. He backs up his statement with the different reactions of cats in ESB in different parts of hypothalamus and amygdala, and the fact that Adams & Flynn (1966) showed that predatory biting is unconnected with fear or avoidance behaviour.

Panksepp (1998) states that hunting and finally killing emerges from the "seeking system" of the brain and thus puts predatory aggression in the same category as Archer and Gray. However, Panksepp also concedes that predators surely experience pain, irritability or frustration in struggling with or trying to catch their prey. So he predicts sudden shifts in emotion in real life situations, depending upon the success or failure of specific behavioural acts. An animal may thus momentarily exhibit true aggressive behaviour during predatory sequences.

1.3.1.9 Summary: aggressive behaviour in general

Aggressive behaviour has been shaped by evolution as one possible means for an animal to increase or at least maintain its fitness level. Aggressive interactions start mainly over resources necessary to increase or hold fitness, including food, water or a partner for reproduction, and also perceived or actual status in a social group or the intact body of an individual animal.

Neither a single "aggression gene" nor a simple neurophysiological pathway have been identified to elicit aggression. Aggressive behaviour occurs as a result of an individual situation and subsequently an individual process of decision, as a response to some form of aversive environment, which may be a threat to fitness status or any resources held by the animal. Emotions as fear, anxiety or frustration will be involved but are difficult to distinguish completely. The correlation between an animal's fearfulness and its aggressiveness is not a simple, straightforward matter anyway. For example more aggressive mice (SAL) scored lower for fear behaviour in special anxiety/fear tests than the less aggressive mice (LAL). Under evolutionary considerations this constellation (high aggressiveness – low fearfulness) should not develop into an ESS: an animal that is not fearful and also very aggressive (i.e. goes for attack in nearly every conflict) would significantly threaten its own fitness when living under natural conditions. The probability of eventually meeting a stronger and better armed opponent is highly increased. In the long run such behaviour could be labelled as pathological. When offensive behaviour is a means to heighten one's fitness by winning in a contest or holding/gaining certain resources, then this should rather be positively correlated to fearfulness. I.e. an animal that quickly experiences a high level of fear should equally show a high level of fight (or flight) behaviour, according to individual cost-benefit-relations.

The following sections will now concentrate on aggressive behaviour of dogs; the question of the correlation between fearfulness and aggressiveness will be raised again.

## 1.3.2 Aggressive behaviour in the dog

As already stated, aggressive behaviour belongs to the behavioural repertoire of any dog. Completely "non-aggressive" dogs have not been bred so far and there is a good chance that they never will. Aggressive behaviour belongs to the social behaviour of the dog and it will be difficult to filter and strip the genes for aggressive components from those for social behaviours in general. Although it has been possible to produce less aggressive strains of mice this does not mean that they do not show any aggressive behaviour at all.

### 1.3.2.1 Form and function of aggressive behaviour in the dog

Aggressive behaviour in the dog fulfils the same functions as in other species, especially those that are both highly social and well-armed (see section 1.2.2 and 1.3.1). The wolf, as the dog's ancestor, evolved a finely differentiated system of aggressive behaviour, ranging from very subtle aggressive communication to serious biting and finally killing. Especially in the type III social system, the pack, attacking behaviour shown on a regular basis would be counterproductive for any individual's fitness. Solutions to competition and conflict arise from communication, enabling each individual to work for its own fitness as much as possible, without incurring physical damage.

Today's dogs still show this subtle and finely differentiated aggressive communication and offensive behaviour to a large extent, though modified through breeding by man over the last 3-4,000 years. The considerable morphological diversity of the dog, compared to the wolf, has inevitably resulted in changes in visual communication. Goodwin et al. (1996) found that the German Shepherd, which was developed from shepherding stock with the deliberate intention of producing a physically wolf-like animal (Willis, 1991), displayed fewer wolf-type signals than did the Siberian Husky and the Golden Retriever. Goodwin and colleagues assumed, that little emphasis had been put on the maintenance of a full range of ancestral behaviour patterns when breeding such a morphologically wolf-like dog. They suggest that once a single behaviour pattern, e.g. a distinct signal, is definitely lost from the repertoire of a breed it cannot be reconstructed by merely altering the appearance of the breed. It was supposed that the functions of remaining signals have also altered slightly, for example the Golden Retriever displays its remaining wolf-like signals with higher frequency than is typical of wolves. They concluded that the function of agonistic signals, which in wolves regulate the escalation of aggression during social conflict, has changed during domestication. For the dog it is less costly to fail in displaying submissive behaviour, as humans may intervene in a conflict in favour of the dog. There might also be a lesser necessity for finely differentiated agonistic communication as real competition for resources is negligible because of provisioning by humans (Bradshaw et al., 1996).

At its most basic, aggressive communication and offensive behaviour, e.g. attack, is a means to increase distance in time and space from an opponent or other threat. The underlying motives (emotions like fear) and further influences e.g. learning, as specified in earlier sections, apply to the wolf as well as to the dog. So far astonishingly little scientific research has concentrated on aggressive behaviour in dogs, although such behaviour has both been exploited by humans for a long time, and has produced greater or lesser problems for ownership.

Behavioural elements from threat up to attack are used to protect people ("Schutzdienst"), e.g. by the police. The territoriality of dogs is also used: dogs that give alarm when territorial borders are violated, and subsequently threaten the violator, are helpful in protecting human possessions. Humans tended and still tend to perceive this useful dog behaviour in an anthropomorphic way. Preferable "character-traits" in the nature of certain breeds, e.g. German Shepherd, were, for example, "braveness, drive to fight or sharpness". Even today breed standards contain descriptions like "will to defend the owner". In scientific reality no dog has a certain "will to defend the owner". The dog has the "will" (if one wants to retain the word) to increase its own perceived fitness as much as possible, at least not let it decrease. Behaviours such as territorial defence or responding to a perceived threat against any member of its social group, including itself, fulfil just this function.

According to Feddersen-Petersen & Ohl (1995) aggressive behaviour in the dog should not be looked at as something static. Dogs engaging in competitive and possible aggressive interactions constitute a complex functional unit with multiple changing positions between attacker and defender. The authors differentiate categories of aggressive communication and offensive behaviour (i.e. agonistic behaviour) in dogs: offensive or defensive threat, and inhibited or uninhibited offensive or defensive attacking behaviour.

Altogether Feddersen-Petersen & Ohl and Rottenberg (2000) differentiate six categories of social behaviour:
1) social approach, 2) passive submission, 3) agonistic behaviour (a: free aggressive behaviour, b: inhibited aggressive behaviour, c: offensive threats, d: defensive behaviour, e: flight), 4) imposing behaviour, 5) play behaviour, 6) sexual behaviour. The problem with such defined categories is, that they could complicate rather than make it easier to understand, label and differentiate, competition and conflict in dyads or a complex social group. For example, "mounting" is listed by the authors only under sexual behaviour, whereas it can also be shown for imposing (showing rank) against members of the same or the opposite sex or as a direct threat at the beginning of a conflict (Schenkel, 1967).

Feddersen-Petersen & Ohl (1995) speak of different stages of escalation in a conflict. "Approach" is followed by "demonstration" (e.g. of status) and then "imposing"; the next stages would be "offensive threat", "attack" and "fight". The respective reactions to each of these stages of escalation would be, on the opponent's (i.e. defender's) side: "submission", "defensive threat", "flight" or "counter-attack". While it looks plausible to arrange such stages of escalation on the "offender's side", it is problematic to do it in the same way for the "defender's side". Escalation might here be present in the intensity with which a certain behaviour is shown. Thus the "defender" might show a low intensity submission, when the "offender" is imposing, whereas an attacking "offender" might elicit submission of high intensity. And it must always be kept in mind that such escalation of conflict will not happen in a static way with participants easily identified as offender and defender respectively. As mentioned earlier dogs in competitive or conflict may change positions between attacker and defender.

When dealing with dog aggression in this thesis, I differentiate between aggressive communication, attack and flight. Attack and aggressive communication can be both further labelled "offensive" and "defensive". There is an implication that a certain emotional state underlies the terms defensive and offensive (e.g. "defensive" behaviours triggered by the emotional state of fear). Aggressive communication signals an intention to fight but produces no physical damage, although physical contact may occur at its strongest level, e.g. in the form of a sharp muzzle nudge. Behaviours preventing a conflict from escalating (e.g. submissive behaviours) also belong within aggressive communication. Flight means that one opponent in a conflict abandons social interaction and leaves rapidly. Attack comprises all behaviour leading to physical damage to the opponent.

Attacking behaviour, e.g. biting, can be performed in a state of fear and can thus be called a defensive attacking behaviour in a specific situation. Thus certain behaviours shown by a dog in aggressive interaction are not *per se* "defensive" or "offensive" but can be either, according to the situation.

The following behavioural elements will be described in detail in Chapter 3. The list here just gives an overview of what is included in either category:
Aggressive communication: active and passive submission; submissive and offensive facial display; avoidance; jumping at; chase; raise paw in front of opponent; leaving from an interaction; muzzle nudge; snapping; growling; wrinkled nose; raised hackles; baring teeth; raised hair; barking; lurking; creeping along; licking intention; biting over the muzzle; mugging; wrestling; pressing the opponent down; standing over opponent; laying on the back defending; behaviour for de-escalation from other categories of social behaviour (behaviours shown as displacement behaviour, elements from play behaviour including play-fighting or play-biting). Attack: biting, from a one bite-attack up to serious fighting involving teeth and/or claws; bite-shaking.

Behaviours for demonstration of social status and imposing ("dominance") include inguinal approach; placing paw on back of opponent; mounting; raised bodily posture; raised tail; genital, anal and tail sniffing; pushing; showing neck; T-position; laying head on back of opponent; many of these can subtly become aggressive communication. Additionally, situations that start as play-interaction can change into an aggressive interaction, be that communication or attack/flight. A distinction between inhibited and uninhibited attack is not made here, as any inhibited attack would tend to resemble aggressive communication.

1.3.2.2 Ontogeny of aggressive behaviour in the dog

Behaviours like biting can first be observed in puppies between the third and fourth week of age and are mainly directed against siblings. Here no difference in ontogeny between wolf cubs and puppies exists (Scott & Fuller, 1965; Bekoff, 1972; Althaus, 1982; Dürre, 1994; George, 1995; Redlich, 1998; Schöning, 2000a). In the third and the beginning of the fourth week puppies bite without any inhibition (Fox, 1971b; Feddersen-Petersen & Hoffmeister, 1990), as can be deduced from the whining and screaming sounds made by the bitten puppy (George, 1995). Reactive biting or flight behaviour by the opponent usually ends these dyadic interaction at this early stage (Venzl, 1990). Such dyadic interactions start accidentally as puppies at that early age start to investigate their immediate environment with muzzle and teeth rather than by sniffing, as they would do when older.

Althaus (1982) assumed that social contacts carried out with the mouth developed from the behaviour "yawning", which itself develops from "suckling behaviour". He observed a quite stereotypic opening and short closing of the mouth around body parts of siblings in his Siberian Husky puppies in the first two weeks of age. From the type of behaviour ("reflexlike, stereotypic"), he assumed, agreeing with Menzel & Menzel (1937) and Schmidt (1957), that yawning develops into a precursor behaviour of biting. By chance a puppy yawns nearby another puppy or object and starts making contact with full or partly open mouth, leading consequently to a more intentional and direct interaction with the open mouth against that object or sibling in further interactions.

From the end of the fourth week, dyadic biting starts changing in both quality and quantity, as the development of true agonistic interactions with all communicative elements and variations (including biting inhibition) happens. Puppies will now subsequently interact longer and with more variations in behaviour, including changing positions between "offender" and "defender" (Althaus, 1982; Feddersen-Petersen & Hoffmeister, 1990; Venzl, 1990). In parallel, elements from play behaviour (signalling play) develop. Fox (1971a) described hand reared puppies that were not allowed to play at all during their socialisation period. At the age of 12-16 weeks these puppies showed no inhibited biting and no "understanding" of play signals.

Other authors who have described the development of puppy behaviour from birth till the time the puppies left the breeder, have spoken of an age-dependent development of bite-inhibition and knowledge of social (including aggressive) communication at the eighth week. Such research on behavioural ontogeny and development of social behaviour, has been done for the following breeds: Siberian Husky (Althaus, 1982), Beagle (Venzl, 1990), Bullterrier (Schleger, 1983; George, 1995), Weimaraner (Dürre, 1994), German Shepherd Dog (Feddersen-Petersen, 1992), Labrador-Retriever (Feddersen-Petersen & Hoffmeister, 1990; Feddersen-Petersen, 1992, 1994a/b), Golden Retriever (Feddersen-Petersen & Hoffmeister, 1990; Feddersen-Petersen, 1992, 1994a/b), Standard Poodle (Feddersen-Petersen, 1992, 1994a/b), Miniature-Poodle (Feddersen-Petersen, 1992, 1994a/b), American Staffordshire Terrier (Redlich, 1998), Fila Brasileiro (Gramm, 1999), Rhodesian Ridgeback (Schöning, 2000a), Border Collie (Heine, 2000).

The results of these studies were not quite comparable, even though they followed a similar protocol (following Altman, 1974). Ethograms were slightly different, as was the aim of each investigation. Schöning (2000a) summarises the difficulties in comparing these studies, and describes their differences and common ground. It can be stated that such studies are necessary for more understanding of dog behaviour. Puppies of many more breeds and litters should be monitored for comparison, especially considering the welfare aspects and the "dangerous dog problem".

Differences in the development of aggressive behaviour between the wolf and the dog are described in these papers, but usually concentrate on the respective breed vs. wolf rather than between breeds. In general, dog puppies develop faster than wolf cubs, especially where agonistic behaviours are concerned. Until more research is done with more breeds and a larger number of puppies/adult dogs, it will be difficult to undertake a more differentiated comparison between dog and wolf. For example, Gramm (1999) saw distinct play-fighting behaviour in her Fila Brasileiro puppies from the third till fourth week on, whereas wolves start showing this behavioural element in the $12^{th}$ week (Feddersen-Petersen, 1988). But even these results have to be a carefully compared due to slight differences in the ethograms used and, for example, the definition of "distinct" play fighting in these papers.

Zimen (1988) saw differences in the ethograms of the European wolf and Poodles. He characterised 362 different behaviour patterns for the wolf of which 231 (i.e. 64%) were identical to behaviours in the Poodle. 46 (13%) of the wolves' patterns were no longer present in the Poodles. These were mainly communicative behaviours the Poodles were unable to display due to morphological differences from the wolf. The other 85 (23%) wolf-behaviours comprised behaviours that lacked the fine-tuning in performance by the Poodles, or the respective information of that signal/behaviour seen when displayed by a wolf.

In the socialisation period, lasting until the $12^{th}$ to $14^{th}$ week of age, the dog learns the "language" that is spoken among dogs: the basic skills in social behaviour and communication are laid down here. Puppies need their siblings and adult dogs during that period to learn and train. Puppies also modify their communication and social interaction with any other living being that provides some sort of social contact and communication that the puppy is physically able to react to and easily become attached to. Thus puppies at that age can easily become socialised to humans and later on use the same elements of communication (including aggressive communication) towards humans (Serpell & Jagoe, 1995).

In the socialisation period the puppy not only starts training its social and communicative abilities, but also becomes habituated to the environment it will subsequently live in. The crucial point is that any environmental elements not introduced in the socialisation period will probably produce fear later on in life, as the puppy and subsequently the adult dog will regard them as "not known and thus possibly dangerous". Freedman et al. (1961) and successors like Scott & Fuller (1965) showed this connection between "not having experiences in certain fields" and "being fearful later on" in different breeds. The proposed second critical period at around four till six months of age with a sudden onset of heightened sensitivity to fear-arousing stimuli

(Mech, 1970; Fox, 1971a) has already been mentioned. This is the period which leads into puberty and sexual maturity. Hormonal imbalances, mainly in the field of sexual hormones, may trigger conditions allowing this fearfulness to develop again for a certain period (see section 1.3.1.6).

As fear is a major trigger for aggressive behaviour it has been proposed that dogs with insufficient experience (social, communicative and environmental) during their socialisation period(s) will subsequently be more ready to react aggressively, and be more inclined to escalate their aggression. Such dogs should also show lower competence for regulating aggressive communication and social communication at large. Appleby et al. (2002) looked at dogs showing signs of avoidance behaviour or aggression and compared their developmental history to dogs from the same clinical population showing no such behaviour. Non-domestic maternal environments and a lack of experience of urban environment between three to six months of age were both significantly associated with aggression towards unfamiliar people and with avoidance behaviour.

1.3.2.3 When do dogs react aggressively - are there "different kinds of aggression"?

In general, dogs react with aggression when they subjectively determine the necessity to do so in an individual situation. Such situations generally do not differ from the triggering situations listed in section 1.3.1.5, with fear, frustration and stress being the main triggering internal factors. Learning also influences both quality and quantity of aggressive behaviours shown.

In the literature, labelling of aggressive behaviour in dogs is sometimes confused with anthropomorphic ideas of how dogs should behave in human society. Overall (1997) gives examples for appropriate (i.e. normal) and inappropriate (i.e. abnormal, pathological) aggressive behaviour shown against humans: "appropriate" would be the biting of a man trying to rape a female owner; "inappropriate" would be the biting of a friend/guest hugging the owner in the house. But in both cases the biting might have been "appropriate" in the eyes of the dog and the underlying emotion might have been fear, thus leading to a display of "normal" agonistic behaviour, directed at causing an intruder to retreat.

Biologically and clinically, "abnormal behaviour" is defined as a distinct qualitative and/or quantitative deviation from normal, species-typical behaviour for a longer or shorter period. This leads to a decrease in species-specific capacity for adaptation to the environment, and finally poses a serious threat to the individual's fitness. Abnormal (i.e. pathological) behaviour may have a genetic origin (e.g. mutations) or illnesses (e.g. brain traumata). Abnormal behaviour may also develop as a reaction to animate or inanimate environmental factors (via learning). Individual coping strategies to optimise individual situations and eliminate deficiency or stress can develop into fixed behaviour patterns, which then come to be regarded as abnormal (Gattermann, 1993).

Abnormal aggressive behaviour is often attributed in the literature as being shown quite rapidly without typical warning signals (Overall, 1997). Looking at dog aggression with the scientific biological/clinical definition for "abnormal behaviour" in mind, it can be stated, that abnormal aggressive behaviour in dogs is rather rare - though it definitely does exist. The mentioned lack of warning signals would leave the canine or human victims no time for appropriate action (e.g. for de-escalation of a conflict), thus increasing danger for both parties.
The majority of aggressive behaviour from dogs, be it shown against conspecifics or humans, can be attributed to "normal" dog behaviour, but, from the human perspective, as occurring in the wrong context, place and/or time. In the following section where and when dogs in general react with aggression will be described, with categories for dog aggression which might prove helpful in directing logical and effective treatment of problematic aggressive behaviour.

Dogs can show both inter-species and intra-species aggression. Another possible differentiation is the one between inter-group and intra-group aggression. If predation is excluded, both differentiations can apply to the human-dog connection/interaction. Although humans belong to a different species, dogs and humans can form social groups with one another. When categorisation of dog aggression is attempted, especially with the aim of developing effective behavioural treatment, neither differentiation is helpful. Rather, any differentiation should focus on certain general causalities and underlying emotions, keeping in mind that even this approach is unlikely to produce mutually exclusive categories.

Overall (1997) lists 13 different categories of aggression in dogs: maternal aggression, territorial and protective aggression, interdog aggression, redirected aggression, food-related aggression, possessive aggression, predatory aggression, idiopathic aggression, dominance aggression, pain aggression, fear aggression, play aggression.

Beata (2001) differentiates between 8 categories of aggression: predatory aggression, irritation aggression – either by a submissive or a dominant dog - territorial aggression, maternal aggression, fear aggression, hierarchical aggression, instrumentalised aggression. Apart from these categories he also tries to differentiate between certain syndromes as underlying causation for those different forms of aggression: primary and secondary dyssocialisation, hyperactivity-hypersensitivity-syndrome, deprivation syndrome and social phobias, dysthymias, hyperaggressiveness of aged dogs, secondary hyperaggressiveness, sociopathy or anxieties.

A syndrome is defined as the complete picture of a specific illness, consisting of individual pathognomonic symptoms. In sociology, syndrome is the name for a group of features or factors, that, if occurring together, characterise a certain condition or correlation. Thus, from a general point of view, it appears plausible to define and characterise certain syndromes that cause/consist of dog aggression. But this approach can also be criticised, as it simplifies the labelling of diagnoses on the one hand, and on the other creates a collection of "behavioural diseases" that have questionable ethological reality. A certain superficiality lies in such approach, in which the cure (behavioural therapy) for any problematic aggressive behaviours might be sought in a catalogue of therapeutic catchphrases. Beata (2001) so far does not give plausible explanations on ethological and neurological basis for his differentiation between e.g. primary and secondary dyssocialisation, deprivation syndrome and social phobias, hyperactivity-hypersensitivity-syndrome or sociopathy. Especially such terms as "hyper" should not be used, until a baseline of behaviour, that serves as basis for comparison, has been defined.

Lindsay (2001) tries a nomenclature of descriptive and functional characteristics of aggression. He differentiates 19 different types of aggression, giving each its motivational aetiology, and subsequent description and function. He mainly follows Overall (1997), further differentiating for example "avoidance motivated aggression" and "xenophobic aggression" from fear aggression, and making a distinction between idiopathic and pathophysiological aggression.

From an ethological perspective aggressive behaviour in dogs can be categorised into groups that contain certain pathognomonic situations and commodities, and groups that have the emotional background "fear/anxiety" in common, bearing in mind that in the former groups fear, anxiety, stress etc. can be emotional triggers. Maternal aggression, male and female interdog aggression, territorial aggression, pathological/idiopathic aggression, pain induced aggression or play aggression are examples of the former group. Aggression in a hierarchical context, or aggression out of fear of any kind, belong to the latter group. Predatory aggression will be dealt with separately. These categories will be described further in the following paragraphs.

Maternal aggression occurs during pregnancy or pseudocyesis, proximate to whelping or postpartum (Freak, 1968; Allen, 1986; Overall, 1997). The bitch reacts with aggressive communication or attack towards an actual or perceived threat to real or perceived puppies, den or territory. Typically such dogs are not aggressive otherwise. When the specific hormone status triggering the behavioural change abates, the aggressiveness abates as well (Overall, 1997).

Another mainly hormone-induced form of aggressive behaviour is female or male inter-dog aggression. When it happens between dogs sharing a social group, it overlaps with aggression in a hierarchical context. Usually this category of aggression occurs between same-sex dogs and generally becomes apparent at social maturity between 18 up to 30 months of age when dogs start competing seriously over resources (Voith, 1980; Hart, 1981; Overall, 1997). According to Neilson et al. (1997), castration reduces the display of such aggression in male dogs in over 50% of cases.

According to O'Farrell (1986) it is difficult to clearly distinguish inter-dog aggression from territorial aggression against other dogs, which is first observed (i.e. territoriality in general) at around social maturity also. She says that one helpful distinguishing aspect is the fact that in territorial aggression threats are much less pronounced, be they against other dogs or humans. Overall (1997) says that one pathognomonic symptom for territorial aggression, both against dogs and humans, is the fact that those dogs show no or significantly less aggressive behaviour when away from their territory.

All those "hormone facilitated" forms of aggressive behaviour or aggressiveness can be differentiated up to a certain point from a predominantly fear-based aggression. One distinction is that the hormone-facilitated form may have peaks in quantity around the breeding season. A dog that predominantly reacts aggressively due to fear might do so at any other time, and in other situations as well. There might be deficiencies in social and communicative skills in a dog that has been badly socialised (thus reacting fearfully) whereas even the best socialised dog, able to express a great variety of aggressive communication, will start showing territorial or inter-dog aggression if hormones give the command. On the other hand normal, species typical, hormone facilitated aggression needs a trigger, just as any other normal behaviour does. The main motive might here also be fear – e.g. of losing a resource (territory, status, food, social partner etc.).

The validity of this category of "hormone-facilitated" aggression is supported by epidemiological information. Intact male dogs represent quantitatively the biggest group showing aggressive behaviour in any form, whereas intact females give the reverse picture (Borchelt, 1983; Wright & Nesselrote, 1987; O'Farrell and Peachey, 1990). In wolves serious fights mostly occur around the time when females are receptive (Derix et al., 1993). In dogs an increase in quantity of aggressive interactions can also be detected during the periods most bitches come into oestrus (Walker, 1997). Influences of sexual hormones on aggressiveness have been described in earlier sections. Overall (1995, 1997) further assumes that intra-uterine androgenisation in dogs can happen and might be responsible in females, that show aggression regularly and at a high level at around the age of six months. She says that these dogs become worse when spayed due to the consequent reduced effect of oestrogen on the limbic system, i.e. reduced inhibition of aggressiveness.

Pain and/or shock induced aggression is usually shown as an inherited defensive attack reaction in the form of a fixed action pattern and is very rarely preceded by aggressive communication. Konorski (1967) wrote of such incidents as protective behaviours that are highly influenced by learning and thus will rapidly change quality and quantity once having been elicited initially.

The term Pathological aggression can encompass several forms of aggression. First, "pathological" can be used in the direct medical sense. Aggression is elicited by some disease (e.g. rabies, borreliosis, distemper), trauma (e.g. injury of the brain), poisoning (e.g. lead, cumarin) or inherited predisposition that affects brain function in such a way, that aggressive behaviour can easily be triggered by non-specific environmental stimuli. Special forms of epilepsy e.g. limbic epilepsy, might have aggressive behaviours as a symptom (Dodds, 1992; Dodman et al., 1996). Typically the attacking behaviour is fast, usually without any preceding aggressive communication. The behaviour seems unprovoked, unpredictable and uncontrollable (Overall, 1997). Second, incidents of "unprovoked aggression" could be labelled as pathological in the sense of maladaptive behaviour. The term "idiopathic aggression" qualifies as pathological aggression in both senses, and comprises any form of aggression where no unambiguous causation can be detected, though a special form of limbic epilepsy is often suspected: e.g. rage syndromes in Cocker Spaniels, English Springer Spaniels, Bernese Mountain Dogs or Golden Retrievers (Borchelt & Voith, 1985; Podberscek, 1995, 1996,1997).

Play behaviour does include play(ful) aggression as one element among others. According to Feddersen-Petersen (1994) social play is a means of solving conflicts without the risk of serious aggressive interaction leading to possible injury. Lindsay (2001) considers that play offers a powerful non-intrusive means of controlling the direction of social polarity and attention, balancing affection and leadership, and increasing affiliation and cooperation between individuals. Rooney & Bradshaw (2002) concluded from their observation of tug-of-war play between humans and Golden Retrievers, that dominance relationships were unaffected by the outcome of such games. It seemed to be more important which partner had initiated the play session (Rooney, 1999).

True play as such is relatively incompatible with fear and subsequent "serious" actions like attack or flight, although playful interactions may change their emotional content and slip over into overt aggression, e.g. due to increasing frustration or more serious involvement with certain resources (Lindsay, 2001). Elements from play behaviour, e.g. play bow, may be used as a signal for de-escalation during a conflict

Feddersen-Petersen (1994) observed that dogs, when kept in groups, displayed aggression (aggressive communication and attack) arising out of social interaction and social play much faster than wolves. Here lies a potential risk, since dogs might also show such aggressive behaviours faster against humans. Interactions that started as playful on both sides may change to something more serious from the dog's side without the human readily noticing (Schöning, 2000b). Rooney & Bradshaw (2002) suggested that the effects of games may be modified by the presence of play signals, and when these signals are absent or misinterpreted, the outcome of games may have more serious consequences. Here also learning will affect the quantity and quality of aggressive behaviours that are shown, be they playful or more overtly agonistic.

Fear related aggression, i.e. aggression stemming from fear, frustration and stress, plays a major role in dog behaviour problems. Overall (1997) states that such aggressive behaviour is the second most frequent aggression problem presented at her behavioural clinic (the first being "dominance aggression").
Borchelt (1983) states that among his cases of canine aggression, "fear aggression" was the most common diagnosis. Much has been said about the connection between fear and aggression in earlier sections. Aggression, be it aggressive communication or attack, can be shown by dogs in any situation where the loss of a resource is feared. Learning profoundly influences its expression, in that showing aggressive behaviour successfully (i.e. defending or gaining a resource including one's life) has enormous positive reinforcer qualities. Another factor relevant to the overt display of aggression is the individual's tolerance for stress, frustration or fear-eliciting stimuli, and the behaviour patterns released in general when being stressed, fearful etc. Again, learning also profoundly influences behaviour patterns and tolerance levels.

Feddersen-Petersen (1996) and Lindsay (2001) both point out that elements of defensive and offensive communication can alternate in the same dog in the same situation. This can especially be seen in dogs which have had some experience of acting aggressively in threatening situations and have learned through reinforcement. They become progressively more confident in their ability to control such threatening situations and demonstrate such confidence with the help of imposing behaviour. But defensive elements are still shown as well, since fear is the emotional background. Fatjó (2001) interprets the exhibition of both behavioural elements in a dog as a sign of motivational conflict.

Overall (1997) has to be criticised in her statement, that showing "fear aggression" in a situation in which no threat to the dog is apparent, e.g. in a vet's office, is abnormal. This is a very anthropomorphic view as an individual dog might well feel threatened by a vet or by other stimuli present in a vet's practice, even when the vet is not deliberately and/or directly threatening the dog. Overall further states "a dog, that is fearful of an unknown person walking along, is not normal". Here again it can be proposed that it might be quite normal for an animal to react fearfully towards objects, subjects or situations it does not know (or does know already in combination with negative/painful qualities). Fear per se can be considered as a "very healthy emotion". An emotion and subsequent action should then be considered as "abnormal" when it is not appropriate to the situation, in the sense that it does not elicit an adequate physiological stress reaction and behavioural action to successfully eliminate the stressor, or to hold or gain a certain resource etc. From a dog's point of view biting the vet might be very "appropriate".

Problems with and for dogs arise in our modern human/urban environment, when a dog reacts to a high proportion of animate and inanimate signals in its environment with fear, possibly due to bad socialisation. Another relevant factor in labelling such fearful behaviour, apart from just looking at frequency and intensity, would be whether it might have welfare implications for the dog, repeatedly experiencing the emotion of fear. Fear, i.e. stress, for a longer period, can lead to a distorted hormonal control, especially in the physiological system for stress management of the organism, with subsequent physiological and psychological damage (Gray, 1987).

Lindsay (2001) states that most forms of aggression that arise out of fear, such as forms of aggression in a conflict over social hierarchies, are motivated to gain control over a frustrating or threatening social situation. A threatening social situation could equally well be the violation of a territory by an intruder. A loud noise threatening the dog (e.g. thunder) very rarely elicits aggressive behaviour against humans or other dogs but rather withdrawal or flight from the noise. Thus it can be said that fear (i.e. fear, frustration and stress) is a major aggression-eliciting emotion, but it also depends upon the individual situation whether aggression is shown or not, e.g. whether a susceptible target is available.

Redirected aggression can be listed under fear related aggression, as the main eliciting emotions are frustration, fear and stress. Redirected aggression is shown against a stimulus, that as such has not directly elicited the frustration, but happens to be near the dog in that situation (see section 1.3.1.5). When the real frustrating stimulus is inaccessible or the frustration has not abated, even though the dog has shown behaviour specific to reaching that goal, the dog switches focus and can attack a different accessible stimulus. This predominantly happens without any preceding aggressive communication. Another form of redirected aggression can be a situation when an animal is thwarted from proceeding with ongoing aggressive behaviour. Typical situations are dogs that show aggressive communication against a conspecific but are impeded in further action due to the lead. The main risk here is that owners might get bitten.

Aggression in a hierarchical context can also be termed rank- or status-related aggression. Rank-related aggression among dogs can happen any time where dogs meet on a regular basis or live together, thus knowing each other as individuals. The boundaries between different types of aggression, e.g. hormone influenced aggression or aggression influenced by learning, are especially fluid here. Dogs that live in the same group can use aggressive communication, up to full attacking, to gain information on the other's supposed rank and to assert their own.

During evolution "true" signals as well as "lies" have developed in communication, and wolves and dogs show both when necessary (Feddersen-Petersen & Ohl, 1995). "Lies" can sometimes allow an animal to pursue its own interests while having low costs, e.g.

withholding information or deliberately giving false information on its own strength or fighting abilities (Zahavi, 1979). However, it is unclear whether all aggressive incidents between dogs in the same household are status-related, although this is often the assumption.

Sherman et al. (1996) and Roll & Unshelm (1997) state that the majority of status-related aggression directed against nonresident but socially well known conspecifics is shown by intact males; the majority of aggression directed against a conspecific resident in the household is shown by spayed females. There are several potential explanations for the observation on spayed females. Since it may be more common to keep large single-sex groups of females rather than males together in the household, incidents involving female-female aggression may be over-represented. Alternatively, aggression by females, as by males, is facilitated by the effect of androgens, which might have a greater effect on aggressiveness once the effect of estrogens decreases following neutering (Van de Poll et al., 1988).

When considering bites against humans, Guy et al. (2001a, 2001b) observed the following risk factors for humans being bitten by the family dog: small female dog, one or more teenage children within the family, a history of skin disorders, aggression over food within first two months of ownership, high status of dog within first two months of ownership on the basis of human reaction to an excited dog. Biting dogs were more likely to have exhibited fear of children, men and strangers in general.
Overall, there were more males than females among the biting dogs, but when they were differentiated by size, age and sex, small neutered female dogs stood out. The authors' explanation for this being the riskiest group was that they sampled from ordinary veterinary practices; assuming that aggression in male and/or bigger dogs might be more frightening, owners of these dogs might seek help from a behavioural specialist, whereas owners of small and female dogs might tolerate such a problem for a longer period. This assumption fits the findings from Takeuchi et al. (2001), who found males over-represented in the group of dogs biting their owners in the caseload of the Cornell University Animal Behavior Clinic.

When dogs show aggressive behaviour towards their owners, family members etc., this is often referred to as "dominance aggression" in the literature (Askew, 1996; Landsberg et al., 1997; Overall, 1997). A further definition for dominance aggression is that it usually occurs in circumstances compatible with protecting access to critical resources, or resisting dominant gestures by members of the family (Voith, 1981). Such behaviour is more commonly reported in intact males and neutered females (Serpell & Jagoe, 1995). The term dominance aggression is, like defence-aggression, too broad and is thus misleading. Feddersen-Petersen (1996) considers that dogs do not build linear hierarchies with humans, as they would with other dogs. She writes about rank-related relationships that vary in time, place and situation, which she terms micro-hierarchies. Thus it is not helpful simply to label all aggression towards the owner "dominance-aggression" without looking at the individual and specific situation. E.g. the dog that bites when being pushed from the sofa might not mind its food-bowl being taken when it is still eating.

As mentioned in the beginning, an attribute of the dominant partner in a dyad is often its restraint in showing aggression. The dominant partner may only act aggressively when personally important resources are in acute danger (Lindsay, 2001). This could explain the different reaction in the example just mentioned. But the subordinate partner in a dyad needs access to some resources as well, e.g. food, and may defend these resources with much more aggression than the dominant partner would show when competing over them. Such behaviour is evident in the wolf. Mech (1999) concluded that the typical wolf pack is a family group with the parents directing the activity through a system of "job-sharing". The hierarchy is built due on differences in age, sex and reproductive status, with the male parent of the cubs dominating all other pack members using subtle visual communication (not overt aggressive behaviour). When the cub's mother is still lactating, the male does show submissive gestures towards her, which diminish when the cubs are weaned. Imposing behaviour was not observed by Mech, apart from special situations where food was involved; but access to food as such did not follow the hierarchy observed in other situations.

Dominance relations appear self-reinforcing whenever assertion of dominance leads to access to limited resources (Preuschoft & van Schaik, 2000). This might be an attribute of social relationships among wolves, and therefore of dogs also. Dogs that are of a more fearful character (inherited or gained) might then assume that their position is being seriously challenged, even by benign dominance challenges from the dog or human partner (e.g. postures, intentional movements). Such situations may then induce more overt threats or even attack especially when the dog has a low threshold for such behaviour (either due to learning or as an inborn trait).

For human-dog interactions this may include human behaviours like bending over the dog to stroke it, talking to the dog, or looking at the dog (Lindsay, 2001). Interestingly, Konorski (1967) assumed that a reflexive defensive reaction can be neurologically hardwired and elicited in response to tactile stimulation (like a touch on the back). From this, Lindsay (2001) suggested the existence of a reflexive mechanism mediating aggressive behaviour, which is subject to rapid learning. In general, aggression is most likely to occur under circumstances in which the likelihood of success is high and potential costs are low, should the strategy fail. Conversely, it is least likely to occur when the likelihood of success is low and potential costs are high. As mentioned earlier, such cost-benefit considerations are themselves subject to other factors. E.g. Quatermain et al. (1996) found that stressed mice more readily engage in risk-taking behaviour than unstressed controls.

The outcome of dyadic confrontations has an impact on social signalling and as such influences dominance relationships. Mice repeatedly defeated in social male confrontation changed from active submissive communication to passive one. Possibly because this left them without the behavioural means to resolve conflicts, they developed symptoms of chronic unavoidable social stress (Kudryavtseva et al., 1991). Taking Quatermain et al. (1996)'s results into consideration, chronic social stress might lead to aggressive behaviour becoming shown more readily, and less flexibly.

Kudryavtseva et al. (2002) showed that repeated experience of aggression in a social setting provoked the development of anxiety in male mice, leading to an increase of aggressive motivation. It is therefore likely that human behaviours like yelling or hitting, with their associated body language, are seen as signals of threat or attack by dogs. Owners might thus start a vicious cycle of escalation when they constantly try to "dominate" the dog via pressure and punishment.

In conclusion, "dominance aggression" appears inadequate as a unitary diagnosis, as far too many differentiating factors are involved. Rather, a more descriptive diagnosis should be attempted, considering all aspects and factors that may have lead to an outcome such as "dog bites owner".

Some incidents where dogs injure or kill other dogs or humans can be interpreted as a sort of prey-predator-interaction (Borchelt et al., 1983). As stated by Archer (1976), predatory behaviours include biting and final killing but have a different emotional background compared to aggression directed against a conspecific. However, true predatory aggression is unlikely to be seen in isolation in attacks by dogs. The victim of such predation, when struggling for survival, could induce frustration and/or thwarting, and thus is potentially able to trigger "true" aggression also. One suggested cause of "predatory aggression" against non-prey individuals could be too broad a template for the identification of "prey" (Coppinger & Coppinger, 2001).

1.3.2.4 Genetics of aggression in dogs

Since it has been possible to produce inbred strains of mice and rats which have different tendencies to exhibit fearfulness and aggressiveness, this should theoretically also be possible with any other domesticated animal. Under natural conditions, selective pressure acts predominantly on traits which ensure or heighten fitness. Under domestication, traits favoured by man are selected for, which might be of neutral for biological fitness or even counteradaptive (e.g. certain coat colours). Genes that are not under selective pressure undergo random genetic drift (Falconer, 1984) and may vanish or become more pronounced in their influence on certain traits. The speed of genetic drift is inversely proportional to the population's size, i.e. small populations show random changes in their gene-pool more rapidly.

From the early days of the dog's domestication, selection by man has presumably emphasised confidence (=less fearfulness) towards humans. Subsequently, working abilities will have become a major selection factor. Especially during the last 150 years dogs have been bred less and less to fulfil a certain function, but rather to resemble a certain defined phenotype. While breeding for phenotypes in certain dog breeds, certain behavioural traits might have been selected more or less unconsciously and/or unwillingly.

It can only be speculated how many genes are involved in traits like fearfulness or aggressiveness. One of the major triggers for aggression is fear (see section 1.3.1.5). The ability to react fearfully is presumably genetically influenced in wild animals, as fearfulness ensures survival. Qualitative and quantitative differences in the capacity to react fearfully seem to be genetically influenced, up to a certain limit, in different strains of different species, and not only domesticated ones; for example foxes as well as mice and rats.
Belyaev (1979) showed, that by inbreeding silver foxes (*Vulpes vulpes*), which already showed a reduction in fear reaction to humans compared to the wild type, a line of foxes resulted that were relaxed in the presence of humans. In parallel his foxes changed coat colours and other fox-like appearances; e.g. some got a curled tail. Kenttämies et al. (2002) succeeded in selectively breeding a silver fox line with no variation in coat colour, but also very confident (i.e. less fearful) towards humans, suggesting that fearfulness and coat colour are not automatically linked. They postulated a low to moderate heritability for confidence in their foxes and suggested some maternal effects, without specifying what these might be.

There is evidence that besides distinct behavioural traits e.g. fearfulness, predispositions for the development of certain behavioural patterns are to some extent genetically influenced. For example, this holds for stereotypic behaviours. For horses (Kiley-Worthington, 1987), bank voles (Ödberg, 1986; Schoenecker & Heller, 2001) or mice (e.g. Schwaibold & Pillay, 2001) a genetic basis for the development of stereotypies has been found. Schwaibold & Pillay found that social influences appeared to be minimal. For dogs, certain breed dispositions for the development of certain stereotypic behaviours are reported, but so far are only anecdotal. A predisposition for acral licking dermatitis (ALD), tail chasing and tail biting is supposed to be inherited in some lines of German Shepherds and, for ALD only, in Golden Retrievers; other examples include tail chasing in the Bullterrier, and flank-sucking in the Dobermann Pinscher (Luescher et al., 1991; Hewson & Luescher, 1996).

It is generally assumed that the early dog's genome, inherited from the wolf, included all alleles that lead to the different traits humans have so far differentially bred for (Coppinger & Coppinger, 2001). The behavioural elements for hunting have been widely looked at, attempting to address the question of the extent to which they are genetically fixed (Mackenzie et al., 1986), not only in hunting dogs, but in herding dogs (e.g. Border Collie) as well. Behavioural elements of herding (e.g. orient, eye-stalk, chase, grab) have their origin in hunting behaviour, with the full hunting sequence being selectively depleted of killing, dissecting and consuming (Coppinger & Coppinger, 2001).

Christiansen et al. (2001) looked at behavioural differences in three breeds of hunting dogs. When confronted with a single sheep while being walked off leash, Elkhounds showed the highest interest, displayed the highest intentional movements for hunting and showed the highest attack severity. Hare Hunting Dogs were intermediate in their behaviour and Setters showed the lowest values for the mentioned variables. The authors observed that the dogs that scored highest among the "hunters" scored lowest for fearfulness when subjected to aversive signals.

Brenoe et al. (2002) looked at heritability for hunting performance in three other hunting breeds: German Short-haired Pointer, German Wire-haired Pointer and Brittany Spaniel. They found low to moderate heritabilities for traits like hunting eagerness, speed, seeking width, independence or cooperation. No significant link to any of the breeds was found, and the genetic correlation between some of the performance tests was higher than the phenotypic one.

Ruefenacht et al. (2002) have summarised the literature so far regarding the heritability of behavioural traits in dogs, be they activity, concentration, confidence, hunting or other working abilities, fear, intelligence etc. Overall, only low to a few medium heritabilities have been found.

1.3.2.5 Differences in aggressiveness between dog breeds

As stated earlier, up to about 100 years ago selective breeding of most types of dogs was based upon the different functions the dogs had to fulfil. Aggressive behaviour as such (threats and attack) and traits like aggressiveness and fearfulness were probably favoured in certain types or breeds. Dogs that should "protect" their owner, territory or possessions e.g. livestock, had to react early enough to an intruder/offender to allow the owner to take action or alternatively to take action (aggressive communication, i.e. threats, and/or attack) themselves. Thus fearfulness (i.e. reduced tolerance level to become fearful) up to a certain extent would have been a favoured trait.

Other dogs were bred to show fast attacking behaviour against well armed prey in a den or burrow during hunting, and other dogs were required to show the same fast attacking behaviour against prey or livestock above ground. In the last two examples the attacking behaviour was associated with other hunting behaviours, e.g. scenting, fixing, chasing or grabbing. Here the ability to show threatening behaviour was probably somewhat selected against. Aggressive communication would not be functional between predator and prey, since it might warn the prey and/or delay the attack, leaving the prey time to escape. Fearfulness on the other hand would have been a trait of some importance (in either direction) for some hunting and herding dog breeds. The ability to react fearfully together with the ability to learn from experience, would have been important for assessing risk from large and/or dangerous prey (Coppinger & Coppinger, 2001).

Some breeds (e.g. Pit Bull Terrier, American Staffordshire Terrier etc.) have been misused and specially bred by humans for dog fights (Lockwood & Rindy, 1987). A dog that is successful in contests might have an advantage over its contestant when not showing any intention to attack, thus being able to take the opponent by surprise; additionally, threatening behaviour would probably not have been favoured by those breeders who wanted a "game" dog. But on the other hand a dog attacking too fast would run the risk of not biting in the right place or missing the opponent. Some sort of "evaluating" behaviour, thus weighing costs, should be retained in such fighting lines, but probably not the complete set of aggressive communication as in other breeds/lines. Such reduced communicative abilities have not only been described in breeds used for fights.

Feddersen-Petersen & Ohl (1995) observed the same for Pugs; in addition, some communicative elements e.g. biting over the muzzle, were impossible in this breed due to phenotypical changes. The authors stated that the inaccurate signalling produced a high amount of social stress, which might itself be a reason for the exaggerated and less ritualised aggressive behaviour observed in their Pugs.

Clifford et al. (1983) observed that dogs with a history in the pit were not able to live in a group later on. Even when the dogs had known each other for some months, aggressive interactions started, irrespective of sex. Puppies from such parents had to be separated at the age of ten weeks due to an increase in serious aggressive interaction. According to Feddersen-Petersen (1994c) these observations in "fighting-dogs" and Pugs, regarding group life, apply to standard Poodles also. Her Poodles, though socialised with Poodles, proved unable to live in a structured group without occurrence of serious damaging fights among group members on a regular basis. Feddersen-Petersen again proposes phenotypical differences in the different breeds as one major reason for her observation on reduced communicative abilities. She concluded that following domestication and selective breeding, dogs from many of our contemporary breeds are not able to adapt to "natural conditions" again in just a few generations.

Thus there is a possibility that it is not so much the history of being used in dog fights that accounts for the observations by Clifford et al. (1983), but some general differences in the development of communicational skills in those breeds. Having a fighting history might just be associated with deprivation in social and communicative skills. Again the problem remains to distinguish accurately between genetic and environmental influences. Owners/breeders that want to use a dog for fighting, will probably not invest much time or effort in a well socialised dog, so far as other dogs are concerned.

Lockwood & Rindy (1987) state that it is difficult to draw scientifically sound conclusions about the danger posed by a specific breed just from epidemiological information. This has already been explained in detail in section 1.1.2.2. These authors summarise five factors influencing a dog's tendency to bite: early socialisation, training for obedience or mistraining for fighting, actual care and provision provided by the owner, behaviour of the victim, and last but not least a dog's genetic predisposition to become aggressive.

Some earlier authors distinguished a separate tolerance level for showing aggressive behaviour from the tolerance level for showing fearful behaviour, and did not place much emphasis on fear, stress or frustration as triggers for aggressive behaviour. Kreiner (1989) stated that working dog breeds like German Shepherd, Rottweiler, Dobermann or Giant Schnauzer have been bred for a low tolerance for aggression in just a few generations. Thus he proposes a medium heritability for such a tolerance level, without further defining the tolerance level for aggression he is proposing. Stur et al. (1989) differentiated between an independent heritability of aggressiveness and tolerance level for showing aggression. They distinguish four types of dogs: a) non aggressive dogs with a high tolerance, b) non aggressive dogs with a low tolerance, c) aggressive dogs with a high tolerance, d) aggressive dogs with a low tolerance.

These different approaches to the concept of a dog's character, including certain traits that elicit aggressive behaviour, and their possible genetic background, definitely need to be evaluated in the near future to evaluate the problem of "dangerous dogs" effectively. In particular, such vague terms as "tolerance level for aggression" should be defined – or, better, avoided.

Bradshaw et al. (1996), from a questionnaire survey on reported behavioural traits of pure bred dogs in the UK, detected three underlying traits, which they named aggressivity, reactivity and immaturity. Breeds like Rottweiler, German Shepherd or Bullterrier scored high on aggressivity, average on reactivity and low in immaturity. Some small terriers e.g. Jack Russell Terrier, Border Collie or Cocker Spaniel scored the same as the former group but with high immaturity. Staffordshire Bullterrier, Border Terrier or Beagle scored average in every trait. It was questioned by the authors whether such telephone or postal surveys rather reflect public prejudice and the anthropomorphic eye of lay people, even though the group asked comprised vets and animal behaviourists.

Serpell & Hsu (2001) more recently concentrated on the reliability and suitability of such questionnaire surveys. They tried to overcome methodological problems by comparing owner/keeper–derived questionnaire evaluations with independent assessments of the dog's behaviour. They concluded that when a survey is conducted to look for certain traits in a special group of dogs (they looked at behavioural traits in dogs further to be trained as guide dogs for the blind) a questionnaire can be validated.

Goddard & Beilharz (1982, 1984, 1985) found the German Shepherd in general more fearful than Labrador Retrievers, Boxers or Kelpies. They stated that the trait for fearfulness is moderately to highly heritable. Thorne (1944) concluded that "shyness" is a dominant characteristic in dogs that is normally strongly selected against in the pet dog population. He observed that 52 % of the abnormally shy and fearful dogs in a laboratory colony he was dealing with, were directly descended from a single Bassett Hound bitch, which was a notorious fear biter.

Serpell & Jagoe (1995) qualified these earlier investigations on the heritability of fearfulness by saying that much empirical data has the drawback of non-standardised diagnostics (how is "fearful behaviour" defined etc.), but that the increasing number of results from designed studies now seem to confirm the earlier assessments. They stressed that one main problem for defining grade of heritability is the often unknown, thus not calculable, environmental influence.

Just recently Svartberg & Forkman (2002) published their data from the behavioural evaluation of over 15,000 dogs from 164 breeds and all ten breed classifications by the Fédération Cynologique Internationale (FCI). Following factor analysis the authors found five personality traits: playfulness, curiosity/fearlessness, chase-proneness, sociability and aggressiveness. Higher-order factor analysis then showed that all factors except "aggressiveness" were related to each other, creating a broad inherited factor influencing behaviour.

It has to be borne in mind that Svartberg & Forkman (2002)'s data was collected during a standardised behavioural test ("dog mentality assessment", DMA), and consisted of descriptive scores that each included a range of single behaviours from the dog's ethogram (e.g. "no signs of aggression", "threat displays and attacks" etc.). Such a scoring system is prone to influences from the tester's personality and the results are therefore biased to some extent.

Svartberg (2002) then compared the DMA results from the German Shepherd dogs with the Belgian Tervuerens within the sample, and looked at the general relationship between personality and learning performance. Among the potential confounding variables, owner/handler experience influenced the learning performance of the dogs, irrespective of breed and irrespective of shyness or boldness. The shyness-boldness score influenced performance across both breeds: in Tervuerens of both sexes, and female Shepherds, high performing dogs had significantly higher scores for boldness. In general, German Shepherds scored higher in boldness than Belgian Tervuerens and males scored higher than females.

1.3.2.6 Differences in aggressiveness within dog breeds

Murphree et al. (1977) described different strains of abnormally fearful and nervous Pointers, which had been deliberately bred to serve as models for research in human anxiety disorders. So it seems important to look at variations in fearfulness and aggressiveness within breeds. As fear is one major trigger for aggression, lines or families in dog breeds with a enhanced propensity to develop fear might also show aggression more often and/or at greater intensity. This hypothesis does not appear to have been tested systematically.

Coming back to Goddard & Beilharz (1982, 1984, 1985), who found German Shepherds in general more fearful than Labrador Retrievers, Boxers or Kelpies when looking at their performances as guides dog for the blind, these authors promoted a strong selection program against fearfulness, which proved successful over 30 years, allowing German Shepherds to be used as guide dogs. Pfaffenberger (1963) spoke about an improvement in character of his German Shepherds, used in guide dog training: from 9% non-fearful dogs the number rose up to 90 % in 12 years. In this connection Willis (1995) wrote about different lines in the German Shepherd that could be responsible for differing results concerning the heritability of fearfulness or confidence. If this is not considered during breeding, a breed might not improve or even might deteriorate in certain behavioural traits.

Ruefenacht et al. (2002) stated that the improvement within the German Shepherd in Switzerland over the last 25 years in favoured traits e.g. self-confidence, temperament, hardness or sharpness, was only modest. This was supposed to be on the one hand due to low heritabilities of the traits, but on the other hand due to low selection intensities by breeders.

For certain breeds a so-called inherited rage syndrome is described in certain lines. Here dogs attack without prior warning, typically directed against human family members (Borchelt & Voith, 1985). The attacking behaviour is said to be unprovoked or to be elicited by low level stimulation, e.g. petting the dog. Again it is problematic that data are scarce and still largely consist of anecdotal observations, so it remains difficult to verify such descriptions as "unprovoked". What might look "unprovoked" to a human being might not be so for the dog.

Rage syndrome is relatively rare and is believed by some authors to resemble a special form of limbic epilepsy (Hart & Hart, 1985; Voith, 1989). Podberscek (1995, 1996, 1997) lists different breeds where the rage syndrome is described in certain lines or families (not the breed as a whole): English Cocker Spaniel, American Cocker Spaniel, Bernese Mountain Dog, Chesapeake Bay Retriever, Doberman Pinscher, English Springer Spaniel, Golden Retriever, English Bullterrier, German Shepherd, St. Bernard, Pyrenean Mountain Dog. He states that it is a rather rare disease and difficult to distinguish from dominance aggression. A pathognomonic criterion for the distinction of rage from dominance aggression would be, when the dog would not only attack members of its family but, when showing "rage", other things which are nearby in that situation, e.g. pieces of furniture (Podberscek, 1997). Another criterion could be the dog appearing to be "dissociated from its behaviour", showing a dazed expression, with glazed or deep reddening of the pupils, or a sort of momentary "possession", as reported by some owners (Voith, 1989).

For the following breeds the existence of abnormal, i.e. a heightened level of, aggressive behaviour in certain lines is postulated in an expert submission for the German Welfare Act from 1998: Bullterrier, American Staffordshire Terrier, Pit Bull Terrier (BMVEL, 2000). The authors of this submission conclude that in some lines of the mentioned breeds, individual dogs show fast and excessive attacking behaviour in response to low level stimulation and without preceding aggressive communication; as such it does not fulfil any adaptive function (i.e. can be categorized as abnormal behaviour). This expertise is based just upon a little empirical data and some research done on early ontogeny in Bullterrier and American Staffordshire Terrier puppies with a very limited number of litters (Schleger, 1983; George, 1995; Redlich, 1998).

Schleger (1983) observed serious biting and substantially reduced aggressive communication in her eleven litters, starting at about the fourth week of age. George (1995) observed the same in her two Bullterrier litters. The puppies started showing this behaviour at around the fifth week. George also observed aggressive behaviour from one bitch against her puppies, partly in the context of play. George discussed this behaviour as misdirected object or predatory play behaviour.
Redlich (1998) looked at three litters from American Staffordshire Terriers and also observed rather early agonistic behaviour with reduced aggressive communication, compared to other breeds or the European wolf. Redlich also observed some "manipulating" behaviour from the bitch against her puppies, which she termed misdirected predatory behaviour.
The studies mentioned cannot give an accurate picture on the postulated behavioural deficiencies in the mentioned breeds as the sample size is too small, even in Schleger, who looked at eleven litters but whose litters were all very much inbred. Nevertheless these data should be kept in mind and can form a basis for further research.

As argued already, the genetics of canine aggression are still poorly understood (Lockwood & Rindy, 1987). So far there is no evidence for a "single gene or group of genes for aggressiveness" in the dog. "Aggressiveness" involves too many different factors and elements e.g. tolerance levels for fear, stress, and frustration, together with different motor patterns for communication, withdrawal or attack, to be elicited by one single or even one group of genes.

Research on how different traits influence each other during breeding has to be intensified – with the traits being reliably defined beforehand. For example defining "nerve stability" with " neither nervously nor hypersensitively nor jumpy" is not a scientific approach, as each tester will define "not nervous" individually, thus biasing any data.

1.3.2.7 Can aggression or aggressiveness be tested in advance?

Behavioural testing of aggression in dogs could be one among several possible measures for reducing the rate of bite-incidents. Currently, together with banning certain breeds, it is the method of choice for governments in many European countries. In 13 out of 16 German states certain breeds are listed and dogs face certain measures unless they have passed a so-called "temperament test for aggression", e.g. being leashed and muzzled when outside or being neutered. In contemporary Germany dogs are tested in many different ways and by people from a whole range of different qualifications and backgrounds, e.g. dog trainers, veterinarians, police officers, "officials" from dog breeding clubs etc. One thing all these testers have in common, irrespective of how they test – no test definitely predicting a dog's future aggressiveness and aggressive behaviours, has been validated so far.

There exist a number of so-called temperament tests for dogs. Temperament is defined as an individual's disposition or nature; i.e. the sum of all inborn and acquired traits, aptitudes or predispositions, which have impact on the individual's actual behaviour (Seiferle, 1972). Elements of a dog's temperament would be, for example, its aggressiveness, its fearfulness or its sociability. Temperament tests for dogs are not a new invention, as it has long been of interest for breeders to gain information on which dog to best breed with, and for looking at possible offspring. Previously, working abilities (trainability and elements like "sharpness" or "hardness") were the traits to be examined in such tests, thus trials such as the already mentioned SWDA were developed.

In Germany "Schutzhund" trials were invented for adult dogs of many working breeds, and are still a prerequisite for a German Shepherd to become stud dog or bitch today. Dogs were favoured that, for example, showed a considerable amount of "sharpness" (i.e. ability to adequately react aggressively towards a serious or apparently serious attack) or "hardness" (i.e. ability to accept unpleasant experiences without becoming fearful afterwards) (Pfleiderer-Högner, 1979; Ruefenacht et al., 2002).

Around the 1960's, focus was applied to the puppy as well. It became important for breeders and dog users to reliably predict an adult dog's behaviour at an early age. Dogs used for certain tasks, e.g. as guide dogs for the blind, have to undergo a long and expensive early education and later training. The earlier usefulness could be predicted, the lower the costs involved. Pfaffenberger (1963) developed a test for puppies that were supposed to become guide dogs later on. His results when testing puppies between the age of six and sixteen weeks showed a positive correlation between the test results and a later success in training to become a guide dog (Pfaffenberger et al., 1976). Pfaffenberger and colleagues also looked at rearing conditions of such puppies, and could show that careful and intensive socialisation (including special situations important for a dog working as a guide dog later on) showed a very strong positive correlation to success in the test and thus to later success in training. So the puppy-test as such could give information on a puppy's temperament status on a particular day – but not necessarily valid information on the heritability of any temperament traits, e.g. fearfulness or learning ability.

Scott & Fuller (1965) used different tests to look for genetic differences between breeds, rearing their puppies under standardised conditions. They looked at certain individual behaviours from an ethogram in the puppies, to give information on accompanying traits without any quantitative evaluation. They found some genetic differences between breeds in those traits responsible for forming social bonds. For example, Cocker Spaniels and Basenjis differed significantly in 35 out of 50 variables connected with this trait.

Scott & Fuller's test was later modified by Campbell (1972, 1975). The "Campbell-test" has been widely used since and has been the object of some intensive peer discussion. The Campbell-test comprises of five subtests, done when the puppies are seven weeks of age:

1. <u>Social attraction</u>: how the puppy (isolated from its mother and siblings in an unknown area) reacts to a tester trying to draw the puppy's attention to himself.
2. <u>Following:</u> the tester tries to coax the puppy into following him.
3. <u>Restraint</u>: the puppy is turned over on its back by the tester and held for max. 30 seconds.
4. <u>Elevation dominance</u>: the puppy is then turned on to its belly again and is lifted up about 15 cm off the ground for 30 seconds.
5. <u>Social dominance</u>: the puppy is stroked gently from head to tail for 30 seconds.

Scoring is done looking at clusters of behaviour rather than single behaviours from an ethogram. For example in subtest 1) a puppy, that quickly approaches the tester, together with raised tail and puppy-like exaggerated movements, scores a "B". When it additionally bites into the hand, it scores an "A". A puppy that approaches very timidly, scores a "D". In subtest 5) a puppy scores an "A", when it struggles heftily, growls and bites; it scores a "C", when it surrenders after an initial struggle and licks the tester. Puppies that get two or more "A's" and apart from that only "B's", are defined "dominant-aggressive" and are, according to Campbell, unsuitable for owners with small children or elderly people. Puppies that score three or more "C's" are very adaptable and flexible without being excessively socially expansive.

Queinnec (1983; cited in Venzl, 1990) stated that the Campbell test was suitable for detecting inherited elements of a puppy's temperament and those that survive into adulthood. Venzl (1990) herself rejects Campbell's (1972) method of summarising all reactions of a puppy in the five subtests into one final definition of temperament-type per puppy (i.e. social rank). She says that the puppy's traits should be differentiated into "contact behaviour" (subtests 1, 2) and "willingness for submission" (subtests 3, 4). Subtest 5 should be looked at separately, as Venzl found the same passive reaction in over 80% of the 256 beagles she tested. Venzl then retested 55 of the puppies as juveniles and from these, 35 as adults. At both stages she found similar test results between the different age groups in 50% of the tested dogs.

Beaudet (1993) tested 91 puppies of five different breeds at the age of seven weeks and retested 39 of those at the age of 16 weeks. He found no significant correlation for Campbell's value for social rank between both age groups. He concluded that the Campbell test provides only a weak prediction of the future social rank of a puppy. Beaudet et al. (1994) recommended looking also at the overall activity level of the puppies, to allow a better prediction of future temperamental elements.

Reid & Penny (2001) evaluated puppies following a refined Campbell test. In their "puppy aptitude test" (PAT) they added four additional subtests, looking at the puppy's reaction to its environment (Fisher & Volhard, 1985; Bartlett, 1985). The puppy was exposed to tactile, auditory and visual stimuli after it was encouraged to play with a ball of paper. Reid & Penny looked at 279 puppies at the age of seven weeks. About six months later they conducted a telephone survey with the owner of these puppies about the puppy's typical reactions to a variety of stimuli, e.g. being greeted by a stranger at home or being examined by a vet. Again, as in Beaudet (1993), only a few instances of agreement between owner answer and previous test results were found.

Young (1985) found that a significant proportion of her puppies displaying aggression (barking, growling) during testing, exhibited aggressive tendencies as adults. Wright (1980) did notice individual variation in puppies with respect to competitive behaviour and social dominance between test and retest, and no significant prediction by the test. Bondarenko (1995) again as Young sees such puppy tests as a useful tool to place a puppy in the optimal situation, be it as a pet or future working dog. She emphasises that the key for successful puppy assessment is avoiding any interpretation of the puppy's behaviour during the test. Rather, a thorough description following an ethogram should be done, with subsequent deduction of any emotional background.

Slabbert & Odendaal (1999) looked at an early prediction of adult police dog efficiency. They used a test consisting of five subtests altogether, comprising situations the dogs would most likely encounter while working as a police dog. The puppies had to manage obstacles to reach their handler at eight weeks of age; a retrieval test was performed at eight and twelve weeks of age; a startle test was undertaken at twelve and sixteen weeks; the puppies were exposed to gunshots at twelve weeks; finally the dogs were provoked into aggressive behaviour at the age of six and nine months. The authors concluded that the tests, except the gunshot test, had statistically significant links, to a greater or lesser extent, with the dog's later success. The most significant tests were retrieval at eight weeks and aggression at nine months. From their test results with 167 puppies the authors concluded further that they could support Willis (1989) in that aggression was not necessarily inherited.

A weak point for comparing Slabbert & Odendaal (1999)'s results to others is the fact that their puppies lived under special conditions where they were being prepared for later police work. For example, the puppies were allowed to observe their mother being provoked into aggressive behaviour, and were exposed to gunshots regularly when eight weeks of age. Another weak point for comparison are the descriptions of the dog's behaviour in the scoring system. For example in the aggression test, a dog hiding behind the handler scored zero, a dog showing no fear but also not attacking scored five, and a dog biting and holding the obstacle used as a threat, scored ten points. Thus the higher the score, the more the puppy's/dog's behaviour resembles the desired behaviours for a police dog. In common with other subjective systems, the scoring system is prone to be biased just by the fact that different testers work with it. For example a description such as "showing no fear" is not objective but is open to individual interpretation by the judge.

Just recently Ruefenacht et al. (2002) have stated also that the individual judge had a major influence (i.e. significant effect) on the scoring of behaviour traits, and thus on the evaluation of an individual dog's temperament. Ruefenacht et al. looked at 3497 German Shepherds over 12 years. The dogs were tested following a standardised behavioural test (Seiferle, 1972; Seiferle & Leonhardt, 1984), consisting of eight and later on six parts with an individual number of subtests in each: judge approaches handler plus dog; dog's behaviour in certain friendly situations involving different people; dog's reaction to different environmental stimuli; reaction to gunfire; play with a toy; the handler with dog on leash is attacked ("handler-defence").

Since 1990 two additional parts ("self-defence", "fighting drive") have been omitted. Again, comparisons between dogs were not made using single behaviours from an ethogram. Instead, complete behaviour patterns, e.g. tendency to run away or stay friendly and calm, were looked at and put into a numerical scoring system. The most favourable behaviour pattern in each subtest was scored 1 (e.g. self confident, stable nerves, good-natured etc.), the least favourable was scored 5 (e.g. aggressive, over sharpness, etc.). Eight different behaviour traits were evaluated: self-confidence, nerve stability, reaction to gunfire, temperament, hardness, sharpness (i.e. aggressiveness), defence drive, fighting drive. The paper from Ruefenacht et al. (2002) demonstrates a classic dilemma facing the scientist in this field. Ruefenacht et al. used scientific methods and approaches for the evaluation of their data – but the data as such can be considered as biased as the data sampling did not follow any standardised ethological approach and used measures and terminology, where anthropomorphic ideas and human applications for dog behaviour (e.g. handler-defence) were mingled.

The same problem applies to the work of Svartberg & Forkmann (2002) and Svartberg (2002). They used a slightly more differentiated temperament (personality) test for working dogs than Ruefenacht et al. (2002), but again scored according to "which behaviour was wanted and appreciated by humans" rather than describing the individual behaviours shown by the dog following an ethogram. Already Bartlett (1985) and Schenker (1982) had criticised such approach. It would be more important to look for single behavioural traits and possible combinations from such than have a "behavioural goal" in mind, thus categorising dogs as "good" and "bad" on the spot. In this connection Schenker (1982) stated that a gunshot test has no significant prognostic value for "good" and "bad" dogs later on anyway, as many dogs will come to react sensibly to gunshots at different ages.

Aggression or aggressiveness was not explicitly looked for in the papers cited so far, which have focussed on working abilities in connection with traits favoured by humans. Netto & Planta (1997) designed a special test looking for aggression in dogs, comprising of 43 subtests, which will be described in detail in Chapter 2. Planta (2001) further developed the aggression test into a test looking for socially acceptable behaviour in dogs. This test (MAG-test) now comprises of just 16 subtests. From testing 300 dogs, Planta considered her test a valid instrument for testing aggressive biting behaviour.

In Germany the Ministry of Agriculture from the state of Lower Saxony installed an expert commission to design a temperament test for those dogs facing measures from the Lower Saxony DDA, which the author of this thesis has been a member of. Despite the large number of dogs tested, not many results of these tests have been published so far. The Veterinary School at the University of Hannover has recently started to present some results, which will be discussed in Chapter 2.

Some data has been released recently by other persons testing dogs, but unfortunately not allowing useful comparisons between tests, as little information on methods or system of scoring has been given. Baumann (personal communication) has pooled the results of 410 dogs tested in the German state Saxon between 2000 and 2003 (breeds: American Staffordshire Terrier, Bullterrier, Pitbull Terrier, Staffordshire Bullterrier): 11% of these dogs did not pass the test. Baumann and his colleagues in Saxon used a different test than testers in Lower Saxony. In Hesse a total of 3006 dogs from 15 breeds plus their respective crosses have been tested by an unknown number of testers (Hessian Ministry of Inner Affairs to Hessian Veterinary Board, letter from 12.6.02); there, 6.8 % of dogs did not pass the test. Here, comparisons to other test results are difficult, as tests in Hesse for that period of time might just comprise "walking the dog down the street", with a few additional situations, like the tester threatening the dog.

To conclude the topic of temperament tests for dogs, so far no valid and significantly evaluating test exists that can definitely predict any individual dog's aggressiveness later in life – with "later in life" meaning "starting with the day after the test".

1.3.2.8 Summary on dog aggression

Aggressive behaviour evolved in the wolf as one possible means to increase fitness. As with other species, the wolf needs certain resources to increase or hold its fitness; and as in other species aggressive interactions between wolves must have mainly been disputes over such resources. Resources include such elements as food, water or a partner for reproduction, and also the perceived or actual status in a social group, or an intact body. The dog has retained these behavioural traits while being domesticated from the wolf. Breeding by humans has focused on the selected development of individual behavioural traits from the ancestral repertoire, mainly those necessary for hunting and protecting resources.

No single "aggression gene" exists in the dog to elicit aggression, leaving no straightforward way to define more or less aggressive breeds or dog populations. Aggressive behaviour occurs as a result of appraisal of an individual situation and subsequently an individual process of decision. The basic emotion underlying aggressive behaviour in the dog, as in the wolf, is fear. Something, a situation or individual, is detected by the dog, which it may perceive as a threat to its actual fitness status or to resources that it holds. Accordingly the dog starts action to counteract that stimulus and its possible threat. The correlation between an animal's fearfulness and its aggressiveness is not a simple, straightforward matter, as already mentioned earlier.

Thus it is difficult to design valuable and significant tests for preceding how and when an individual dog will react aggressively later on in its life.

## 1.4 The approach

### 1.4.1 Experimental studies

It is not only dangerous for anyone concerned to observe aggressive behaviour of dogs "in the real world", it would also be difficult to analyse and interpret such field-data. The studies in this thesis were therefore all designed. This had the advantage that data that already existed in the literature on behavioural tests was available for comparison, and it also facilitated the comparison of data between the different subject dogs.

In order to test the general hypothesis that a tendency towards aggression has its roots in ontogeny, a structured ethological study of behavioural development was carried out. As there is little data available so far on behavioural development of puppies, a breed was chosen which had not much been investigated in this field so far, but was on the other hand listed as an "aggressive breed" in a German DDA. Another factor for deciding on this breed was the willingness of breeders to participate in this work without demanding anything in return.

The adult dogs were tested using a method which had been established by the German state of Lower Saxony as the standard temperament test for "dangerous dogs", incorporating test elements from Wilsson & Sundgren (1997) and Netto & Planta (1997). This meant that there was at least some existing literature for comparison. Certain test situations, which had previously been developed, practised and standardised by the author (learning test, frustration test), were added, and incorporated into the test of Lower Saxony later on.

## 1.5 Thesis aims and chapter outlines

The aim of this thesis is to contribute to understanding about the assessment and development of aggressive behaviour in dogs, thus providing useful information for the prevention of danger resulting from dog aggression. The literature in this field is diverse but in general suffers from a deficiency in empirical hypothesis testing. The focus for prevention of danger so far is on banning certain breeds which are supposed to be more aggressive than others, and performing temperament tests on dogs with the aim of detecting those with low thresholds for aggression.

Four general hypotheses are proposed in accordance with the problem just stated, arising from the existing literature on dog aggression.

1. It can be deduced from the behavioural patterns of a puppy in dyadic interactions how it will behave when adult, especially when reacting to threatening stimuli.
2a. Dog breeds differ from one another in their aggressiveness due to their different genetic make up.
2b. The owner, as potentially the most salient part of the dog's social environment, plays an important role in the development of the dog's social and aggressive behaviour, once it has left its siblings and mother.
3. The main emotional background for aggression is fear.
4. So-called temperament tests can discriminate between dogs that have bitten previously and those that have not, and may therefore predict aggression in the future.

This thesis is divided into seven chapters, with the first one giving a general overview on the literature existing on social and aggressive behaviour in general, and especially in dogs.

Chapter 2 deals with "temperament tests for aggression" on adult dogs. The current literature on temperament tests is reviewed in detail. The results of a standardised aggression test on 254 adult dogs are described and discussed. Hypotheses 2a (i.e. breed differences) and 4 are tested.

In Chapter 3 ethological measures taken from the same dogs in the same situations as in Chapter 2 are described, and the results are compared to the scoring results from Chapter 2. Hypothesis 3 is addressed.

In Chapter 4 the scoring results from Chapter 2, and the ethological findings from Chapter 3, are analysed for associations with the dog's education, training, biting history and character as estimated by the owner. Hypotheses 2a – 4 are tested.

Chapter 5 deals with the behavioural development of Rhodesian Ridgeback puppies. Four litters were observed from the beginning of their socialisation period up to the day they were given to the new owner with eight weeks of age. The focus was on the puppies' social behaviour in dyadic interactions, and comparison of the observations with the existing literature on other breeds. The development of behaviour in time is examined, and also differences between the litters. Special emphasis is put on the behaviour shown in week eight, for comparison with the behaviour of the adult dogs in the standard aggression test. Hypothesis 2a is tested to a certain extent.

In Chapter 6 the behaviour of the Ridgeback puppies at eight weeks of age is compared to the behaviour the same dogs showed when adult in the standard aggression tests. Here all hypotheses are addressed.

Chapter 7 discusses the results in general, suggesting some implications for breeding and keeping dogs, and preventing danger from dogs in the future.

# Chapter 2:

## Testing adult dogs for aggressiveness and acceptable social behaviour: internal and external validation

## 2.1 Aims

To date, the strategy in Germany, for prevention of danger originating from dogs, has been a) to ban certain breeds which are supposed to be more aggressive than others, and b) to apply a variety of temperament tests to dogs of all breeds, with the aim of detecting those with elevated aggressiveness. There is some literature in this field already, but it still suffers from a deficiency of empirical hypothesis testing. In this chapter the current literature on "aggression tests" and tests for adequate social behaviour are reviewed further to section 1.3.2. The focus is particularly directed towards whether "dangerous dogs" can be reliably selected and distinguished from the background population of "normal" dogs.
The empirical section describes a variation of the test established by the German state of Lower Saxony (NMELF, 2000) as the standard temperament test for "dangerous dogs" in Germany, incorporating additional test elements derived from Wilsson & Sundgren (1997) and Netto & Planta (1997). Test results derived from 254 adult dogs from different breeds are compared to results from the current literature. Validity and reliability, as given by sensitivity and specificity, will be discussed. The data gained here will be compared in the subsequent chapter with data from the same dogs, examined using ethological principles.

The specific hypotheses addressed here are 2a and 4: can so-called temperament tests predict aggression later in a dog's life, and are aggressive traits heritable in certain breeds?

## 2.2 Temperament tests and aggression tests for adult dogs: results and validation so far

Plomin (1982) describes temperament as the relatively stable characteristics of behaviour that show some consistency over time and across situations. As such it is similar to the term "personality" as used for humans (Svartberg & Forkman, 2002). Seiferle (1972) defined temperament as the dog's individual disposition or nature, which is the sum of all inborn and acquired traits, aptitudes or predispositions which impact on a dog's actual behaviour. Elements of a dog's temperament might be its fearfulness, aggressiveness or sociability. If the heritability of traits such as fearfulness, intelligence, search proneness, motivatability or nervousness can be predicted at a young age, or even by looking at the parents, this would be of great help for breeders, trainers and kennel clubs in general. Knowledge of a dog's temperament or personality should enable humans to predict behaviour in certain situations in the future and to decide which husbandry and training methods might be suitable to correct or prevent undesirable behaviour. "Undesirable" is defined not only in the sense of what humans might like a dog to do or not do, but also which training methods might be appropriate from a welfare perspective, i.e. avoiding stressing the dog in certain ways, thereby inhibiting certain goals in training.

The problems with interpreting temperament test results are twofold. Firstly, methods can bias the results even when looking at such straightforward traits as "hunting eagerness", "seeking width"(Brenoe et al.; 2002) or "fetch" (Wilsson & Sundgren, 1998). These traits can be distinguished from traits like "handler-defence" or "obedience", as they resemble more clearly identifiable elements from the dog's behavioural repertoire (i.e. hunting behaviour) whereas the latter subsume a wider range of behavioural elements under the umbrella of anthropocentric thinking. But even with traits like seeking or hunting in certain situations it is difficult to isolate behaviours shown in a test from any earlier learning effects and training in the broadest sense.

Secondly, bias from methods becomes even greater when looking at traits like nervousness, hardness, willingness, affability, obedience or defence drive (cited in Ruefenacht et al., 2002). Here "biological traits" mingle with what humans want from the dog and how they interpret certain actions by the dog, i.e. anthropocentrism leads the way.

Thus it can be said that for any test that is used to identify dogs suitable for any specific use and/or training, the goal sets the method and scoring system, rather than method and scoring system reflecting any objective biological measures. Subsequent problems, like different interpretations of certain behaviour by individual observers, have already been mentioned (see section 1.3.2), thus leading Ruefenacht et al. to the statement that even for well defined behavioural traits the grading of the performance of a dog will always be subjective. The effect of judges was highly significant for all traits in the population that they investigated and was supposed to be defused only to a certain extent via a very large sample size.

In other recent investigations on temperament, the investigators did not look explicitly for single predictive traits, but tried to find broader personality dimensions. For example, Wilson et al. (1994) propose that a "shyness-boldness-axis" (MacDonald, 1987), which shows a greater or lesser tendency to approach novel objects and to take risks, is apparent in many species.

Svartberg & Forkman (2002) found five narrow personality traits for dogs to be subsumed under an analogue of the shyness-boldness axis: playfulness, curiosity/ fearlessness, chase proneness, sociability and aggressiveness. Higher-order factor analysis showed that all factors except aggressiveness were related to each other, creating a broad factor influencing behaviour. This higher-order personality factor correlated positively to playfulness, interest in chase, exploratory behaviour and sociability towards strangers and negatively to avoidance behaviour. The authors concluded that the personality dimensions found are general for the dog as a species. The single major behavioural dimension in all groups of dog breeds, together with comparable results previously found for wolves, led to the authors suggesting that this dimension is evolutionary stable and has survived the varied selection pressures encountered during domestication. The observation that the factor "aggressiveness" did not relate to the broad personality dimension, as the other factors did, could indicate that an individual's actual "aggressiveness" is not an inherited personality trait as such but rather a conglomerate of different inherited and acquired behavioural and personality elements. As a second option aggressiveness could be an isolated personality trait on its own, but this would seem to disagree with what has already been said about the correlation between fear and aggression.

Svartberg & Forkman (2002) evaluated results from 15,329 dogs in a standardised test used by the Swedish Working Dog Association (SWDA) and based on Wilsson & Sundgren (1997), the so-called "dog mentality assessment". The test consisted of 10 subtests and subsumed situations like social contact, manipulation, play (tug of war) and startling situations (sudden appearance of objects/persons/loud noise). Results were given as scores from one to five. Usually a "1" indicated the least reaction of the dog to the presented stimulus and a "5" the most intense possible reaction. The scoring for the situation "sudden appearance of a human shaped dummy" was: startle reaction (1 = short hesitation, 5 = long flight), aggression (1 = no aggression or threat, 5 = threat display and attack against dummy), exploration (1 = no approach to dummy, 5 = immediate approach), remaining avoidance behaviour (1 = no avoidance when passing dummy, 5 = significant avoidance when passing), remaining approach behaviour (1 = no interest in dummy, 5 = approaches together with grabbing and/or playing with dummy).

From their description of the scoring system it can be deduced that the ultimate goal of the test is not to look for dogs that get an overall score of one or two (i.e. are the least aggressive etc.), but rather to get information about which dog will fulfil certain functions best. Thus a dog that is intended for use as a protection dog will probably not fulfil this function satisfactorily if it does not score 5 in certain tests, e.g. immediate approach to dummy, approach together with grabbing the dummy etc.

Nevertheless Svartberg & Forkman (2002) did show that such tests can be a suitable way to gain overall information on temperament tendencies within a breed and between breeds, when the biasing factors are taken into consideration and the sample size is very large. Biases resulted from there being many different testers and test-situations, the dog's age, and the training that the dog had undergone before the test. However, it must be borne in mind that the goal determines the methods and scoring system, and that the goal for these tests is influenced to a large extent by anthropocentrism.

Netto & Planta (1997) were the first to work on an explicit "aggression test", i.e. a test that might reliably predict the quality and quantity of aggressive behaviour shown in the future. They designed a test consisting of 43 subtests; this test was developed on the basis of two preceding pilot-studies.
Netto & Planta looked at the context in which aggressive behaviour from dogs is generally observed, thus ending up with a variety of subtests in which the dog would be startled, threatened, frightened or otherwise stressed. Interspersed were situations that belonged to the ordinary environment humans provide for their dog, and should therefore neither stress nor frighten a well socialised dog. Scoring was based on the

intensity of aggressive behaviour. For example, no aggression observed scored a "1", growling or barking scored a "2" and biting or attacking without biting scored a "5".

Netto & Planta (1997; see also Planta & Netto, 1999) tested 112 dogs, 75 of which had a previous history of showing aggression. Their approach to validation was to compare the dog's actual behaviour in certain test situations to its "biting history", and to re-test individual dogs after an appropriate amount of time. Dogs with a biting history showed a significantly higher level of aggressive behaviour in the test (biting, attack) than dogs without that history. Comparison of the test–re-test results showed a significant correspondence for the results from both biting and non-biting dogs.
Some drawbacks to the test were discussed by the authors: information from owners on the previous history of their dogs might have been wrong; the criteria chosen for a subtest to be passed with a certain score will influence the results as they might differ from tester to tester; the number of aggression-eliciting subtests is limited.

Later on Planta (2001) shortened this to a test for sociable acceptable behaviour (MAG-test) with 16 test elements, to act as an alternative that could be performed more easily by kennel clubs. As before, each test element lasted 20 seconds. Half of them were performed in the presence of the owner. Test situations included: friendly approach by the tester, unfriendly approach by the tester, confrontation with an unfamiliar dog of the same gender, different acoustic and visual stimuli, confrontation with a doll. She based the validation of her test on the behavioural elements "aggressive biting" and "aggressive attacking", testing about 300 dogs of different breeds with and without a history of biting humans. She concluded that this test was a valid instrument for testing aggressive biting against humans, since 82% of the "biting-dogs" showed a positive test result, when the threshold of no biting at all in the tests was used. The correct differentiation into biting and non-biting dogs improved slightly, when biting in one test situation was allowed.

One thing to criticise here is the point that Planta in fact only looked for biting behaviour (aggressive attacking, aggressive biting) when validating her test, leaving out such elements as signs of fear or threat etc. She considers them (fear, threat etc.) not to be a reliable predictor for aggressive biting. According to Planta only aggressive biting should be taken into account when assessing a biting threshold for an individual dog, but she gives no specific explanation for her statement. So far no "threshold measure" for dogs exists which will definitely predict for any possible situation when an individual dog might bite.

As already stated in section 1.3.2.7, the Ministry of Agriculture from the German state of Lower Saxon (NMELF, 2000) appointed an expert commission to design a temperament test for those dogs facing measures from the Lower Saxon DDA. The author has been a member of this group. Dogs passing the test would not be considered a "dangerous dog" any more; apart from four breeds (Bullterrier, Pitbull Terrier, American Staffordshire Terrier, Staffordshire Bullterrier) which were considered dangerous in general up to the end of 2002, when Lower Saxony changed the law (Niedersächsisches Gesetz über das Halten von Hunden, NhundG (NMELF, 2003)). The commission designed a test, mainly following Netto & Planta's (1997) and Wilsson & Sundgren's (1997) papers, including the scoring system. The test consists of 36 test elements (NMELF, 2000) and a learning- and frustration-test (Schöning, 2000c).

About 5000 dogs of supposed "dangerous breeds" were tested between summer 2000 and 2003, by roughly 35 - 40 different testers. Despite the large number, few results have been published so far, apart from some doctoral theses from the University of Hannover.

Mittmann (2002) found no significant differences in aggressive behaviour in general between dogs from Bullterrier, American Staffordshire Terrier, Staffordshire Bullterrier, Doberman Pinscher, Rottweiler and "pit bull type". Just 5 % of her 415 dogs showed inappropriate aggressive behaviour towards certain stimuli. "Inappropriate" described biting behaviour when the dog had not deliberately been threatened by the test person, or when the dog bit without prior threats. Mittmann stated that the test elucidates aggressive behaviour in dogs, although she did not look for any correlation between previous biting and the reactions in the test. She named the following situations as most potentially able to detect inadequate or pathological aggressive behaviour: those comprising fast and/or abrupt human movements, and behaviour capable of challenging the supposed status of the dog.

Bruns (2003) looked at the same dogs and test results as Mittmann (2002) and focused especially on subtests in which the dogs were actively threatened by the test-person (shouted at, fixed with the eyes) or in which "everyday" events from the human environment occurred (e.g. drunkard passes, human screams nearby, human stumbles nearby). She divided 113 of the dogs into two groups according to their reaction in the tests: group B showed aggressive behaviour e.g. biting or snapping, group K showed at most threatening behaviour from a distance. In addition to the scoring system Bruns looked at displays performed by the dogs, e.g. active submission and friendly approach, play behaviour, freezing, confident threats or uncertain (i.e. fearful) threats. Aggressive behaviour in the dogs from group B was strongly associated with behaviour indicating uncertainty or fearfulness. Bruns also looked for correlations between the dog's behaviour and actions by the owner/handler. Owners from group B, for example, were significantly more likely to use a harsh leash correction. Bruns speculated that "aggressiveness" should not be attributed so much to inherited temperament, but more to how the environment, here predominantly the owner, influences the behaviour and character of the dog.

Böttjer (2003) looked at subtests comprising dog-dog interaction, using a subset of the dogs used by Mittmann (2002) and Bruns (2003). She extended the scoring system used by the other two authors, adding numbers 6-8 for describing inadequate and pathological aggressive behaviour: six = no threatening signals at all prior to biting, seven = high arousal in connection with biting did not disappear within 10 minutes, eight = arousal persisted over consecutive subtests. Böttjer noted that just 3.75 % of her sample failed, mainly due to scores of "6" for aggressive behaviour (biting) towards other dogs. There was no significant difference between the different breeds. In agreement with Bruns, Böttjer found a significant association between harsh leash correction and the display of aggressive behaviour (threats, biting). Furthermore, in the dog-dog context the aggressive behaviour, especially when excessive, contained elements of hunting behaviour. Böttjer found that dogs with a positive biting history scored significantly higher (i.e. showed aggressive biting) in the test, but that a high percentage (74%) of owners whose dogs scored five or higher, stated that their dog had no biting history. This could be explained if owners were either afraid to admit biting history due to possible negative consequences for the dog, or had different interpretations of the term "aggressive biting", that was asked for by Böttjer.

Recently Van den Berg et al. (2003) used a shortened version of the test from Netto & Planta (1997), comprising 22 test elements, to test 83 dogs from the Golden Retriever breed. They tested the dogs both outdoors (3 test elements) and indoors (19 test elements). In four situations the owner interacted with the dog (manipulation, playing, raising conflict upon food bowl). Altogether seven situations were included with other dogs. In three of these, competition between test-dog and stimulus-dog was induced over food or access to the owner. The other test elements consisted of situations in which the dog was startled, threatened or confronted with "everyday situations", e.g. opening an umbrella. The dog was never touched by the tester but rather he/she used an artificial hand. The authors noted some qualitative and quantitative differences between their test and that of Netto & Planta (1997), in which of their test elements elicited threatening and snapping/attacking behaviour in the dogs. One reason for this difference might be that Netto & Planta worked with the scoring system already described, whereas Van den Berg et al. used an individual ethogram to describe the dog's behaviour. Their results will be compared to the results gained here from the 254 dogs, in the next chapter, when the ethogram is introduced.

## 2.3 Materials and methods

### 2.3.1 Dogs

A total of 254 dogs were tested: 51 were presented between 1999 and 2003 to estimate their aggressiveness and supposed dangerousness in the course of legal proceedings with the author acting as expert witness, 19 were adult Rhodesian Ridgebacks that had been evaluated as puppies in 1997 and 2001 (see Chapter 5), and the remainder (tested between July 2000 and December 2003) comprised animals that had to be tested for aggressiveness and supposed dangerousness according to the DDA in the respective German state, due to the breed they belonged to. Other dogs (N=233) tested between 1999 and 2003 by the author were excluded since the protocol could not be adhered to, e.g. because of age or health problems of the dog, individual legal requirements, or lack of cooperation from the owner.

During the home test (Table 2.1) owners completed a questionnaire on the dog's background, biting history and living conditions etc. The questions were asked in accordance with the DDA of Lower Saxon (NMELF, 2000) and were aimed at gaining information, that included the owner's knowledge of facts concerning dogs and their husbandry. The original questions (English translation) can be found in Appendix 1. For this investigation the following information was utilized.

- Date of birth, age when purchased by the owner and age when tested.
- Gender and whether the dog was neutered.
- Has the dog ever bitten a family member, a stranger or another dog? Has the dog ever been bitten by another dog? Biting in this respect is defined as any contact with the teeth, that inflicts wounds or death.

### 2.3.2 Testing the dogs

Test elements were performed in order of their numbers in the protocol (Tables 2.1, 2.2). The owner was always present apart from test elements T29 and T30. Test elements T1 to T10 were done at the dog's home, performed by the author and a cameraperson. The dogs were unleashed and not muzzled, unless stated otherwise in the results section. Test elements T11 to T40 were done consecutively on a single day on the training grounds of the dog training school "Struppi & Co." in Hamburg, owned by the author and two veterinarian partners. Testing was done on the following locations on the training grounds: A) a fenced enclosure of approximately 2000 square meters, with 15 obstacles for agility and Schutzhund training (bridge, tunnel, hurdles of different shapes and sizes, hiding places, climbing walls; see Theby & Hares (2003) and Raiser (1979) near the perimeter; B) a car-parking area belonging to the training grounds; C) a street in front of the training grounds; D) smaller fenced area of approximately 300 square meters.

Testing was done in daylight either in the morning or early afternoon; a maximum of five dogs was tested per day. Each dog was held on the leash by its owner; the dogs were not muzzled unless otherwise stated. Owners sometimes came to the tests with prong or choke collars or with extendible leashes. As the standard was to use a flat collar and a "normal" double ended leash, they were provided with these if necessary.

The "group of testers" comprised the author (directing the course of testing, and occasionally functioning as a test-person in elements T12, T16, T20, T29), a camera operator, and three test-persons of both sexes randomly assigned to the test elements. The "unfamiliar dogs" used in certain test elements were owned privately by the owners of the dog training school, and were adult dogs of both sexes, intact as well as neutered, of the following breeds: Labrador Retriever, German Shepherd, Canadian White Shepherd, German Shorthair, Rhodesian Ridgeback, Coon Hound, Border Terrier, Dachshund, middle sized mixed breed of unknown origin with long curly hair. As owners in general came with friends or other members of the family, the fence of the training area was usually lined with a variable number of people of different ages and both sexes.

Table 2.1) Test elements for adult dogs in their own home/territory. References refer to the literature in which an analogous test element or test element with similar features is mentioned. Dogs were neither leashed nor muzzled unless stated otherwise.

| Nr. | Duration | Description |
|---|---|---|
| T 1 | 15 seconds or until dog shows agonistic behaviour of any kind | Test person starts friendly interaction with dog: contact is offered verbally plus intentional movement with hand towards dog; dog is stroked in head/neck area. Test person starts interaction in as non-threatening a position as possible (addressing dog from the side, avoiding visual contact, squatting body posture) and then changes position in the course of interaction into facing the dog while standing (Wilsson & Sundgren, 1997; Netto & Planta, 1997; NMELF, 2000) |
| T 2 | As T1 | Dog is manipulated with hands on whole body: stroking changes gradually to gestures imitating mounting behaviour (i.e. pressing on the back with the hands)(NMELF, 2000). |
| T 3 | As T1 | Test person invites dog to play with a toy or other available object (cloth etc.) (Wilsson & Sundgren, 1997; Netto & Planta, 1997; NMELF, 2000). |

| | | |
|---|---|---|
| T 4 | As T1 | Test person fixes dog with his/her eyes from a standing position (Wilsson & Sundgren, 1997; Netto & Planta, 1997; NMELF, 2000). |
| T 5 | As T1 | Test person gives one or more commands, i.e. SIT or DOWN from standing position |
| T 6 | Three sequences, if dog does not show agonistic behaviour of any kind; agonistic behaviour ends T6, regardless of sequence | Test person introduces a low-intensity frustrating stimulus: dog is offered three treats. The fourth treat is kept in the hand while dog tries to get hold of it. The sequence ends when dog shows any behaviour that puts it in a waiting position (waiting for the treat to come, i.e. sit, lay down) within 10 seconds, when it has not shown any of such behaviour after 10 seconds or until dog shows agonistic behaviour of any kind (designed by Schöning, already partly cited in the directives on execution of the Lower Saxony temperament test (NMELF, 2000; Schöning, 2000c)). |
| T 7 | Three sequences, if dog does not show agonistic behaviour of any kind; agonistic behaviour ends T7, regardless of sequence | Two treats are thrown on the floor and the dog is allowed to take them. Third treat is thrown and access by dog is blocked by test-person with his/her body while stepping forward towards the approaching dog. Sequence ends when dog shows any behaviour that puts it in a waiting position (waiting for the treat to come, i.e. sit, lay down) within 10 seconds, when it has not shown any of such behaviour after 10 seconds or until dog shows agonistic behaviour of any kind (designed by Schöning, already partly cited in the directives on execution of the Lower Saxony temperament test (NMELF, 2000; Schöning, 2000c)). |
| T 8 | Clicking sound | A clicking sound with a clicker (dog training device) is produced three times and accompanied each time with a treat. |
| T 9 | Three sequences, if dog does not show agonistic | Test person holds together clicker and tip of biro in one hand: biro is stuck between third and fourth finger, clicker is positioned on root of first finger with thumb clicking. |

| | | |
|---|---|---|
| | behaviour of any kind; threatening behaviour ends sequence, attacking behaviour ends T9, regardless of sequence | Biro is held in front of dog's face. When dogs sniffs at biro, push-button of biro is slightly tapped against dogs nose, clicker is used in parallel, followed by a treat. If dog does not sniff, the biro gently touches its nose by active movement of test-person, clicker is used in parallel. Before each new sequence the dog gets some time (max. 10 seconds) to touch the biro with its nose on its own. This could mean the test person following the dog, should it try to get out of the way. |
| T 10 | As T 1 | As T1 |

Table 2.2) Test elements for adult dogs away from their own territory. References refer to the literature in which an analogous test element or test element with similar features is mentioned. Dogs are leashed but without muzzle unless stated otherwise.

| **Nr.** | **Duration** | **Description** |
|---|---|---|
| T 11 | 10 seconds | Two unfamiliar dogs of both sexes pass on the lead; distance between dogs is 1-2m (Netto & Planta, 1997; NMELF, 2000). |
| T 12 | 10 seconds | Test-person with hat and coat stands in front of dog and fixes with his/her eyes (Netto & Planta, 1997; NMELF, 2000). |
| T 13 | As long as it takes to pass the dog | Test-person limps past dog at a distance of about 1m (Netto & Planta, 1997; NMELF, 2000). |
| T 14 | As long as it takes to pass the dog | Test-person walks past dog and stumbles in front of dog at a distance of about 1 m (Netto & Planta, 1997; NMELF, 2000). |
| T 15 | 10 seconds | Test-person kneels in front of dog and starts friendly interaction: contact is offered verbally and with intentional movement with hand towards dog as in T1 (Wilsson & Sundgren, 1997; Netto & Planta, 1997; NMELF, 2000). |
| T 16 | 10 seconds | Test-person shouts at dog, standing in front of dog (Netto & Planta, 1997; NMELF, 2000). |

| | | |
|---|---|---|
| T 17 | As long as it takes to pass the dog | Test-person pretends to be drunk, staggering mumbling past dog, holding a bottle in hand and smelling slightly of alcohol (NMELF, 2000). |
| T 18 | As long as it takes to pass the dog | Test-person passes dog and opens an umbrella over own head when close to dog (Netto & Planta, 1997; NMELF, 2000). |
| T 19 | 10 seconds | Test-person comes close to owner and dog, greets owner and touches dog with legs on the body at least once (Netto & Planta, 1997; NMELF, 2000). |
| T 20 | 10 seconds | Test-person makes a fast step towards dog, simulating an attack with a stick, shouting (Wilsson & Sundgren, 1997; Netto & Planta, 1997; NMELF, 2000). |
| T 21 | 10 seconds | Four test-persons move towards dog and owner and circle close around. Dog is touched with leg at least once by one test-person (Netto & Planta, 1997; NMELF, 2000). |
| T 22 | 10 seconds | Dogs is walked towards an approaching group of four persons and gets circled closely by them (Netto & Planta, 1997; NMELF, 2000). |
| T 23 | As long as it takes the dog to pass and person to run at least three steps | The dog is walked past (distance 1m) a lying person who jumps up abruptly and runs off, when dog is nearest (Wilsson & Sundgren, 1997; Netto & Planta, 1997; NMELF, 2000). |
| T 24 | Max. 5 seconds | A very loud shot-like noise is presented twice, person emitting the sound can be identified by dog (Wilsson & Sundgren, 1997; Netto & Planta, 1997; NMELF, 2000). |
| T 25 | As long as it takes to pass the dog | Dog is walked towards and past an approaching group of four persons. When dog passes, a loud noise is presented (Netto & Planta, 1997; NMELF, 2000). |
| T 26 | 10 seconds | Test-person invites dog to play with a toy or other available object (cloth etc.) (Wilsson & Sundgren, 1997; Netto & Planta, 1997; NMELF, 2000). |

| | | |
|---|---|---|
| T 27 | 10 seconds | A large piece of tablecloth is gently swung against dog and around head, held by a test-person in front of his/her body (NMELF, 2000). |
| T 28 | As long as it takes to pass the corner | Dog passes a corner around which a broom is suddenly swept against it over the floor (Netto & Planta, 1997; NMELF, 2000). |
| T 29 | Two minutes plus 10 seconds | Dog is fixed with leash to a solid object and left there in isolation from owner for two minutes. Isolated dog is then fixed with the eyes by an approaching test-person as in T12 (NMELF, 2000). |
| T 30 | 15 seconds | An unknown dog of the same sex is presented to the isolated and leashed subject dog by a test-person. This dog is led on a leash past the test-dog twice, at a distance of 1-2 m (Netto & Planta, 1997; NMELF, 2000). |
| T 31 | As long as in T25 | A skateboard is driven past the dog, distance 1-2 m |
| T 32 | As long as in T25 | A bicycle is driven past the dog and the bell rung, distance 1-2 m (NMELF, 2000). |
| T 33 | As long as in T25 | A "blind person" with a guide-stick walks past (Netto & Planta, 1997; NMELF, 2000). |
| T 34 | As long as in T25 | A person jogs past the dog (Netto & Planta, 1997; NMELF, 2000). |
| T 35 | As long as in T25 | A pram is pushed past the dog, screams of a child or adult person in high pitching voice are heard (Netto & Planta, 1997; NMELF, 2000). |
| T 36 | As long as in T25 | A person kicks a ball past the dog (NMELF, 2000). |
| T 37 | 15 seconds | The dog is presented with other dogs of both sexes in close contact through a fence (Netto & Planta, 1997; NMELF, 2000). |
| T 38 | 10 seconds | Owner manipulates the dog using gestures imitating imposing behaviour from dogs, e.g. hands pressing on back or hands around head/muzzle (Netto & Planta, 1997; NMELF, 2000). |

| | | |
|---|---|---|
| T 39 | 10 Seconds | Owner invites dog to play and plays roughly, tumbling against dog (Netto & Planta, 1997; NMELF, 2000). |
| T 40 | 3 seconds per command | Owner walks with the dog and commands dog, e.g. SIT, DOWN, HERE, OFF (dog has to leave a toy); command can be given twice (Netto & Planta, 1997; NMELF, 2000). |

### 2.3.3 Scoring system

In each test element, responses were quantified according to a 6-point scoring system, following Netto & Planta (1997) and the temperament test of Lower Saxon (NMELF, 2000):

Score 1 = No aggression is observed; dog stays neutral or shows avoidance behaviour.

Score 2 = Either acoustic or visual threats, or both, from a distance

Score 3 = Snapping with or without acoustic and visual threats from a distance

Score 4 = Snapping with or without acoustic and visual threats with incomplete approach

Score 5 = Biting or attacking with acoustic and visual threats

Score 6 = Biting or attacking without acoustic and visual threats

In T40 the obedience reaction of the dog following the owner's command was scored the following:

1 = obedience fast and complete

2 = second command needed

3 = owner has to give command more than twice, dog shows obedience in the end but very slowly; owner manipulates up to the point of pressing the dog down or putting a hand to the muzzle with the "off-command"

4 = dog does not show obedience at all

In addition, how the dog walked on the leash was scored in T40:

1 = loose leash, dog near owner

2 = dogs pulls slightly and intermittently on leash

3 = leash is tight permanently

4 = leash is tight and owner has to struggle to keep dog next to him/her.

### 2.3.4 Data collection

Monitoring took place with a video camera and additional written notes. Cameras: Canon UC9, 8 mm Video Camcorder Hi8; Panasonic Digital Video Camera, NV-DS35EG. The filming started with the start of any test element and was stopped when the situation was finished. The written scoring was done simultaneously with the testing. For the evaluation in this chapter the written scores was taken, supported by watching the videotapes in elements where dogs scored 3 or higher.

### 2.3.5 Data samples and statistical analysis

The data set per dog consisted of dog number, questionnaire results, and assessment following the scoring system for each test element, including the evaluation of obedience level. Statistical analysis was done with SPSS® version 12 for Macintosh and version 12 for Windows. Data files for statistical analysis were produced using the following programs: File Maker 7® and EXCEL®, both for Macintosh and Windows. Data was inspected by crosstabulation, and examined for normal distribution. Parametric tests were applied where possible. Non-parametric analysis of variance was done with Kruskal-Wallis-test, Spearman Rank correlation test and Mann-Whitney-U-test. Cluster analysis was used to group the test elements into groups: the Jaccard method was used because the data was binary (1/0: presence/absence of aggression) and links were being sought based only on co-occurrences of aggression.

## 2.4 Results

### 2.4.1 Descriptive results

Some breeds were over proportionally represented due to the fact that they are listed in a DDA (Table 2.3). Such dogs were required to pass the test or be leashed and muzzled. Thus the numbers are distorted when compared to the general pet dog population, or even statistics on biting incidents, which are led by mixed breeds and German Shepherds (Deutscher Städtetag, 1997). The categorizing of any dog into a certain breed was done following the owner's statement in the questionnaire. As there is so far no valid method of objective breed classification for dogs, some owners might have re-assigned their dogs to a different breed-category, one not put under restrictions by the respective DDA of a German state. This could lead to an American Staffordshire Terrier or Pitbull Terrier (both required to be leashed and muzzled in Hamburg irrespective of the test result) being renamed as a Bullterrier–mongrel, which need not be leashed or muzzled if it passes the test.
These potential biases were taken into account when comparing levels of aggression between breeds within the sample. Breeds for which just one or two dogs were tested, were pooled to gain categories with more individuals (see Figure 2.1).

Almost 40% of the sample were entire males (Figure 2.2). Contingency table analysis showed that the distribution of sex and neuter status was similar between breed groups ($Chi^2 = 24.4$, d.f. = 24, p = 0.438).

Table 2.3) Breeds and number of dogs per breed tested, including information on sex.

| Breed | total number | Female intact | Female neutered | Male intact | Male neutered |
|---|---|---|---|---|---|
| Airedale Terrier | 1 | 1 | 0 | 0 | 0 |
| American Bulldog | 1 | 0 | 0 | 0 | 1 |
| American Bulldog -Mongrel | 3 | 0 | 0 | 2 | 1 |
| American Staffordshire Terrier | 15 | 3 | 6 | 3 | 3 |
| Boxer-Mongrel | 3 | 0 | 1 | 2 | 0 |
| Big Swiss dog | 2 | 0 | 2 | 0 | 0 |
| Bullmastiff | 24 | 4 | 9 | 10 | 1 |
| Bullmastiff-Mongrel | 4 | 1 | 1 | 0 | 2 |
| Bullterrier | 43 | 7 | 12 | 17 | 7 |
| Bullterrier-Mongrel | 26 | 8 | 6 | 8 | 4 |
| Dalmatian-Mongrel | 1 | 0 | 1 | 0 | 0 |
| Dobermann Pinscher | 4 | 0 | 2 | 1 | 1 |
| Dogo Argentino | 3 | 0 | 0 | 3 | 0 |
| Dogo Argentino-Mongrel | 5 | 0 | 1 | 3 | 1 |
| Dogue de Bordeaux | 39 | 7 | 9 | 19 | 4 |
| Dogue de Bordeaux-Mongrel | 2 | 0 | 0 | 2 | 0 |
| Fila Brasileiro | 3 | 3 | 0 | 0 | 0 |
| German Shepherd | 8 | 1 | 1 | 5 | 1 |
| German Shorthair | 1 | 0 | 0 | 1 | 0 |
| Hovavart | 1 | 0 | 0 | 1 | 0 |
| Husky-Mongrel | 2 | 0 | 1 | 1 | 0 |
| Kangal | 1 | 0 | 0 | 1 | 0 |
| Kangal-Mongrel | 1 | 0 | 0 | 1 | 0 |
| Labrador Retriever | 1 | 1 | 0 | 0 | 0 |
| Labrador Retriever-Mongrel | 1 | 1 | 0 | 0 | 0 |
| Mastiff | 6 | 1 | 1 | 4 | 0 |
| Mastiff-Mongrel | 1 | 0 | 0 | 1 | 0 |
| Mastino Napoletan | 1 | 0 | 0 | 0 | 1 |
| Mastino-Mongrel | 1 | 0 | 0 | 1 | 0 |
| Mixed Breed | 3 | 1 | 1 | 1 | 0 |
| Owtscharka | 3 | 2 | 0 | 1 | 0 |
| Pitbull Terrier | 8 | 3 | 3 | 0 | 2 |
| Pitbull Terrier-Mongrel | 1 | 0 | 0 | 0 | 1 |
| Rhodesian Ridgeback | 21 | 9 | 2 | 7 | 3 |
| Rhodesian Ridgeback-Mongrel | 2 | 0 | 1 | 0 | 1 |
| Rottweiler | 9 | 2 | 1 | 5 | 1 |
| Rottweiler-Mongrel | 1 | 0 | 1 | 0 | 0 |
| Staffordshire Bullterrier | 2 | 0 | 2 | 0 | 0 |
| Sum | 254 | 55 | 64 | 100 | 35 |

Figure 2.1) Breeds and breed groups used for further analysis (X-axis) and the absolute number of individuals per breed/group (Y-axis).
American Bulldog/-mongrel, Boxer mongrel, Husky mongrel, Rhodesian Ridgeback mongrel, Rottweiler mongrel, Airedale Terrier, Big Swiss Dog, Dalmatian mongrel, German Shorthair, Hovavart, Labrador Retriever/-mongrel, and the non-classified mixed breeds were combined into one category since they are not listed in any DDA in Germany (group „DDA unlisted")
Bullmastiff mongrel, Dogo Argentino/-mongrel, Dogue de Bordeaux mongrel, Kangal, Mastiff/-mongrel, Mastino Napoletan/-mongrel, Owtscharka, Pitbull-Terrier mongrel, Rottweiler and Staffordshire Bullterrier were combined as comprising breeds listed in different German DDA's (group „DDA listed"). Dogue de Bordeaux mongrel and Pitbull mongrel were included in this group, as it was not known which other breed(s) were involved.
Among the mongrels, just the Bullterrier mongrels were itemized, as a large number were tested. The Pitbull Terriers were left as a single breed for comparison with results for this breed in the literature.

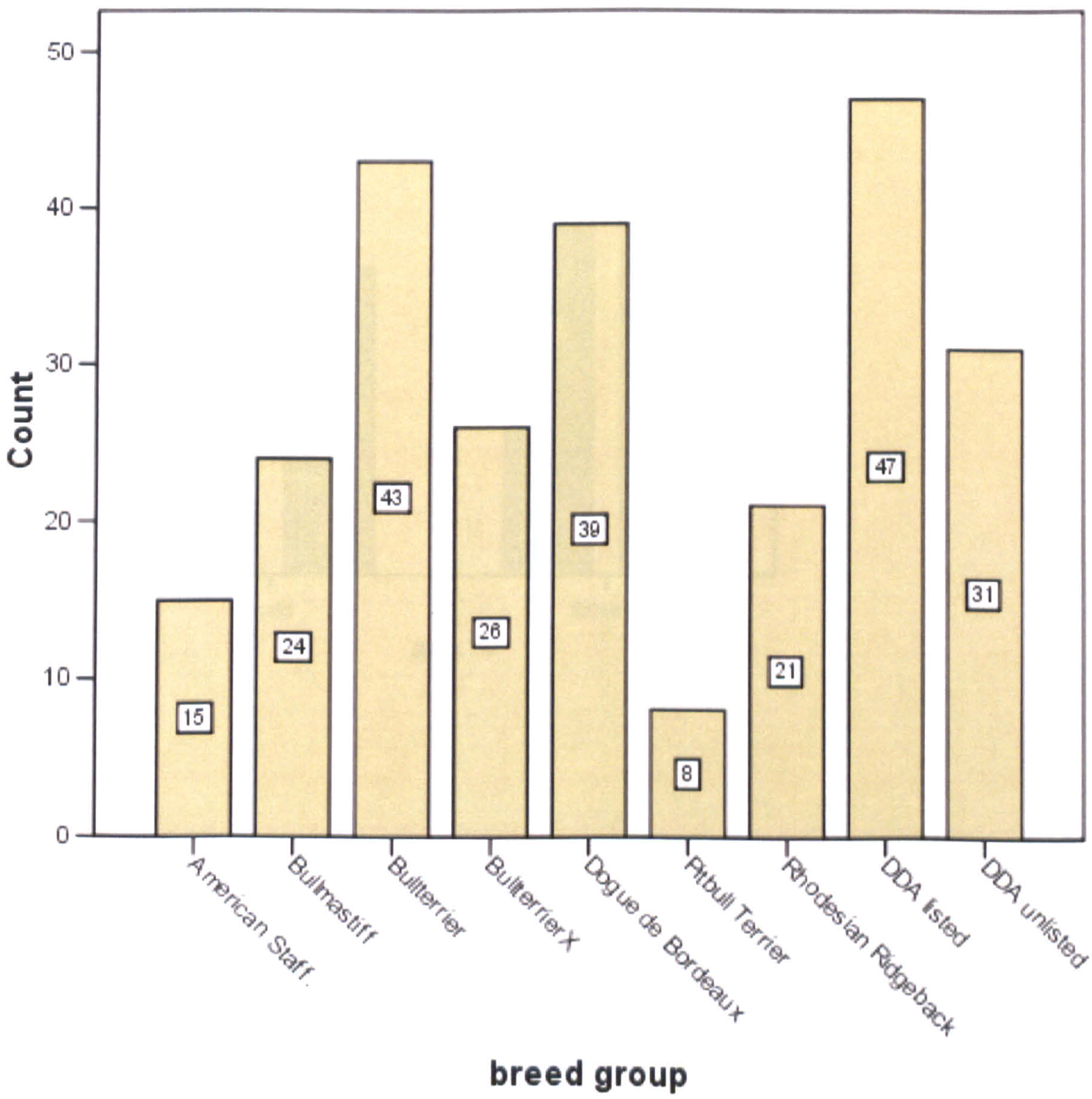
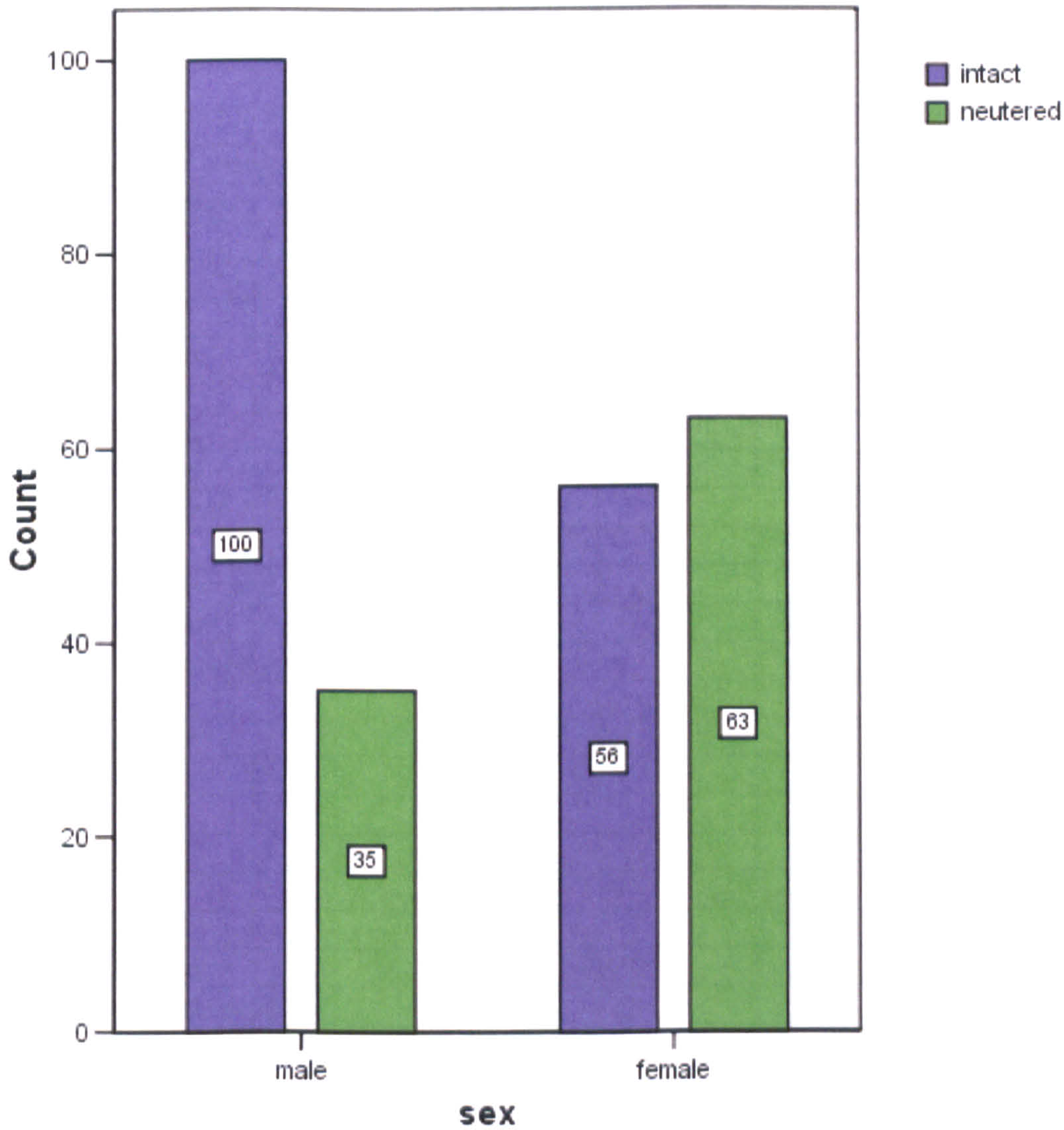


Figure 2.2) Distribution of sex and capability of reproduction for the dogs shown in Table 2.3. The Y-axis gives the absolute numbers of dogs in the respective groups. On the X-axis male and female dogs are each grouped together, split up into dogs with intact reproductive status and neutered individuals.

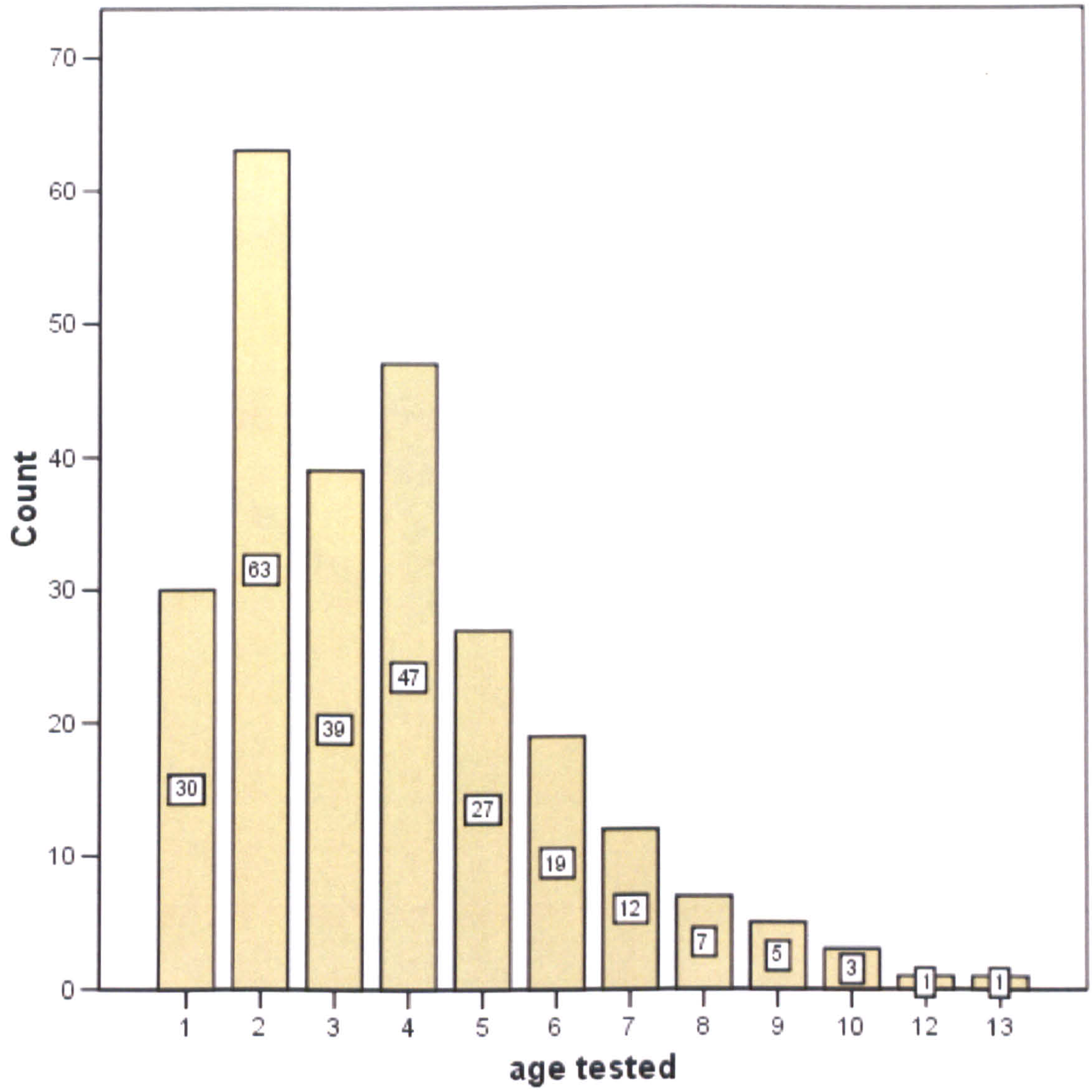



As the majority of the dogs are still alive at the time of writing, the age is given in ranges to assist anonymity of dog and owner. Dogs between seven and eighteen months of age were named one year old, between nineteen and thirty months two years and so on. Table 2.4 and Figure 2.3 show the age distribution for the dogs tested.
The distribution of age was not significantly different between the different breed groups (K-W $Chi^2$=10.8, df=8, p=0.211).

Table 2.4) Age distribution of dogs tested. Minimum age, maximum age and mean age when tested per breed are shown

| Breed | Mean age when tested | Minimum age | Maximum age |
|---|---|---|---|
| Airedale Terrier | 8.000 | 8 | 8 |
| American Bulldog | 8.000 | 8 | 8 |
| American Bulldog -Mongrel | 3.338 | 2 | 2 |
| American Staffordshire Terrier | 4.214 | 1 | 13 |
| Boxer-Mongrel | 3.333 | 2 | 7 |
| Big Swiss dog | 4.000 | 2 | 6 |
| Bullmastiff | 3.750 | 1 | 9 |
| Bullmastiff-Mongrel | 3.750 | 3 | 5 |
| Bullterrier | 4.279 | 1 | 10 |
| Bullterrier-Mongrel | 3.076 | 1 | 6 |
| Dalmatian-Mongrel | 2.000 | 2 | 2 |
| Dobermann Pinscher | 4.250 | 1 | 6 |
| Dogo Argentino | 3.000 | 1 | 5 |
| Dogo Argentino-Mongrel | 3.600 | 1 | 6 |
| Dogue de Bordeaux | 3.358 | 1 | 8 |
| Dogue de Bordeaux-Mongrel | 1.500 | 1 | 2 |
| Fila Brasileiro | 3,333 | 1 | 7 |
| German Shepherd | 6.000 | 2 | 12 |
| German Shorthair | 4.000 | 4 | 4 |
| Hovavart | 3.000 | 3 | 3 |
| Husky-Mongrel | 5.500 | 2 | 9 |
| Kangal | 3.000 | 3 | 3 |
| Kangal-Mongrel | 3.000 | 3 | 3 |
| Labrador Retriever | 3.000 | 3 | 3 |
| Labrador Retriever-Mongrel | 3.000 | 3 | 3 |
| Mastiff | 2.833 | 1 | 5 |
| Mastiff-Mongrel | 3.000 | 3 | 3 |
| Mastino Napoletan | 5.000 | 5 | 5 |
| Mastino-Mongrel | 4.000 | 4 | 4 |
| Mixed Breed | 3.666 | 2 | 6 |
| Owtscharka | 2.666 | 1 | 5 |
| Pitbull Terrier | 4.000 | 2 | 6 |
| Pitbull Terrier-Mongrel | 1.000 | 1 | 1 |
| Rhodesian Ridgeback | 3.380 | 3 | 5 |
| Rhodesian Ridgeback-Mongrel | 3.000 | 3 | 3 |
| Rottweiler | 4.111 | 1 | 9 |
| Rottweiler-Mongrel | 5.000 | 5 | 5 |
| Staffordshire Bullterrier | 7.000 | 4 | 10 |
| **Mean overall** | **3.665** | **2.46** | **5.59** |

Figure 2.3) Age distribution of all dogs tested. X-axis gives the age category (see text) in years, Y-axis gives the absolute numbers of dogs per age group.




On average the dogs had been purchased by the current owner when 0.825 years of age: 201 dogs were bought as puppies, 25 when one year old, 15 when two years old, three when three years old and five each when four and five years old.

Almost two-thirds of the dogs were reported as never having bitten (169 dogs); among the other dogs biting incidents involving dogs were much more common than those involving people (Figure 2.4); 131 dogs had been bitten by other dogs, and 70 of those had themselves bitten other dogs (Figure 2.5). There was a high probability that dogs that had been bitten by other dogs had also bitten other dogs: $Chi^2 = 65.7$, df=1, $p<0.001$. There was also a significant positive association between "biting a person" and "biting another dog": $Chi^2=9.7$, df=1, $p=0.004$.

Figure 2.4) Distribution of victims among the 85 dogs with a biting history
Biting family members only: 4 dogs; biting strangers only: 2 dogs; biting dogs only: 65 dogs; biting family and strangers: 1 dog; biting family and dogs: 8 dogs; biting strangers and dogs: 2 dogs; biting family, strangers and dogs: 3 dogs.

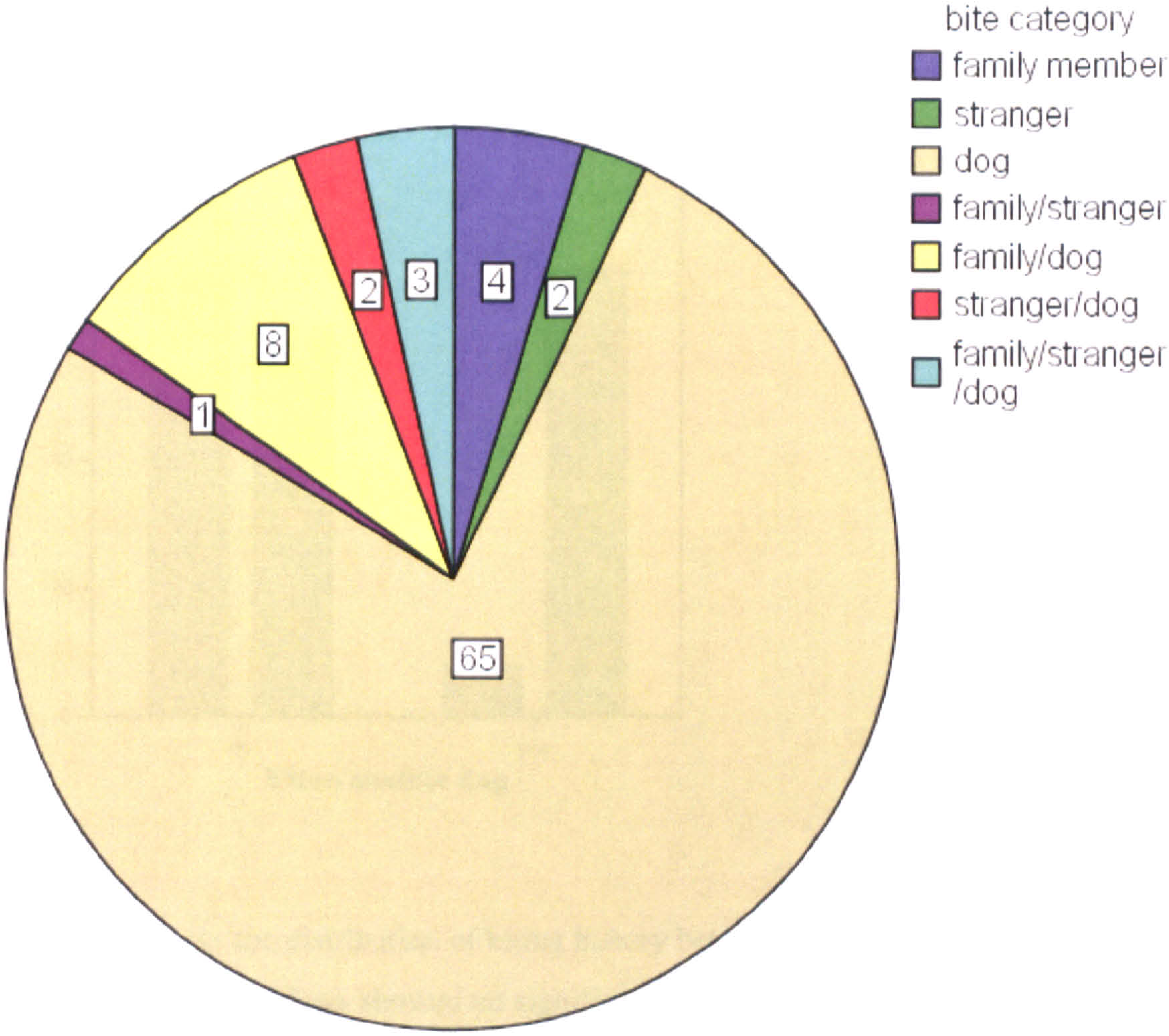


Figure 2.5) Numbers of dogs that had been bitten or not bitten by a dog, that had themselves bitten a dog.

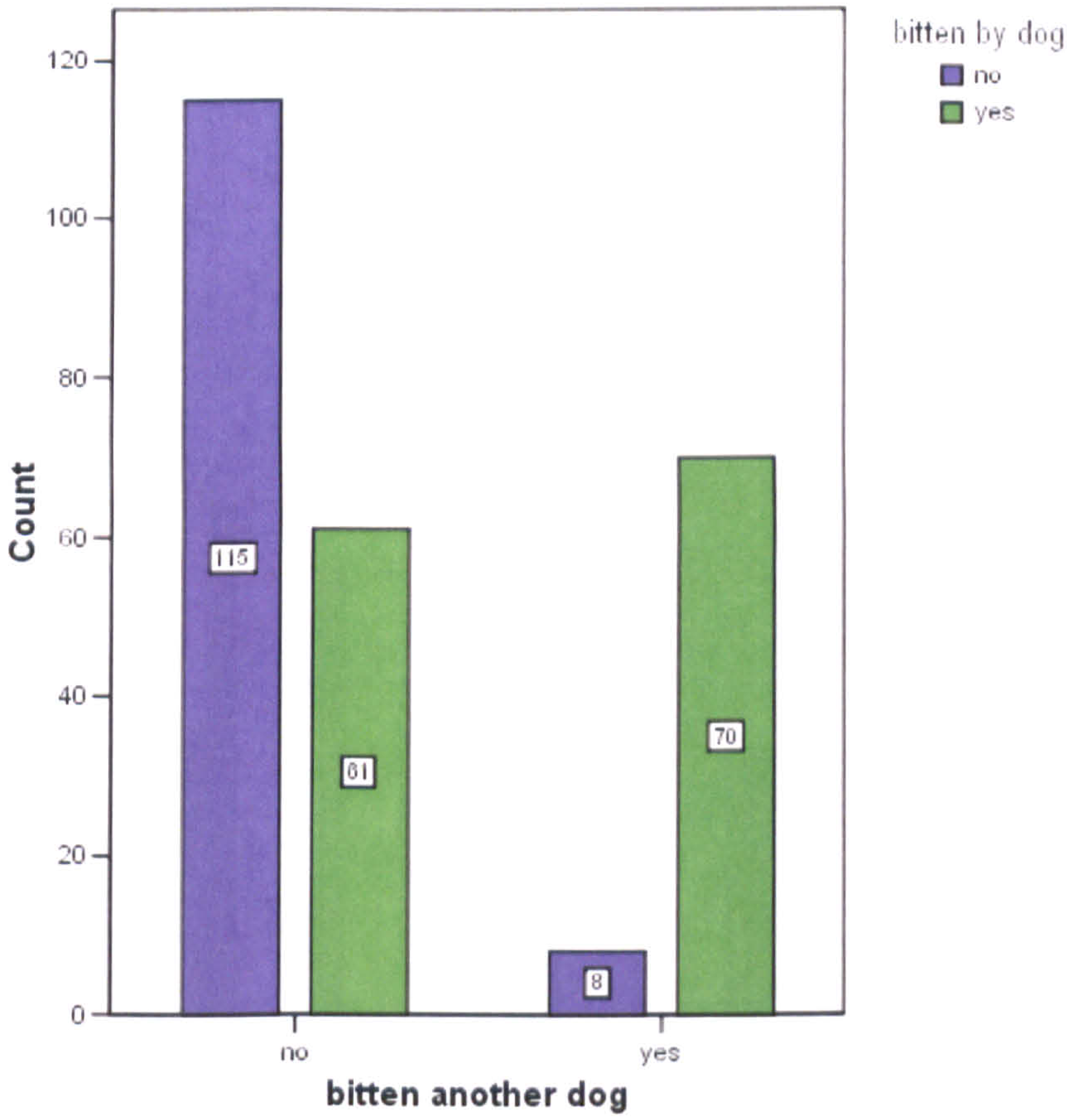
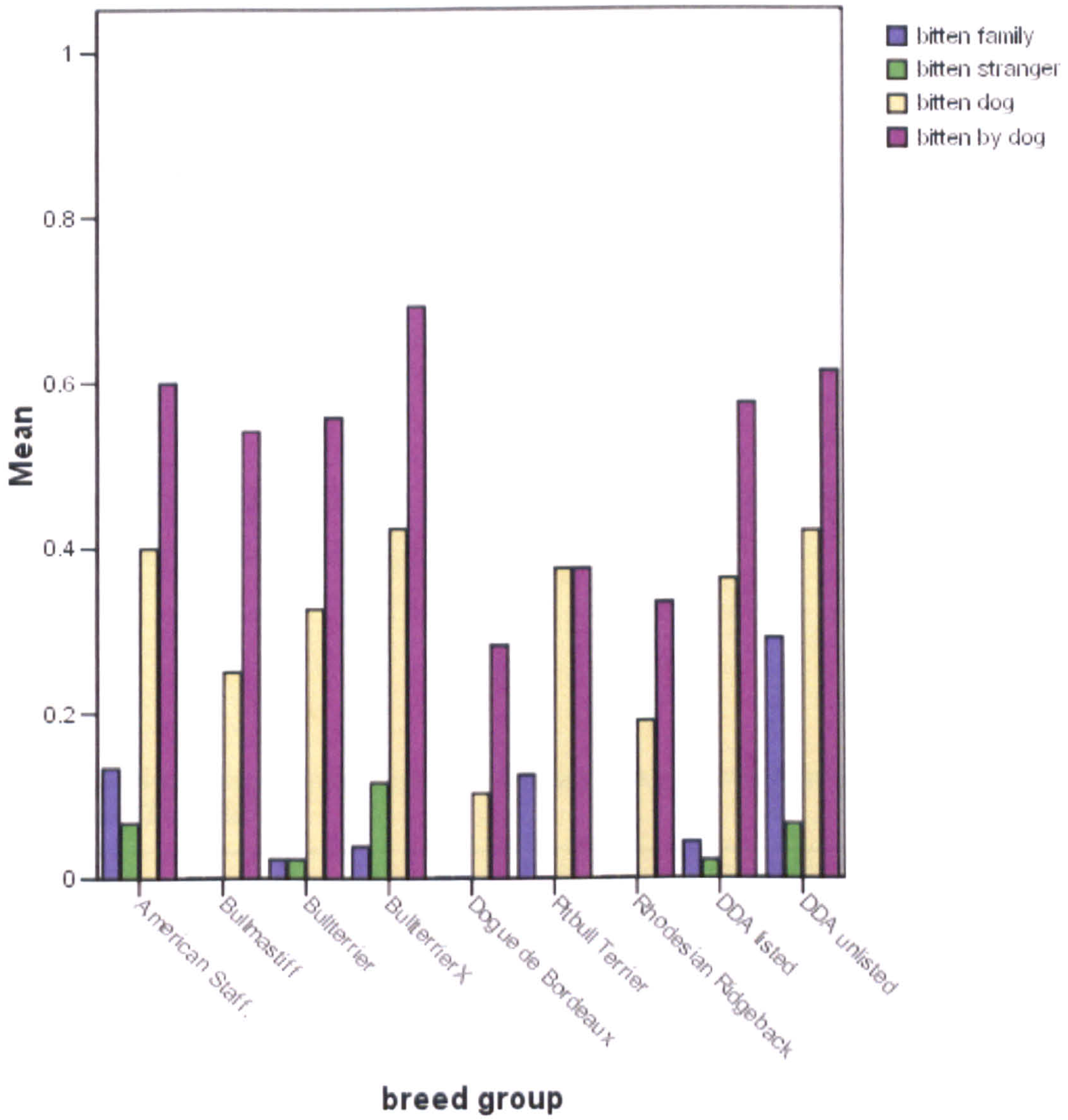



Figure 2.6. shows the distribution of biting history between the different breed groups. Contingency table analysis showed no significant differences between breed groups for biting another dog: $Chi^2=14.4$, df=8, p=0.073.

There was also no significant difference between breed groups for biting a stranger (unfamiliar person): $Chi^2=10.9$, df=8, p=0.204; although this probability is not reliable as 50 % of expected values were < 5. The same problem (50 % of expected values < 5) applied to the numbers of dogs biting family members. Here contingency table analysis showed a significant difference between breed groups: $Chi^2=36.3$, df=8, p<0.001. Pitbull Terriers, American Staffordshire Terriers and non-DDA-listed breeds were responsible for most of the bites of family members (see Figure. 2.6)

There was also a significant difference between breed groups for the probability of dogs being bitten by another dog: $Chi^2=17.8$, df=8, p=0.023. The largest breeds (Dogue de Bordeaux, Rhodesian Ridgeback and Bullmastiff) were the least likely to be bitten. Differences between breed groups for dogs biting any human were marginally non-significant: $Chi^2=13.8$, df=8, p=0.055.

Figure 2.6) Distribution of biting history between the different breed groups. The Y-axis gives the mean proportion of dogs involved in bite incidents. Colours indicate different types of bite.




Sex and neuter status had no statistically significant influence on biting history concerning humans (dogs biting family members: $Chi^2$=6.1, df=3, p=0.109; dogs biting strangers: $Chi^2$=2.3, df=3, p=0.521; dogs biting any human: $Chi^2$=2.4, df=3, p=0.495: all from contingency tables).

Sex and neuter status had a strong effect on biting of other dogs, with neutered males most likely to have bitten (18 cases, 51%), followed by entire males (37 cases, 37%), intact females (17 cases, 30%) and neutered females (10 cases, 16%): $Chi^2$=16.9, df=3, p=0.001. It is possible that some of these neutered males had been entire when they bit, and had been neutered to reduce the probability of their biting again.

A similar statistically significant trend could be seen with the dogs bitten by another dog. Neutered males gave the highest proportion (24 cases, 69%), followed by entire males (59 cases, 59%), neutered females (25 cases, 40%), and intact females (23 cases, 37%): $Chi^2$=12.3, df=3, p=0.006.

The mean score for aggression was 1.184 when all 39 test elements were included. The mean went down to 1.153 for the scoring in test elements performed in the home (T1 – T10) and was correspondingly higher (1.194) in test elements T11 – T39. The mean obedience score for all dogs was 2.398.

Mean aggression scores (Figures 2.7 – 2.9) and for obedience (Figure 2.10) did not differ markedly between breed groups.

Figure 2.7) Distribution of mean aggression scores (Y-axis) between breed groups (X-axis) for test elements T1 - T39

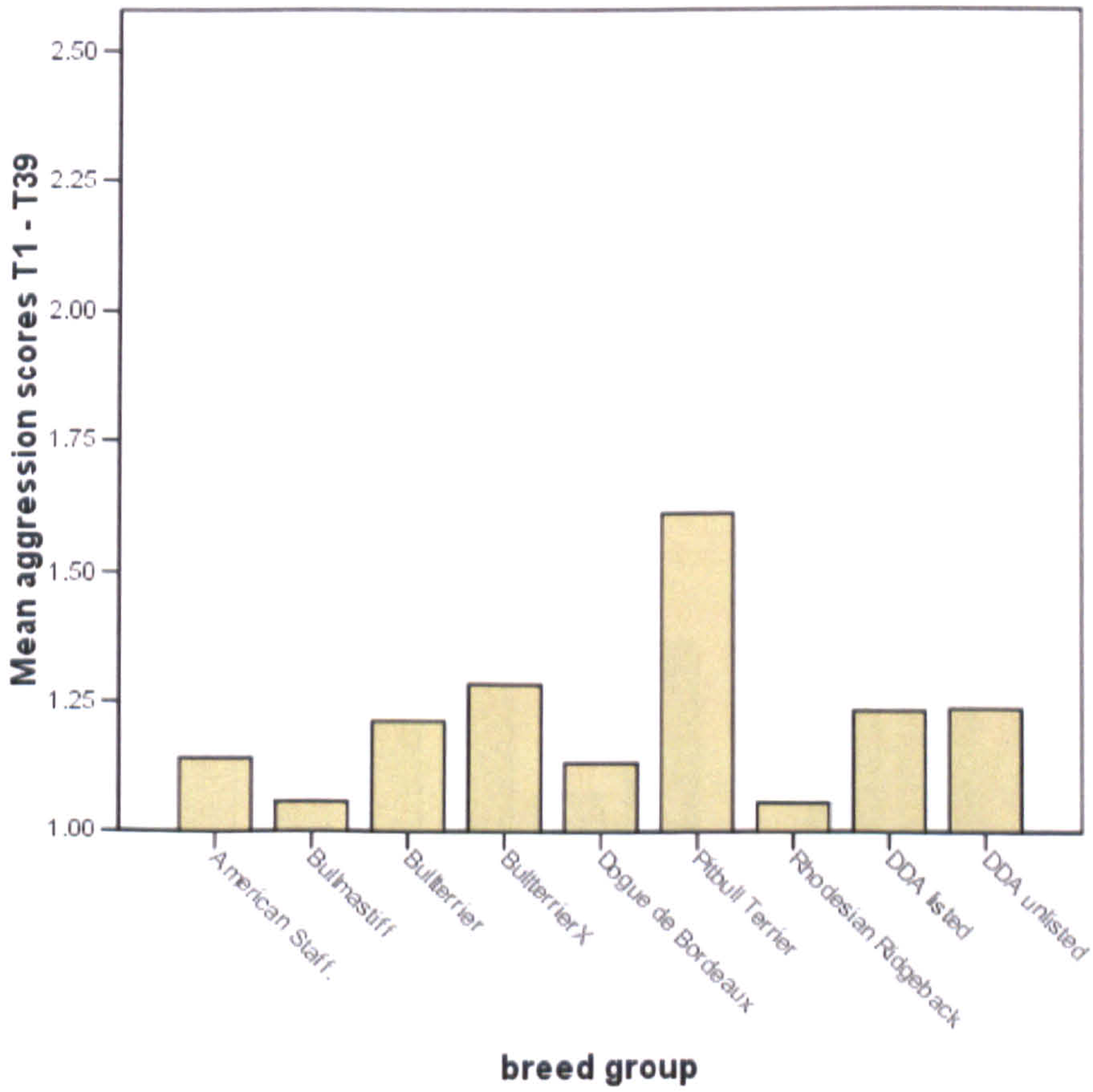


Figure 2.8) Distribution of aggression scores (Y-axis) between breed groups (X-axis) for test elements T11 - T39, conducted in the test arena, off the dog's territory.

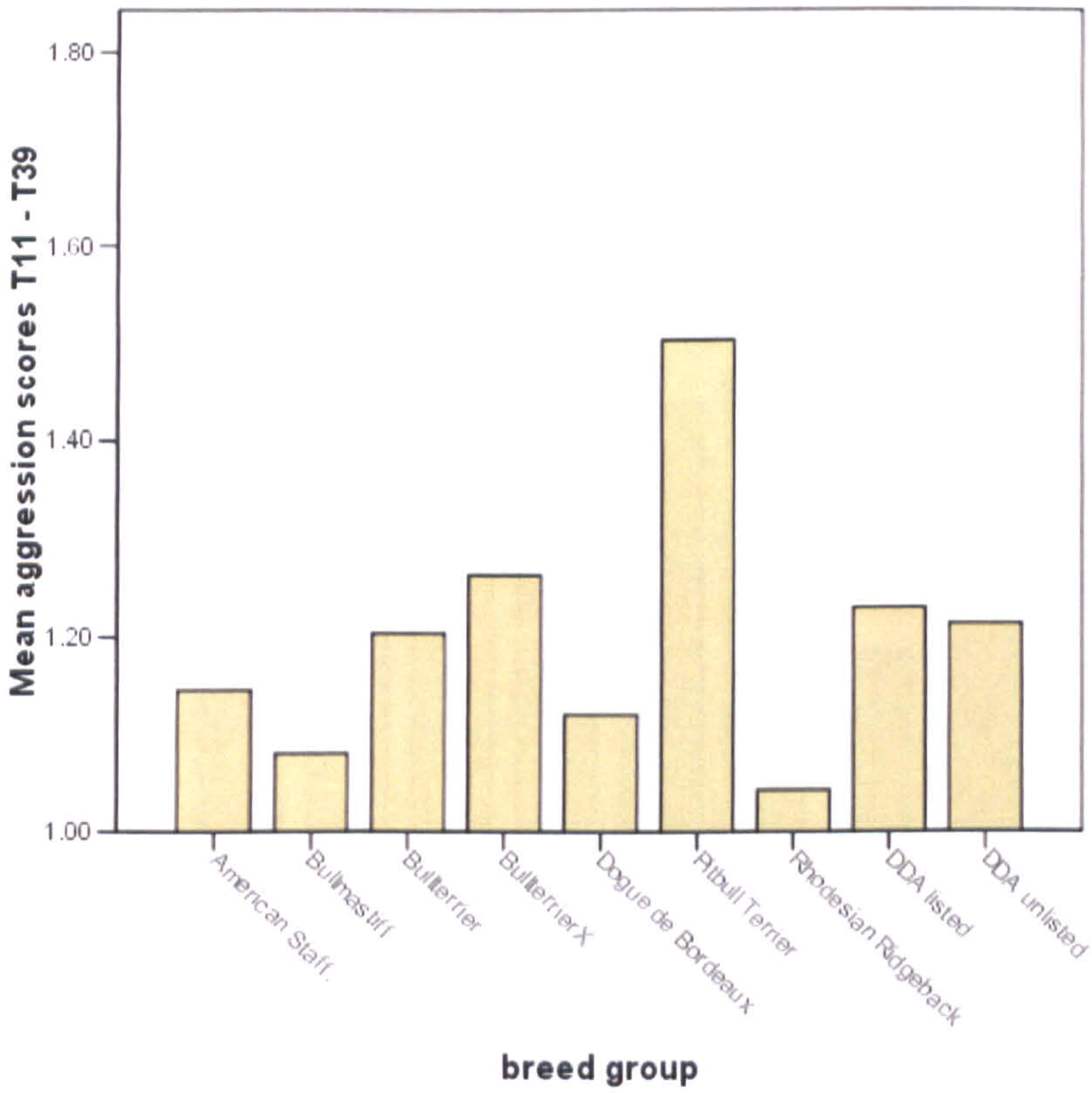



Figure 2.9) Distribution of aggression scores (Y-axis) between breed groups (X-axis) for test elements T1 - T10, conducted in the home.

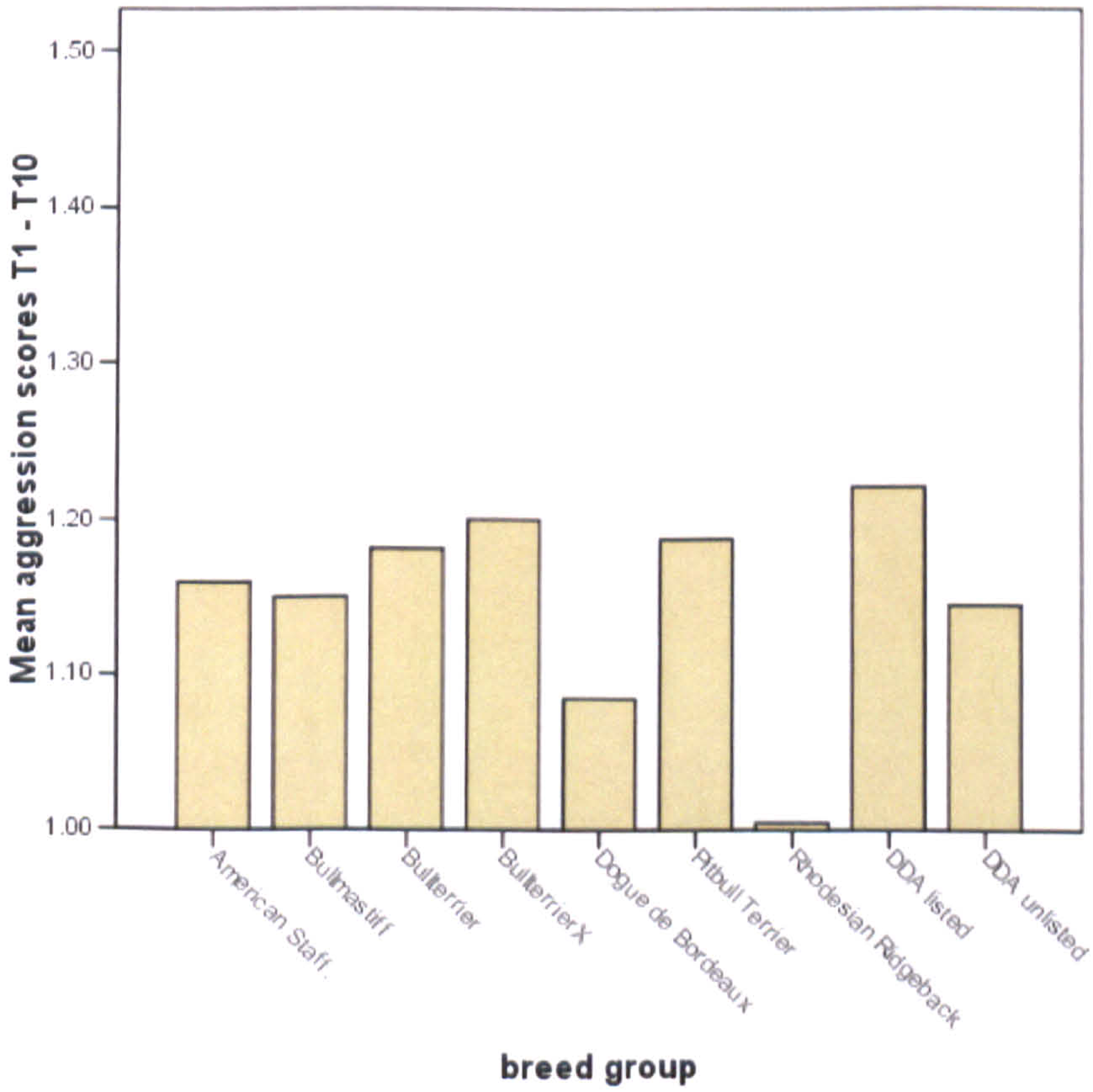
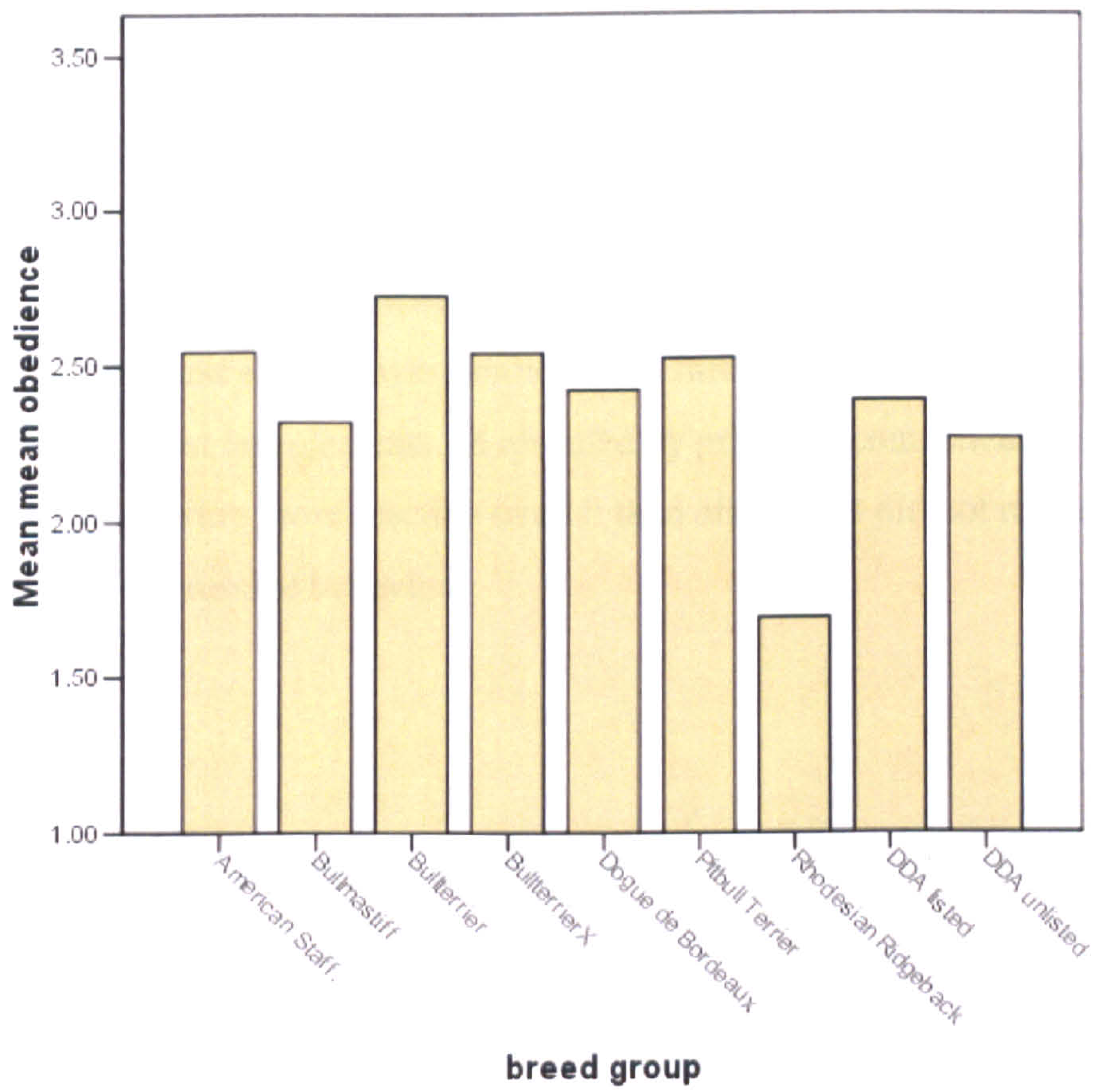


Figure 2.10) Distribution of obedience scores (Y-axis) between breed groups (X-axis)




Since sex, neuter status and age were approximately balanced between breeds/categories, these factors were not included in the following statistical analysis on aggression scores.

### 2.4.2 Aggression scores: differences between breeds/categories, and correlations with biting history, sex, neuter status and age.

The average aggression scores in the individual test elements are shown in Figures 2.11 and 2.12. Few test elements showed mean scores over 1.2, indicating that aggression was generally rare. In test element T39 (play between owner and dog) all dogs scored 1, and so this test element was omitted from further analysis. Weak positive correlations between most test elements, as revealed by principal component analysis, suggested that some dogs were more reactive overall than others, but did not reveal any interpretable types of aggressive behaviour.

Figure 2.11) Mean aggression scores for all dogs in test elements T1 - T10 performed in the home

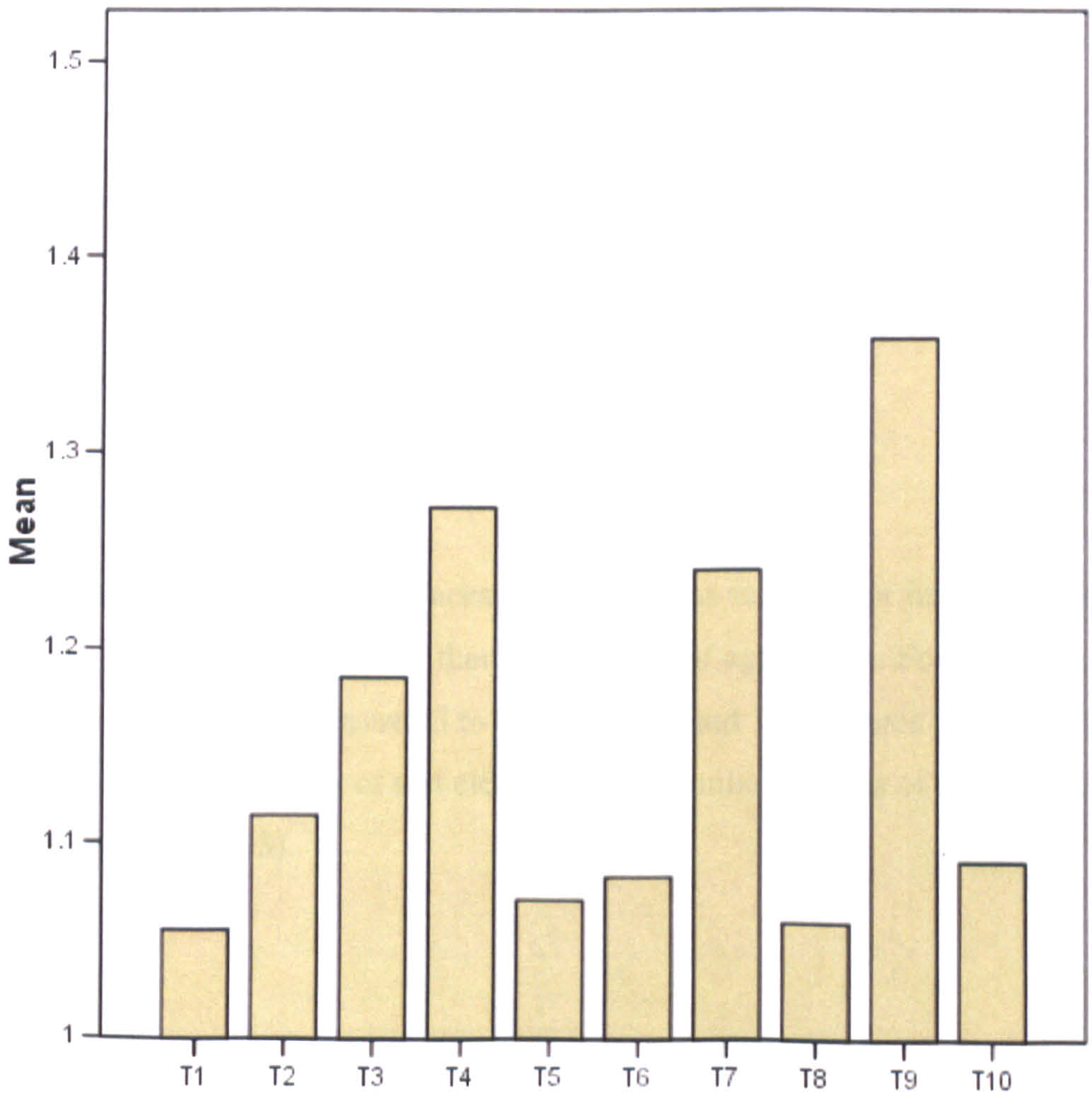
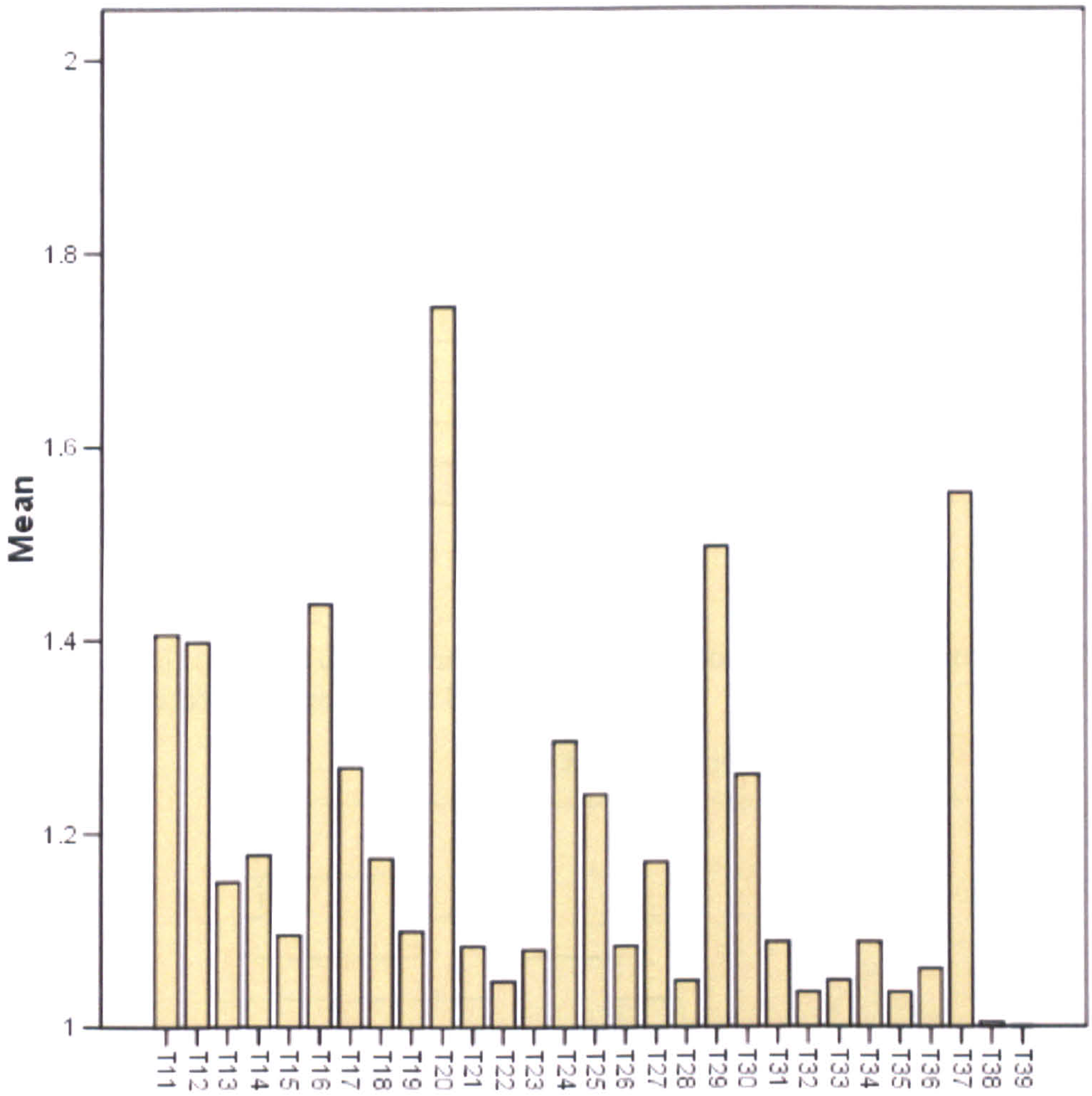


Figure 2.12) Mean aggression scores for all dogs in test elements T11 - T39 performed in the arena




Cluster analysis (binary data, Jaccard method) was selected for further analysis in order to focus on the presence rather than the absence of aggression. For this, data from test elements T1-T38 was converted to 0 (= score 1) and 1 (all scores >1). The cluster analyses revealed groups of test elements with similar patterns of scores of 2 or more (Figures 2.13 – 2.15).

Figure 2.13) Hierarchical cluster analysis (Jaccard method) for test elements T1 – T10. Dendrogram using average linkage between groups

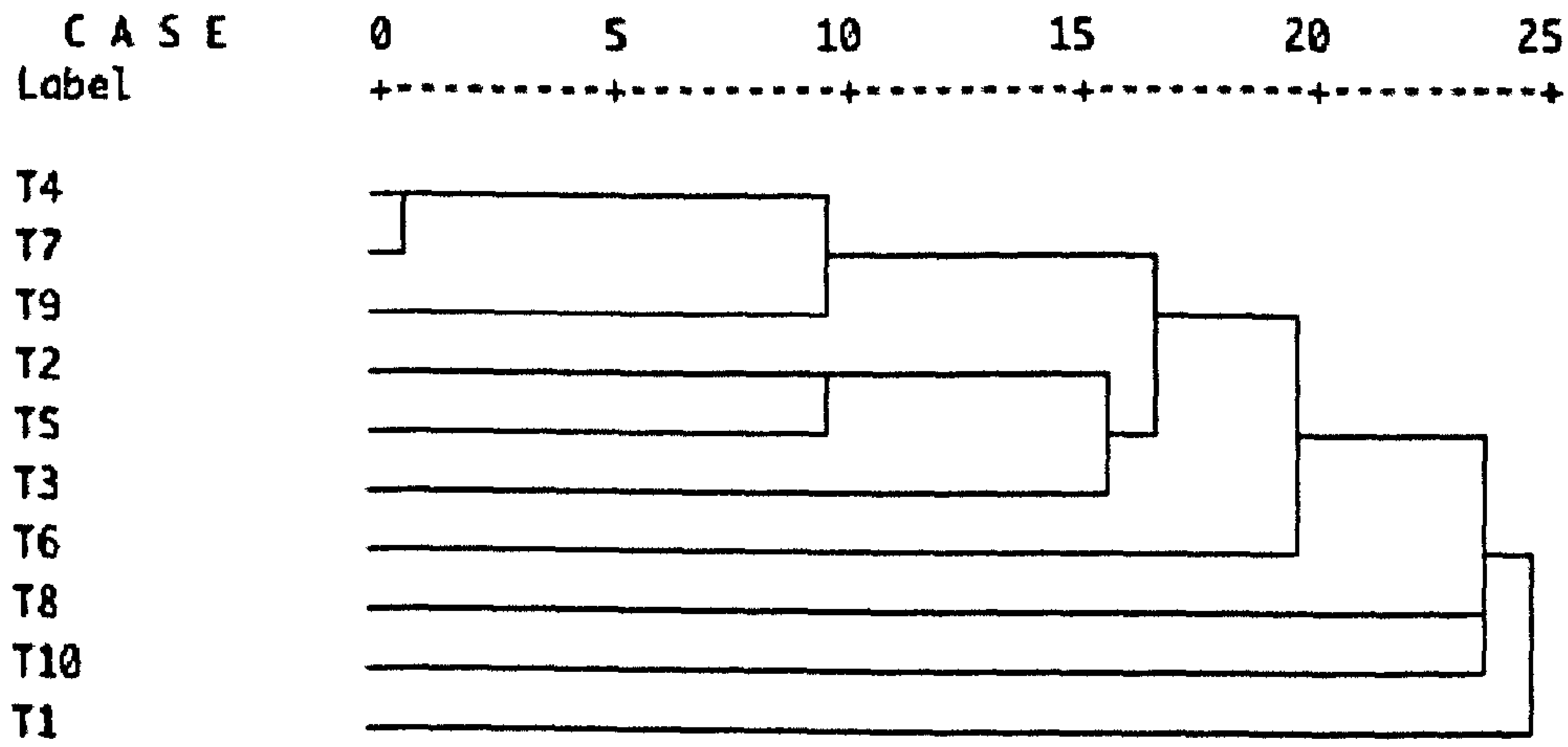



Figure 2.14) Hierarchical cluster analysis (Jaccard method) for test elements T11 – T38. Dendrogram using average linkage between groups

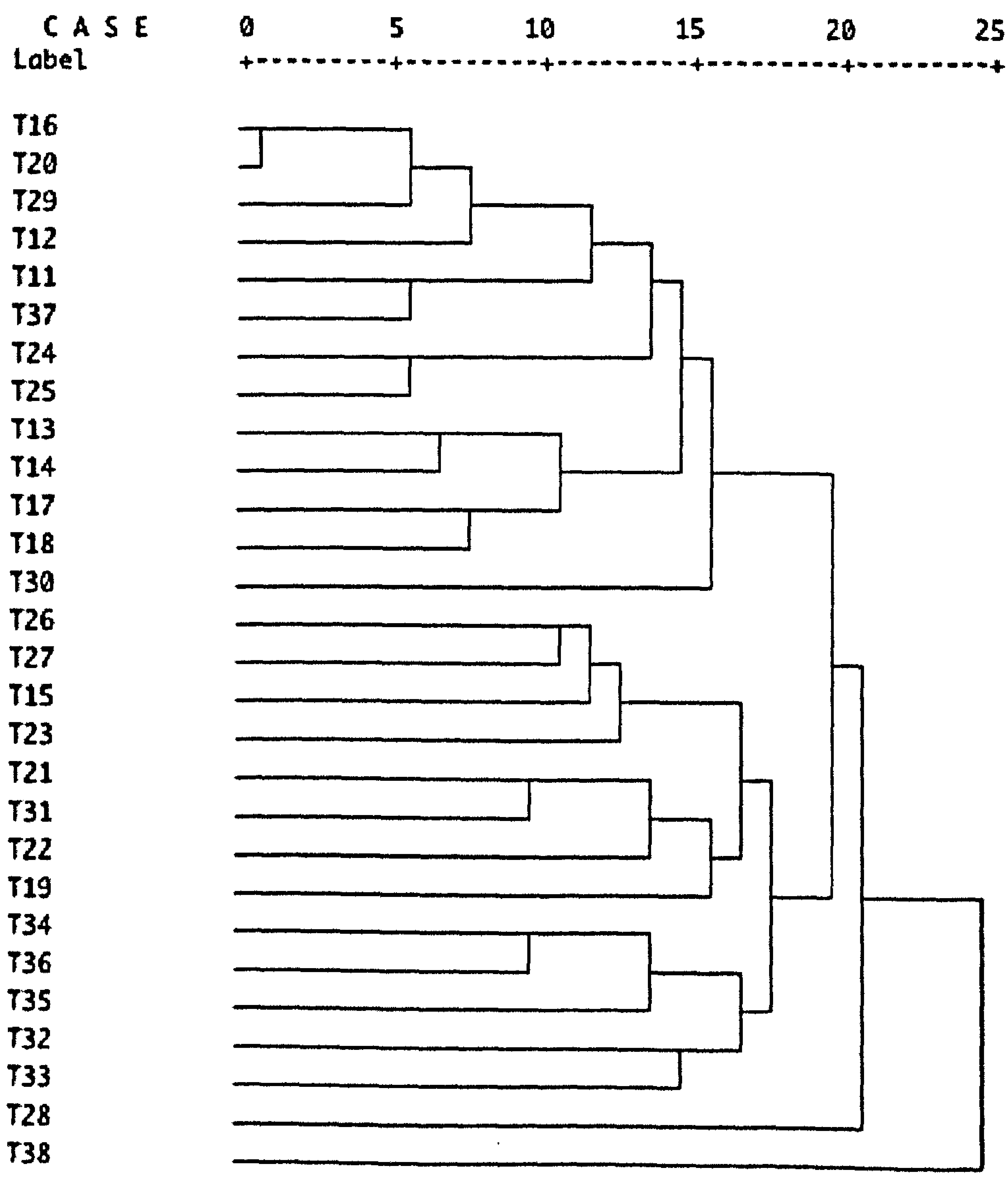
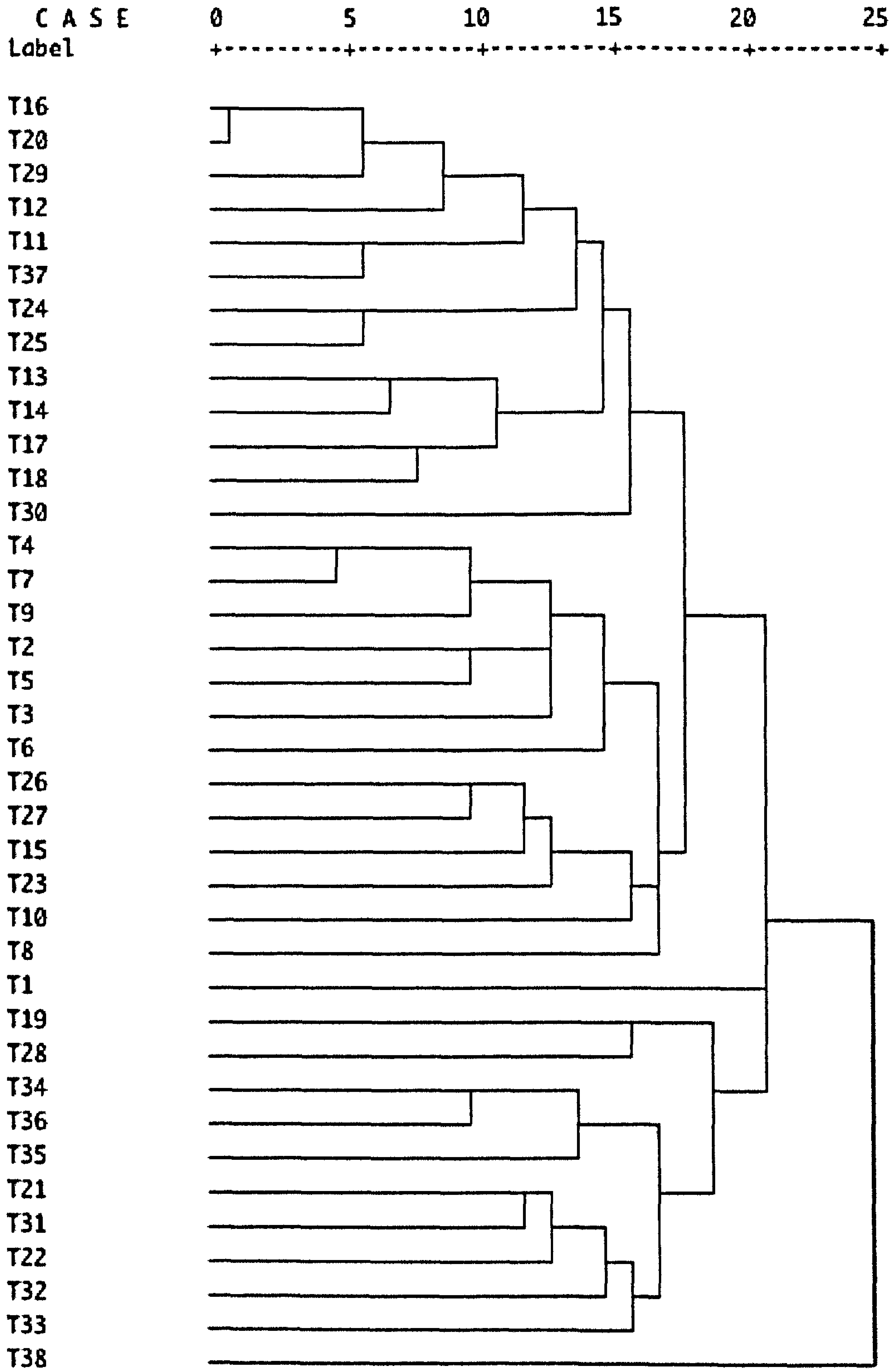


Figure 2.15) Hierarchical cluster analysis (Jaccard method) for test elements T1 – T38. Dendrogram using average linkage between groups



Test elements were grouped in the following subtest groups, based on the clusters:

Group A: "Accidental interaction". Test elements T 19 / 21 / 22 / 28 / 31 / 32 / 33 / 34 / 35 / 36, reflecting situations in which people interacted with the dog in an "everyday" way without directly starting contact with, startling or threatening the dog deliberately.

Group B: "Threat". Test elements T 12 / 16 / 20 / 29. This group consists of situations where humans deliberately threatened or attacked the dog.

Group C: "Noise". Test elements T 24 / 25. The dog is confronted with a loud noise in both.

Group D: "Dog". Test elements T 11 / 30 / 37. The dog is confronted with one or more other dogs in all three.

Group E: "Play". Test elements T 15 / 23 / 26 / 27. Situations in which the dog is approached by "friendly" people, either for contact or play, or in which a person rises from a lying position.

Group F: "Strange persons". Test elements T 13 / 14 / 17 / 18. This group comprises situations in which people somewhat startle the dog (stumble, drunkard, umbrella etc.) without intentional threats.

Group G: "Threat home". Test elements T 4 / 7 / 9. The dog is actively threatened or thwarted from reaching a treat in its own home.

Group H: "Manipulation". Test elements T 2 / 3 / 5. The dog is manipulated with hands, invited to play or commanded, all in its own home.

Group I: "Friendly people ". Test elements T 1 / 6 / 8 / 10. Friendly interaction, clicking sound presented or dog being passively thwarted from reaching a treat, all in its own home.

Test element T38 (the second test element from interaction between dog and owner) was not put into any group, and omitted from the following analysis, as scoring was almost always "1" (just one dog had scored "2").

The groupings were further substantiated by performing reliability analysis (calculating Cronbach alphas) for the elements subsumed in each group (see Appendix 2 for an example of the complete calculations of Cronbach alphas for Group B). A Cronbach alpha of =/> 0.7 is a good indicator for reliable correlation of scoring results within each group. Groups A-H, which were based upon the clusters, except for T30 which was placed in Group D because of similar test stimuli, gave acceptable values for alpha

(Table 2.5). Group I comprised elements of the test in the home where the responses are generally unrelated to one another (see Figure 2.13) and this is reflected in the low value for alpha (Table 2.6).

Table 2.5) Reliability analysis: Cronbach alphas for all subtest-groups A – I

| Subtest group | Name | Cronbach alpha |
|---|---|---|
| A | Accidental interaction | 0.7836 |
| B | Threat | 0.7584 |
| C | Noise | 0.8297 |
| D | Dog | 0.6755 |
| E | Play | 0.7265 |
| F | Strange persons | 0.7693 |
| G | Threat home | 0.5615 |
| H | Manipulation | 0.6917 |
| I | Friendly people | 0.4768 |

Correlations between the raw data (scale 1-6) for the individual test elements within each group A – I were examined by Spearman's rho..

Group A: correlations were between rho=0.225 ($p<0.001$) and rho=0.181 ($p=0.004$); except that test elements T22 and T28 were not significantly correlated with each other (rho=0.086, $p=0.172$); also not significantly correlated were test elements T21 and T35 (rho=0.096, $p=0.126$).

Subtest group B: all rho>0.304 ($p<0.001$)

Subtest group C: all rho>0.604 ($p<0.001$)

Subtest group D: all rho>0.292 ($p<0.001$)

Subtest group E: all rho>0.415 ($p<0.001$)

Subtest group F: all rho>0.312 ($p<0.001$)

Subtest group G: all rho>0.388 ($p<0.001$)

Subtest group H: all rho>0.418 ($p<0.001$)

Subtest group I: correlations ranged from rho=0.256 ($p<0.001$) to rho=0.144 ($p=0.022$) with test element T1 and T10 being the ones most weakly correlated.

Despite the two non-significant correlations these groups were kept, based on their face validity and the Cronbach alphas. Test element 30 was kept in group D based upon face validity, Cronbach alpha and Spearman rho, though the clusters indicated that element 30 could also go with group B or F. Element 30 was certainly different to 11 and 37 as the owner was not present, which will be further discussed later. Test element 5 was kept in group H though cluster analysis would have allowed an assignment into group G, but then the Cronbach alpha for group G would have gone down to 0.547. Test element 6 was kept in group I; an assignment to group H would not have changed the Cronbach alpha here but would have left the remaining elements in group I with an alpha of just 0.344.

The scoring within each group was tested for normal distribution. As this was not the case in any group and log transformation for group means did not normalise the data either, further analysis was done with nonparametric tests. The obedience scores showed a normal distribution, but when comparing the obedience scores by age group, breed group or sex group with the data from the nine "aggression-groups", statistical analysis was done non-parametrically as well, to ensure consistency.

The obedience scores were significantly correlated with Group B (threats) (rho=0.139, p=.027) Group C (noise) (rho=0.152, p=.015), Group D (dog) (rho=0.201, p=.001), Group E (play) (rho=0.151, p=.016), and Group F (strange persons) (rho=0.166, p=.008). When the eight Pitbull Terriers were left out, since they showed the highest aggression scores and worst obedience scores in the breed comparison (see below), these correlations did not change much: B rho=0.127, p=.046; C rho=0.130, p=.041; D rho=0.185, p=.004; E rho=0.132, p=.038; F rho=0.173, p=.007. In all cases, the higher (i.e. worse) the obedience score, the higher the aggression score. However, in all instances the correlations are comparatively weak (less than 5% of variation explained), so disobedience alone would not be a reliable predictor of any type of aggression.

The age of the dog had no significant association with the scoring in any of groups A-I or the obedience score (Spearman's rho correlation coefficientsp=0.052) and rho= -0.005 (p=0.940).

Substantial differences between breeds were evident in most types of aggression (Figures 2.16 – 2.18) and in obedience (Figure 2.19)

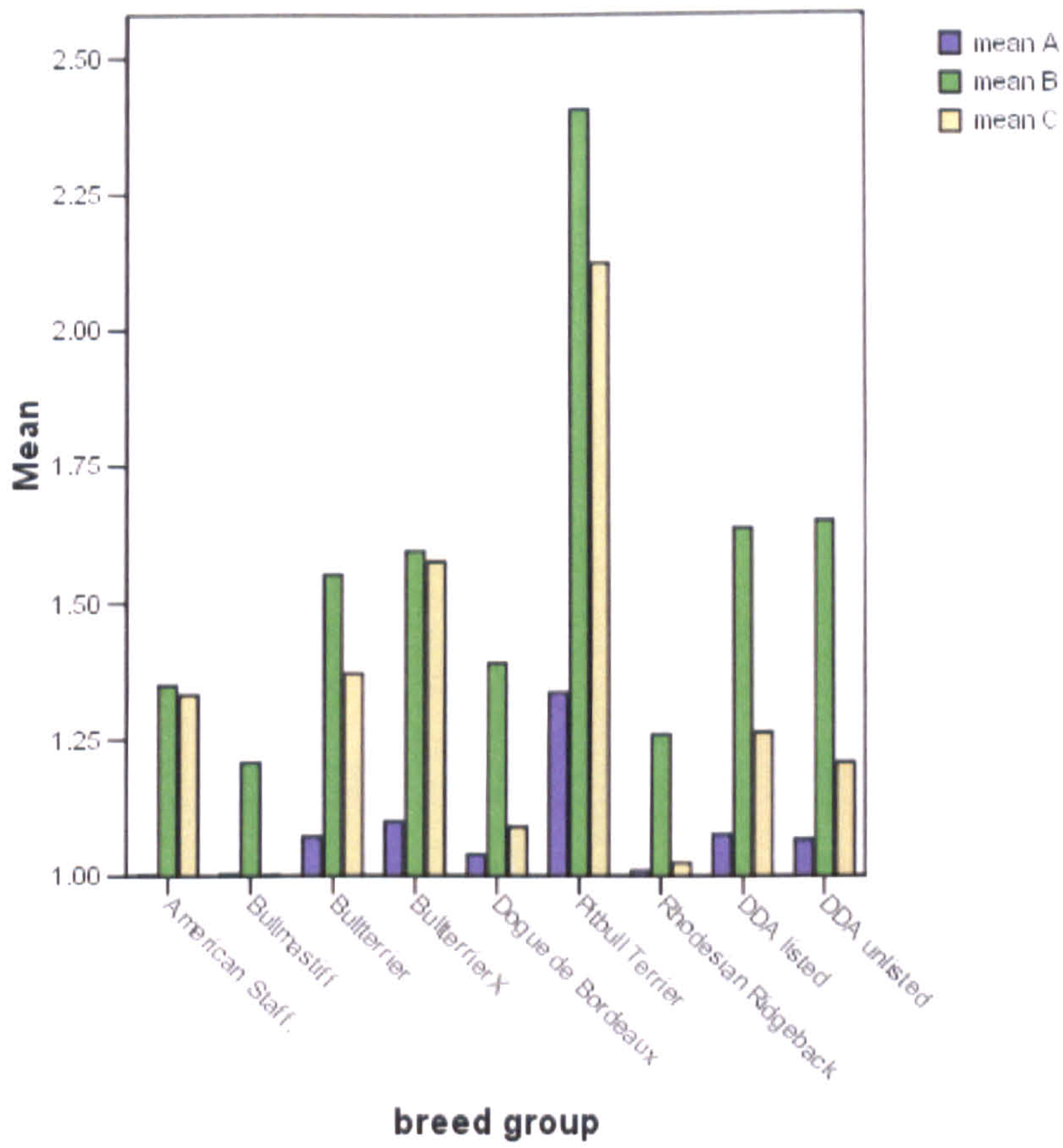



Figure 2.16) Mean scoring in subtest-groups A - accidental interaction (mean A), B – threats (mean B), C - noise (mean C) for each breed group

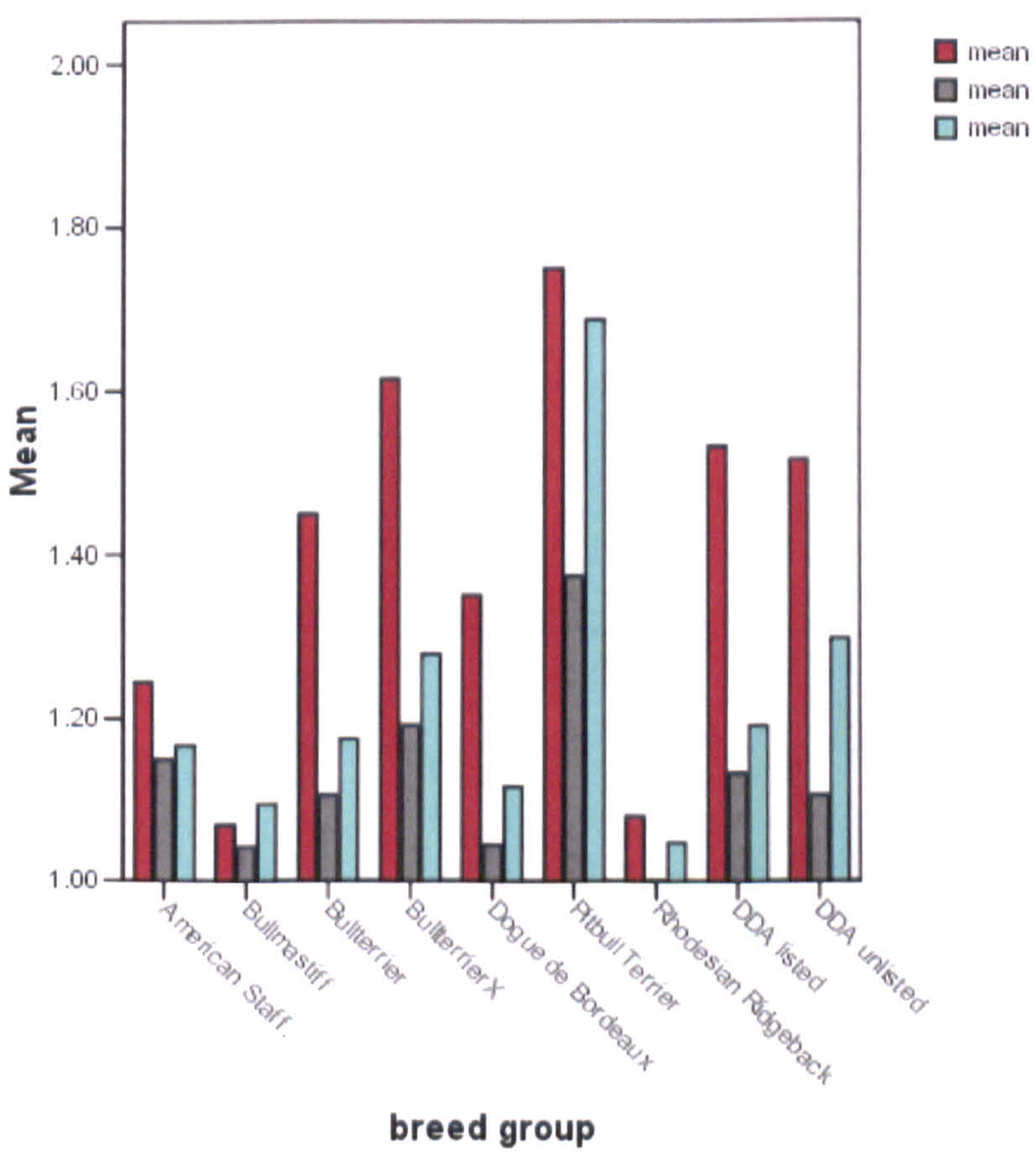



Figure 2.17) Mean scoring in subtest-groups D – dogs (mean D), E – play (mean E), F – strange persons (mean F) for each breed group

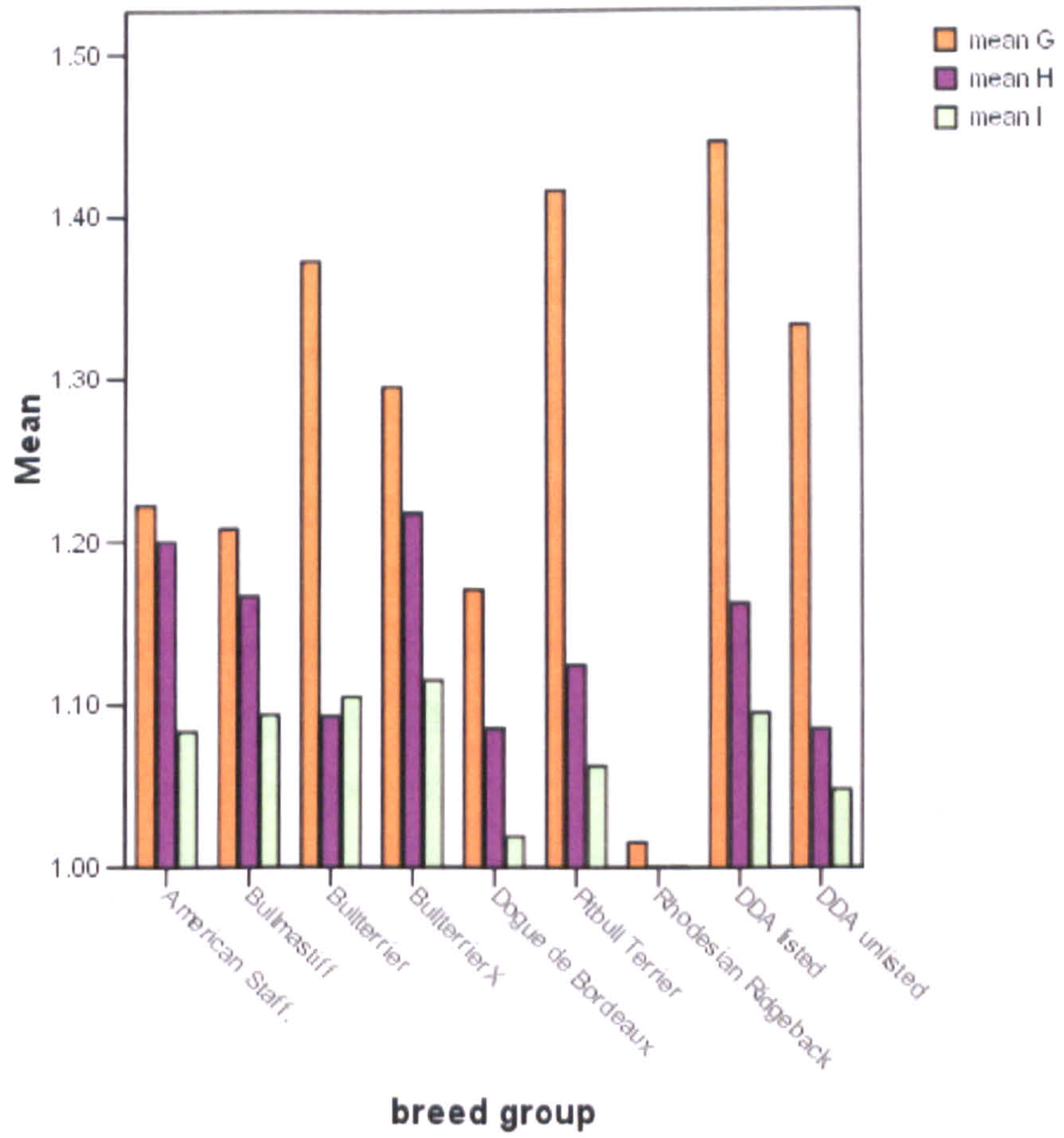



Figure 2.18) Mean scoring in subtest-groups G – threat home (mean G), H – manipulation (mean H), I – friendly people (mean I) for each

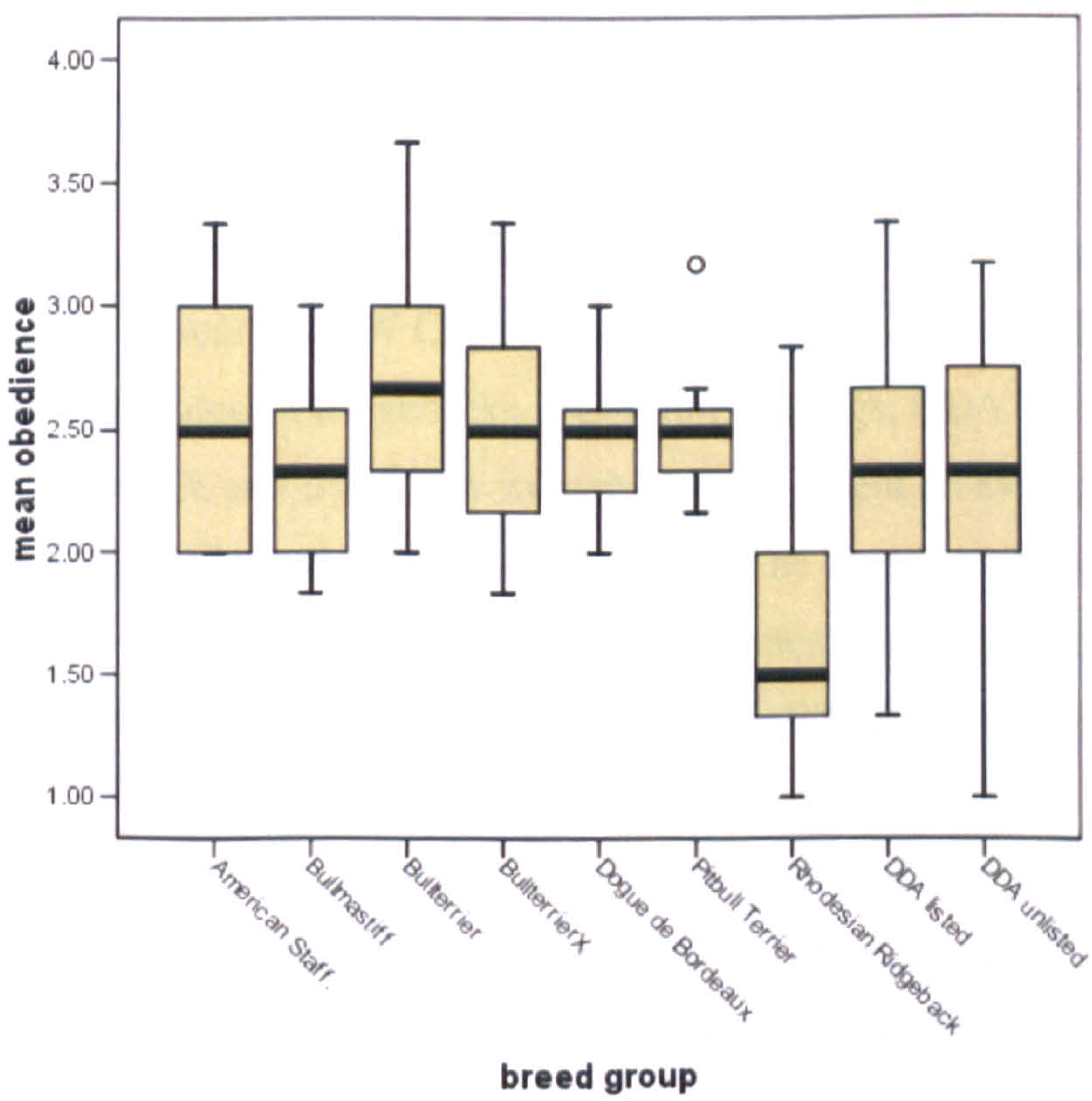



Figure 2.19: Box-plots of the (dis)obedience scores per breed group. Heavy lines indicate medians, the box extends from the 25th to the 75th percentiles, and the horizontal lines indicate minimum and maximum values, except for values more than three interquartile ranges from the nearest quartile, which are shown as individual

Although the scales were not normally distributed, mean scores were used rather than medians, as the medians were all 1 (except for group B and obedience). The mean aggression scores in all but two Groups differed significantly between breeds: Group A (accidental interaction)(K-W $Chi^2=15.7$, df=8, $P<0.05$), B (threat)( K-W $Chi^2=29.3$, df=8, $P<0.001$), C (noise) (K-W $Chi^2=34.7$, df=8, $p<0.001$), D (dog) (K-W $Chi^2=28.7$, df=8, $p<0.001$), E (play) (K-W $Chi^2=22.0$, df=8, $p=0.005$), F (strange persons) (K-W $Chi^2= 19.3$, df=8, $p=0.013$), H (manipulation) (K-W $Chi^2=16.5$, df=8, $p<0.05$) and for obedience (K-W $Chi^2 =56.0$, df=8, $p<0.001$). Further K-W tests were performed on these Groups, omitting the highest-scoring breeds, to determine which were the most aggressive, until P-values of >0.05 were obtained, i.e. all remaining breeds were similarly non-aggressive. The breeds with the highest mean score for each of these groups were (in rank order):

Subtest group A (accidental interaction): Pitbull Terrier.
Subtest group B (threats): Pitbull Terrier, DDA unlisted, DDA listed, Bullterrier X.
Subtest group C (noise): Pitbull Terrier, Bullterrier X, American Staffordshire Terrier, Bullterrier, DDA unlisted.
Subtest group D (dog): Pitbull Terrier, Bullterrier X, DDA unlisted, DDA listed.
Subtest group E (play): Pitbull Terrier.
Subtest group F (strange persons): Pitbull Terrier.
Subtest group H (manipulation): American Staffordshire Terrier.

There was a highly significant difference between the breed groups when looking at the obedience scores (K-W $Chi^2=56.0$, df=8, $p<0.001$. Scores under 2 were most prevalent for the Rhodesian Ridgebacks, DDA unlisted dogs, DDA listed dogs. Pitbull Terrier, Bullterrier X and Bullterrier were the least obedient on average, having the highest proportion of obedience scores above 2.5. The overall ranking for obedience was : Bullterrier, Pitbull Terrier, Bullterrier X, American Staffordshire Terrier, Dogue de Bordeaux, DDA listed, Bullmastiff, DDA unlisted, Rhodesian Ridgeback.

When the four sex/neuter status groups were examined for differences in aggression scores, the only significant difference was in subtest group D (dogs) (K-W $Chi^2=25.8$, df=8, $P<0.001$), with males (intact and neutered) producing higher aggression scores than the females.

Biting history:

Dogs that had bitten a family member scored significantly higher in subtest-Groups G (threats in the home)(K-W $Chi^2=9.49$, df=1, $p<0.01$), A (accidental interaction)(K-W $Chi^2=8.29$, df=1, p=0.004), B (threats) (K-W $Chi^2=13.6$, df=1, $p<0.001$), D (dogs)(K-W $Chi^2=6.51$, df=1, p=0.011), E (play) (K-W $Chi^2=25.5$, df=1, $p<0.001$), F (strange persons) (K-W $Chi^2=7.53$, df=1, p=0.006).

Dogs that had bitten a stranger scored statistically significantly higher in subtest-group G (threats in the home) (K-W $Chi^2=7.75$, df=1, $p<0.005$), H (manipulation in the home) (K-W $Chi^2=4.35$, df=1, p=0.037), I (friendly people in the home) (K-W $Chi^2=10.2$, df=1, p=0.001), A (accidental interaction) (K-W $Chi^2=6.69$, df=1, p=0.010), B (threats) (K-W $Chi^2=6.36$, df=1, p=0.012), C (noise) (K-W $Chi^2=10.2$, df=1, p=0.001), E (play) (K-W $Chi^2=14.3$, df=1, $p<0.001$), F (strange persons) (K-W $Chi^2=5.42$, df=1, p=0.020)
Dogs that had bitten another dog scored statistically significant higher in subtest-group B (threats) (K-W $Chi^2=5.88$, df=1, p=0.015), C (noise) (K-W $Chi^2=4.41$, df=1, p=0.036), D (dogs) (K-W $Chi^2=12.2$, df=1, $p<0.001$).
Dogs that had been bitten did not score statistically significantly higher or lower in any subtest-group. No significant association was found between the obedience level and any aspect of the biting history.

It was examined whether aggression scores in the different subtests could function as reliable predictors for biting (allowing the test to be used prospectively) by performing logistic binary regression. Scores of two or higher in subtest group D (dogs) were significantly predictive of a history of biting dogs (p=.010; optimum cut off at the 26$^{th}$ percentile), producing 61.4 % correct positives. To examine bites directed at humans, dogs with a history of biting family members and strangers were pooled to increase the sample size. Here the scores in groups B (threats) and E (play) were significantly predictive of biting history (cut off at the 10$^{th}$ percentile; B: p=.033; E: $p<.001$; mean scores B+E: $p<.001$). The percentage of correct positives lay between 82.7 % for the mean scores of group B+E and 89.0 % when only group E was considered.

## 2.5 Discussion

The aim of this study was to validate a test of aggressive and unacceptable social behaviour, which might predict aggressive behaviour later in the dog's life. Two specific hypotheses should be addressed here: can so-called temperament tests predict aggression later in a dog's life, and, are dog breeds different from one another in their aggressiveness due to their different genetic make up? A non-random sample of 254 dogs from different breeds, with certain "dangerous" breeds over-represented, was tested. From their responses, six distinct sets of releasers for aggression were identified in the formal test (Groups A-F), and a further three in a supplementary test conducted in-home (Groups G-I). Factors such as breed, age, sex, biting history or previous training, were examined for their influence on quality and quantity of the behaviour shown in the individual subtest groups.

Due to the data being not normally distributed only non-parametrical statistics were used, despite their being less powerful and not being directly open for post-hoc comparisons to prevent an increased risk of Type 1 errors. This risk was especially high for the factor "breed" as it underwent multiple testing. Though a 5% threshold for significance was maintained, in the discussion it was differentiated between highly significant results (</=.005) and weak effects (i.e. <0.05).

### 2.5.1 Test protocol and dogs

No internationally standardised protocol has been established so far for testing dogs for aggressiveness. The formal test used here was based mainly on the protocol for the only "standardised test for dangerous dogs" in Germany so far (NMELF, 2000), designed to be used by a larger group of testers. Slight alterations were made to allow the dogs to be tested in advance in their own home; the formal test was carried out on the subsequent day in an area unknown to the dog. All the published "aggression-tests" (Wilsson & Sundgren, 1997; Netto & Planta, 1997; NMELF, 2000, Van den Berg et al., 2003) comprise situations in which the dog is threatened, thwarted or startled to different intensities by different stimuli. Stimuli range from elements that are likely to be experienced by any dog in most human environments, up to stimuli/situations that consist of intentional and more or less direct threats or have a startling character. Thus the subset of test elements used here resembles analogous situations to those mentioned in the literature.

Netto & Planta (1997) stated that to be useful an aggression-test should be performed by trained testers and judges. No formal research into that topic, e.g. having many different testers/judges looking at the same dog and testing inter-observer reliability, has been reported so far. In this investigation, the test procedure (e.g. location etc.) including the behaviour of the human testers was kept as identical as possible throughout. This was possible as the assistants in the test rarely changed, and the main person in charge of the test was always the same. Nevertheless one hundred percent uniformity can never be achieved in such an open biological system, though Van der Staay & Steckler (2002) highlight this as extremely important when looking at such a complex phenomenon as aggression. The data here was not examined for any effect of change in assistants, as this would have led to over-analysis of the data. For the same reason, no environmental factors were examined, including the owners' individual behaviour, such as their use of the leash to correct the dog's behaviour (see Bruns 2003).

The number of dogs used here was small compared to other evaluations (Wilsson & Sundgren, 1997; Svartberg & Forkman, 2002), in which samples of 1,500 to over 10,000 dogs of different breeds were reached. Errors inherent in such high numbers have been described already, e.g. the test procedures, including environmental context, cannot easily be standardized. The numbers of dogs tested here were comparable with the numbers in other investigations of aggression tests like those of Netto & Planta (1997) or Bruns (2003). Bruns, Mittmann (2002) and Böttjer (2003) only investigated breeds that were listed in the Lower Saxon DDA and compared test results between these breeds. Netto & Planta listed the breeds their dogs belonged to (appr. 80 % DDA listed breeds) but did not discuss breed specific results in the test.

The main goal was to validate the complete test in respect of its potential to forecast aggression, and common factors that influence the display of aggression, other than the individual dog's temperament (i.e. age, breed, sex).

Consequently, breed-specific results in this thesis can only be compared in a limited way with other studies. Hence, they will mainly be compared with each other and not related to the breed's distribution in Germany in general. It cannot be estimated whether the number of biting incidents per dog/breed reported here, reflect the numbers or proportions for the general dog population in Germany. A distorted picture has to be assumed, first as about 20% of the dogs were tested in the course of legal proceedings due to biting; and second, from the dogs that had to be investigated due to DDA regulations, some owners might have lied in answering the questions on their dog's biting history (see Mittmann, 2002; Bruns, 2003). For example German Shepherds represent 10.5% and 13.4% of the dog population in the states Berlin and Brandenburg and 21.1% and 36.0% of the registered "biters" for the years 2000-2003. Rottweilers come to 3.4% / 4.0% of the population and 8.6% / 8.35% of all "biters"; all categorised "dangerous dogs" make up 6.5% / 2.4 % of the population and up to 7% / 2.6% of the biters (Kuhne & Struwe, 2005).

Numbers of dogs per breed group were not identical here. Apart from the Pitbull Terrier and the American Staffordshire Terrier every group consisted of more than 20 individuals, but two groups (Bullterrier and DDA listed dogs) comprised more than twice as many dogs as some other groups. The DDA listed and unlisted groups were a conglomerate of different breeds, and the DDA unlisted group was particularly heterogeneous, containing breeds from many different working- and FCI-standard backgrounds. Despite the low numbers, Pitbull Terriers and American Staffordshire Terriers were kept as separate groups, as they also form separate groups in the cited papers on the Lower Saxon DDA (Mittmann, 2002; Bruns, 2003; Böttjer, 2003), thus allowing comparisons. The distribution of age, sex and neuter status in between the different breed groups was similar, allowing analysis of these factors independent of breed.

### 2.5.2 Age and gender as an influencing factor

Males were more prone than females to be bitten by other dogs and to bite other dogs. This has been described in the literature already (Borchelt, 1983; Wright & Nesselrote, 1987; O'Farrell & Peachey, 1990, Sherman et al., 1996; Roll & Unshelm, 1997). The apparent over-representation of neutered males in the biting group compared to entire may be due to the biting incident being followed by neutering in an attempt to prevent recurrence. It can be assumed that many of the biting dogs got bitten during the same encounters.

Sex and neuter status; together or separately, had no significant influence on the biting history concerning humans (family, stranger or any human). Here Guy et al. (2001a, 2001b) found male dogs over represented for biting directed at humans, but that small neutered females were the majority in biting family members. As was already discussed by Guy et al. their caseload of dogs was sampled in ordinary veterinary practice, whereas Takeuchi et al. (2001), looking at a caseload from a behavioural clinic, found males again over represented when biting within the family. So the reason for these disparities might lie in the fact that owners with a larger breed and/or male dog might more easily seek help with biting problems from behaviour counsellors than asking their general-practice vet. Horisberger (2002), looking at a much larger sample of 646 dogs that had bitten humans in Switzerland, again found male dogs biting humans significantly more often than females.

The dog's age, though stated as relevant by others (Horisberger, 2002; Ruefenacht et al., 2002) did not have any significant association with the dog's behaviour here. Boenigk & Distl (2004), looking for the heritability of certain traits in the breed Hovavart, found no significant difference between temperament test results, when performed after the age of 12 months and again after 20 months. But differences could be seen for some elements between tests performed before and after 12 months of age. These differences concerning the influence of age might be due to different goals of the performed tests. Few owners are likely to have explicitly trained their dogs to pass the aggression tests in Germany (Mittmann, 2002). In contrast, dogs are often trained specifically for the working dog tests described by Wilsson & Sundgren (1997), Ruefenacht et al. (2002), Svartberg & Forkman (2002) or Boenigk & Distl (2004). Thus something labelled an "age-effect" might simply be due to the amount of time available to be invested in special training. Svartberg & Forkman (2002) also observed that dogs with more experienced trainers/handlers performed better in the test. Supporting this idea, Osthaus et al. (2004) were able to show that training influences problem-solving abilities in dogs, as the dogs "learned to learn".

### 2.5.3 Subtest groups and their predictive validity: might so-called temperament tests predict aggression later in a dog's life?

There was a difference between the test elements performed in the dog's home and the test elements performed outside, with the latter eliciting higher mean aggression scores in general. A possible reason could be that interaction between tester and dog in the home, though resembling thwarting and threatening situations, included more communication, thus leaving the dog more possibilities for de-escalation and submissive behaviour. Another reason might be that dogs are more easily stressed in unknown areas and/or when confronted with more than one unknown person or dog (see Archer, 1976; section 1.3.1.5).

Based on the responses of the individual dogs, it was possible to group certain test elements together to form subtests. In most of the cases the test elements in a group shared common stimuli ("releasers"). For example, group A (accidental interaction) comprises situations where people interact with the dog in an "everyday" way (i.e. passing by) without directly starting contact with, startling or threatening the dog deliberately, whereas group B (threats) consists of situations where humans deliberately threaten or attack the dog. Two pairs of test elements in group A were not significantly correlated to each other, even though the Cronbach alphas were high. These were "group of four persons walking up to dog" vs. "broom swept against dog", and "group of four persons circling dog" vs. "pram driven past dog". Possible reasons for those test elements not being significantly correlated could be, that firstly the group had little aggression-eliciting value anyway and secondly, distraction or learning might have influenced the results, as all non-correlated test elements were not consecutive but had

other test elements interposed. In all other groups grouping of test elements proved valid following statistical analysis and checking for face validity.
Test element 30 was assigned to group D (dogs) emphasising face validity. Following cluster analysis it could equally have been assigned to group B, C or F also. It shared the common feature of the owner's absence with element 29 in group B, indicating that a reaction in element 30 may results from a dog's general tolerance towards stress and especially threats. Also, this test element could be significant (together with 29) in detecting any actual owner influence on the dog's behaviour; however, this would need clarification with a much larger sample size.

One primary purpose of the test was to identify dogs which posed a risk of aggression. The amount of aggression elicited varied considerably from one test element to another. As group B (threats) comprised test elements where the dogs were deliberately threatened or attacked, it was not surprising to find the highest mean aggression scores in this group, followed by groups D (dog), G (threats at home), C (noise) and F (strange persons). These groups are generally supported by the findings of Mittmann (2002), concerning which situations are most likely to elicit aggressive behaviour in dogs: i.e. any fast/abrupt human movement, threats and challenges (status provoking behaviour by the owner/another human). Van den Berg et al. (2003) list test elements comprising threats by humans or confrontation with other dogs (conflict upon resources as food bowl) as giving the highest likelihood of eliciting aggressive behaviour. The same applies for the situations eliciting most aggressive behaviour, as stated by Netto & Planta (1997).

Van den Berg et al. (2003) noticed no aggressive behaviour at all in play situations between owner and dog. None of the 254 dogs investigated here showed aggressive behaviour in test element T39 (play between dog and owner) and just two in test element T38 (owner showing status related gestures towards the dog). Bruns (2003) noted no scores above "one" in response to status related gestures presented by the owner. Since the primary objective of the test is to look for any aggressive behaviour, it seems justified to leave out the test elements with the owner interacting, because they appear to be uninformative. However, these tests may be useful for other purposes – this will be discussed in the next two chapters. The test used here was certainly able to elicit aggressive behaviour in dogs and as such can be used as one tool among others to look for an individual dog's tendencies to show aggression (see also Mittmann, 2002).

The question remains whether such a high number of test elements is necessary, or whether the test can be shortened. Logically, emphasis could just be placed on groups with a high occurrence of aggressive behaviour, i.e. groups B, D, G, C and F, and those linked to biting history (E). Netto & Planta (1997) state, that a higher number of test elements is useful, to make it difficult for owners to train their dogs to pass the test; and furthermore the longer the test, the higher the probability that some aggression will be detected. However, they also warn that a longer test can have welfare implications for the dog, as it is a stressful situation overall, and there may even be a risk that some dogs might "learn aggression" from the test (Hart, 1976). In particular, the dog-dog situations seem prone to that risk as they are the most difficult to standardise.
Planta (2001) described a shorter test (16 test elements), consisting of human threats, confrontation with other dogs and different acoustic and visual stimuli. She stated that her test was able to elicit aggression and detect aggressive propensities in dogs, validated by looking at the biting history.
Van den Berg et al. (2003) said the same about their test consisting of 22 test elements, when the test results were compared to the biting history of the dogs. They said that questionnaires on aggressive background should explicitly ask about any biting history, because including dogs with just a history of aggressive communication (growling etc.) would give a distorted validation. The question of welfare and learnt aggression will further be addressed in subsequent chapters. The question of validation will be addressed now, relating aggression scores to the biting history of the dogs.

Scores in groups A (accidental interaction), B (threat), E (play), F (strange person) and G (threats home) correlated significantly with a history of biting in the family and of biting strangers. Taken together, these test elements mimic situations where people might intentionally or unintentionally threaten a dog, thwart it, startle it or show status related behaviour towards the dog. In all groups apart from group B there was no significant correlation between the aggression scores and the probability that the dog had been bitten or had bitten another dog. Dogs acting aggressively in group B had also bitten other dogs disproportionately. This could imply that the test elements in group B give a general picture of a dog's tolerance towards stress and especially threats.
Dogs that had bitten another dog scored high in group D (dogs), but also dogs that had

bitten an unfamiliar person scored high in this group. In group C (noise) biting in the family was not correlated with the aggression scores, but biting strangers was; this could imply that strangers run a higher chance than the family does to be bitten when the dog is unexpectedly startled. Sudden loud noises apparently had no link with dogs biting other dogs or getting bitten. Aggressive behaviour in group G (threats in the home) was highly correlated, in contrast to group C, with biting within the family and being bitten by other dogs. Group H (manipulation) in the end did not correlate with any biting history, nor did the obedience scores. The finding for group H agrees with the observation that play between dog and owner did not elicit any aggressive behaviour, not even threats.

It can be summarised that dogs that had bitten a family member, scored significantly high in all groups apart from H, I and C. Dogs that had bitten a stranger scored higher than others in all groups except group D. A history of biting other dogs correlated highly significantly with the mean aggression scores in group B, C and D (dogs). Dogs that had been bitten were no different to dogs which had not, in mean aggression scores for any group. Being a victim of a biting attack therefore seems to be dependent on the temperament of the biter and not that of the dog bitten, at least as measured by this test.

From this picture it can be deduced that groups B to G are the important ones when it comes to interpreting the results of aggression tests. Group H and I, done at the dog's home, and group A, comprising 10 test elements covering different aspects of "everyday" dog-human-interaction, seem to be not that useful. Reliability analysis further narrowed the important subtest groups down to group D as a prospective means for biting other dogs and B and E as the one for biting humans. Altogether it can be concluded from these results that a dog scoring higher than two in group D bears a certain risk to bite a dog later in its life, and a dog scoring higher than two in group B and E bears a certain risk to bite humans later in its life. But as already said above, the results do reflect a dog's general tolerance towards stress and especially threats to a certain extent, and might not exclusively be correlated to reactions elicited by actual contact with other dogs or humans.

It thus appears, in concordance with Planta (2001) and Van den Berg et al. (2003), that it is not necessary to have as many as 39 test elements in an aggression test. But whether there should be 22 or 16 test elements, and which elements within each group might be omitted, cannot be stated from the results presented here. Further evaluation, with a larger number of dogs and better known biting history, would be necessary to verify these trends further.

As the stimuli presented in the different test elements in this investigation were designed to inflict mild stress of various kinds, training may also be a factor in the aggression test as well, though it can be assumed that fewer dogs had been intentionally trained to pass the test than for the working tests. Thus the interaction between obedience and the aggression scores was also examined (see below). There was a marginally significant positive correlation between high obedience scores (i.e. disobedience) and high mean aggressive scores in groups B to F. For the subtests performed in the dog's home the obedience level was not significantly correlated with aggression. Bruns (2003) stated also, that dogs with poor obedience scored over proportionally high for aggressive behaviour; her statement has to be carefully interpreted as she only looked at obedience level in three breeds and she did not comment on breed differences for obedience.

In answering hypothesis 2a it can be stated that temperament tests, especially when they look at when and how a dog shows aggressive behaviour, can be a useful tool; but they should neither be the only tool nor be used as single prospective means for characterising a dog, as the validation was done using previous biting episodes, which have no ultimate predictive value for future aggressive outbursts. The test used here can elicit aggressive behaviour in dogs. Looking at the biting history of the 254 dogs, it can be said that the test is valid in detecting a certain amount of risk any dog presents, and to qualify it in terms of which stimuli released the aggression. But it has to be kept in mind, that an individual situation or conglomerate of stressors that triggered aggressive behaviour in any individual dog in a test, might never happen in real life. Thus emphasis always has to be put on the whole picture, including emotions and tolerance levels of the dog, as aggression is a multi factorial event. So far, aggression tests are useful when they are put in the context of an existing agonistic incident. They are also useful as a prospective means of deciding which dog to breed from and which one not to breed from at all. But they are not adequate to be used as the only tool to decide which dog has to be muzzled or has to be euthanised.

### 2.5.4 Do dog breeds differ from one another in their aggressiveness due to their different genetic make up?

The nine breed groups did not differ in the proportion of dogs biting a human stranger or another dog. However, there was a significant difference between groups in biting of family members, with the DDA unlisted dogs biting significantly more often in the family. This resembles a tendency already noted by Horisberger (2002) though it might here be an artefact of the sampling method used, since DDA-unlisted dogs were usually only tested following a history or accusation of biting. When biting incidents with any human were examined, no difference between breed groups could be seen.

Böttjer (2003) found no significant difference between breeds in the proportion of biting other dogs in her test, in agreement with this study, but could see a difference when just comparing pairs. Her Rottweilers bit significantly less than Bullterriers or Pitbull-type dogs. Horisberger noted a breed difference, with German and Belgian Shepherds and Rottweilers biting proportionally more compared to their numbers in the dog population. As the Rottweiler is subsumed in this study into the DDA listed group, the same comparison cannot be made.

The probability of being bitten by another dog was different between the breed groups, with Bullterriers and American Staffordshire Terriers running the highest risk. As sex and neuter status distribution was similar between breed groups this difference could not be due to there being a higher proportion of male American Staffordshire Terriers or Bullterriers. Other factors might instead be relevant e.g. factors associated with the owner (obedience level or the effort put into socialisation) or other factors within the dog like its competence in communication. This point will be discussed further in a subsequent chapter.

Pitbull Terriers scored highest in groups A (accidental interactions), B (threats), C (noise), D (dog), E (play) and F (strange person) also and they scored second highest (i.e. worst) for obedience as well. Mean scoring in group B, C, D, E and F was marginally significantly correlated to the dog's obedience score and this might be one possible reason why the Pitbull Terrier scored highest on aggression in so many subtests. The Bullterrier crosses were the second highest scoring breed in group C and

D and scored high in group B also, as well as having a poor score for obedience. The Bullterriers were the worst in obedience and scored significantly higher than other breeds in group C (noise). The American Staffordshire Terriers also scored poorly on group C, and also in group H (manipulation). DDA unlisted dogs scored high in group B, C and D, but were one of the better breed groups for obedience, scoring better than the DDA listed group. However, the DDA listed dogs had significantly higher aggression scores for group B and D than the unlisted. The Bullmastiff and Dogue de Bordeaux did not stand out on the aggression scores, but scored poorly for obedience, though not as badly as others, e.g. all the Terrier breeds/group. The breed with the best obedience scores were the Ridgebacks which also did not show outstanding aggression scores. However, it is dangerous to extrapolate from these findings to general breed tendencies for showing aggressive behaviour. As mentioned above the correlation between obedience level and aggression scoring has to be kept in mind, and a sample of 254 dogs is much too small to find reliable breed differences. Moreover, there were biases in the sample. For example, the majority of the Ridgebacks had been recruited specifically for other aspects of this thesis (Chapters 5 and 6), and many of the DDA-unlisted dogs were tested because of specific incidents that may have involved aggression. Mittmann (2002), Böttjer (2003) and Bruns (2003) did not find any breed differences for showing aggression in their tests. But Mittmann did find breed differences, in concordance with Böttjer (2003), for the dog-dog test elements, when directly comparing breeds in pairs. Her American Staffordshire Terriers scored significantly higher than Rottweilers or Bullterriers; but even the sample used by Mittmann (415 dogs), appears to be an insufficient sample size for measuring breed differences.

In conclusion, it can be said that hypothesis 4 was not substantiated. Considering the results, it is not justified to speak of "more or less aggressive breeds". Rather these findings imply that when looking at factors affecting why a dog may behave aggressively at some time in its life (and what this aggression is directed at), all possible factors should be looked at with equal weighting, with "breed" being just one of many. Further investigations with a much larger sample size might help to verify these points further.

# Chapter 3:

## Applying ethological measures to quantify the temperament of dogs, and comparing those measures to their aggression test scores

## 3.1 Aims

Netto & Planta (1997) and the directives for the evaluation of dogs in Lower Saxon (NMELF, 2000, 2003) only use the scoring system already mentioned for measuring aggressiveness. Although such methods are able to quantify aggressive behaviour, from no aggression shown to high intensity aggression, they do not record the detail of any other events that took place in a test situation, including behaviour of the dog that may indicate the motivation for any aggression. As Chapters 1 and 2 of this paper have already shown, aggressive behaviour in any given situation arises from many different factors, and so far no reasons have been put forward to place the main or exclusive emphasis on any single factor. The existing scoring systems do not record the emotional state of the dog whilst being exposed to the test stimuli. This chapter examines this aspect, by looking more intensively at the individual dog's behaviour, linking it to the scores for each test element, and to the presumed emotional state of the dog.

Hypothesis 3 shall be addressed in particular here: "the main emotional background for aggression is fear". Additionally, potential breed differences in behavioural reactions to individual test elements will be examined.

## 3.2 Introduction

The literature covering this aspect of dog behaviour, especially when testing their temperaments, is scanty. Netto & Planta (1997) state that their scoring system approach is adequate, as their interest predominantly lies in finding dogs that attack. Other authors have already measured aggression in a more differentiated way, by recording certain displays, e.g. dog being neutral, showing active submission, play behaviour, fearful threats, confident threats (Bruns, 2003; Van den Berg et al., 2003), or by adding more detail to the above mentioned scoring system (Böttjer, 2003). Bruns divided her displays into aggressive and non-aggressive conflict-solving strategies, and attributed certain behavioural elements from the ethogram used by Rottenberg (2000) to each display. Bruns noted that dogs showing aggressive displays of any kind were more likely to show uncertainty and fear simultaneously, compared to dogs showing no aggressive display.

Van den Berg et al. (2003) used an aggression scoring system when testing 83 Golden Retrievers in an aggression test but also added short ethograms for "aggressive dog behaviour" (direct stare, raised hackles, snap, stiff posture, bark, growl, attack), and "fearful dog behaviour" (tremble, attempt to flee, shrink back, seek cover, lick nose, flick tongue, break eye contact, lift front paw, smack lip, hunch, startle, squeak). Although not all test elements elicited threatening behaviour in their dogs and even fewer test elements elicited snap/attack behaviour, all elicited fearful behaviour. But they were unable to detect any significant correlation between the quantity and quality of fearful and aggressive behaviour.

The link between fear and aggression has already been evaluated in detail in Chapter 1, but, especially in the context of aggression tests, this point may not have been widely appreciated. In this section therefore the behaviour of the same 254 adult dogs was evaluated using an ethogram, in addition to the aggression scoring system. The ethogram was derived from Rottenberg (2000), supplemented with eight additional behavioural elements directed at the interacting partner in a test element, be that dog or human.

## 3.3 The ethogram

An ethogram is a comprehensive description of all single behaviour patterns that make up the complete behavioural repertoire of an individual species or, in the case of domesticated animals, an individual breed, which are shown under a specific set of environmental conditions. According to Gattermann (1993) the ethogram should not only contain inborn species-typical behaviour patterns (hereafter "behaviours"), but also behaviours that are individually learned or have developed as a reaction to artificially produced environments (such as can be found for many of the domesticated animals), and are observed in a substantial proportion of individuals. The ethogram is the starting point for any deeper investigation, such as the question as to whether different breeds have different ethological profiles (Leyhausen, 1982), how much intra-species variation exists, and how domestication has influenced and modified the behavioural repertoire of the wild form.

The individual behaviour patterns in an ethogram are often grouped according to their overall task, function and effect. In the papers cited in Chapter 1 on behavioural ontogeny, six different groups have been used, following the differentiation of Althaus (1978): 1) position and locomotion, 2) comfort, 3) orientation, 4) metabolism, 5) interaction with the non-living environment, 6) interactions with the living environment – i.e. social and asocial interactions.

The number of individual patterns in their respective ethograms differs for the breeds examined so far. Differences between ethograms can arise from the inclusion of breed-typical behaviour patterns, e.g. the "eye" in the Border Collie (Heine, 2000) or "stamping" in the Poodle (Rottenberg, 2000), but they can also arise as a result of different emphases being placed on the amount of detail to be recorded. As an example of extreme differences: George (1995) differentiated between 76 behaviours, whereas Heine in the most recent work on behavioural ontogeny in puppies counted 140. These differences mainly originate from different levels of detail in functional groups 5 and 6. For example, where George just defined behaviour patterns without having a recipient in mind, Heine differentiated according to the situation in which the behaviour, e.g. play-bow, was shown. The problem with both approaches is that it is an individual decision of the author to adopt one or the other, thus in a sense (without discrediting either author) biasing the results when it comes to comparing different breeds.

The ethogram to be used here (Table 3.1) contains both single element-behaviours e.g. "to place the paw on the back of another dog", or locomotion like "walking", but also complex behaviour patterns e.g. showing a certain state of submission. An ethogram containing just single element-behaviours is called a "first-order-ethogram" whereas an ethogram consisting of complex behaviour patterns is called a "second-order-ethogram" (Feddersen-Petersen, 1994a). It has to be borne in mind, that such a second-order-ethogram is usually derived from combining observations on a first-order-basis with a subsequent interpretation of the dog's motivational and emotional state, deriving from the situation the behaviour was observed in. From his observations on agonistic interactions between dogs e.g. Schenkel (1967) came to the following description for the term "passive submission": "Dog is laying on the back showing submissive display; tail under body, ears flat at the back, submissive grin, avoidance of eye contact with opponent. No active defensive behaviour is shown. Opponent may be standing over dog or close to the side". The terms "submissive grin" or "submissive display" had been defined by him earlier.

Scott & Marston (1950) emphasised that the investigation of behavioural development in dogs should be descriptive and experimental, thus allowing for comparison. They focused on standardised methods and set the framework for subsequent authors. Unfortunately up to now no internationally standardised ethogram for research on dog behaviour exists, although currently most of the German scientists in this field use an ethogram nearly identical to the one used here.

## 3.4 Materials and methods

### 3.4.1 Dogs

The dogs have been described in detail in section 2.3.1.

### 3.4.2 Testing procedures

The procedures of testing have been described in detail in section 2.3.2.

### 3.4.3 The Ethogram

On the basis of existing ethograms (Rottenberg, 2000; Schöning, 2000a), the following ethogram (Table 3.1) was derived, both for recording social interactions between the Rhodesian Ridgeback puppies (see subsequent chapters) and the behaviour of the adult dogs. This ethogram was supplemented with eight additional behavioural elements shown by the adult dogs against the interacting partner, be that dog or human (Table 3.2)

Table 3.1) Ethogram - listing and describing the single behaviours Nr. 1 to Nr 71 for both puppies and adult dogs

| Nr. | Name | Description |
|---|---|---|
| A): <u>**behaviours for social approach**</u>. Zimen (1971) described these behaviours "for friendly or neutral situations. Umlauf (1993) named them "socio-positive behaviours". According to Schenkel (1947) and Feddersen-Petersen & Ohl (1995) most of these behaviours can also be used as a means for de-escalation in a conflict (e.g. can be integrated in the complex behaviour of "active submission"). | | |
| 1 | Fur-sniffing | The fur of the other dog, mostly in its face, neck and back area, is sniffed (Rottenberg, 2000). |
| 2 | Nose-nudge | The dog nudges with its nose at the other dog, making contact mostly in the face, neck and flank area (Rottenberg, 2000). |
| 3 | Running in front | The dog runs in front of another dog, head high and with a slight spring in the step (Rottenberg, 2000). |
| 4 | Muzzle nudge | Dog nudges with muzzle against another dog, making contact with skin preferably head and neck area. Mouth is closed (Eisfeld, 1966). |
| 5 | Nibbling | Dog nibbles at skin/fur of another dog, mainly using its incisors (Rottenberg, 2000). |
| 6 | Licking | Dog licks another dog (Althaus, 1982). |

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| 7 | Anal-sniffing | Sniffing, sometimes licking, at another dog's anal area (Rottenberg, 2000) |
| 8 | Tail-sniffing | Sniffing, sometimes nibbling as well, dorso-proximal at the other dog's tail (Rottenberg, 2000). |
| 9 | Genital-sniffing | Sniffing, sometimes licking, at another dog's genital and/or inguinal area (Fox, 1971; Rottenberg, 2000) |
| 10 | Following | One dog follows another one (Rottenberg 2000). |
| 11 | Rubbing | Two dogs rub their flanks against each other, often in anti-parallel position (Rottenberg, 2000). |
| 12 | Circling | Dogs circle each other with neutral up to raised bodily posture. Facial display is slightly submissive (ears flat at the back, submissive grin (Schenkel, 1967)). Sniffing can be shown, either directly at the other dog or in the air on a short distance. |
| 13 | Pushing | Dogs run or walk close next to one another, bodies touching. One dog can push the other such that the other may stumble or just slightly change direction while moving (Rottenberg, 2000). |
| 14 | Muzzle licking | Dog licks muzzle of another dog (Rottenberg, 2000). |
| 15 | Licking intention | Dog moves own tongue over own nose. This can be repeated and can be shown directly against a partner (Rottenberg, 2000) |
| 16 | Jumping at | Dog jumps at partner, having contact with front paws while hind paws stay on the ground (Eisfeld, 1966). |
| 17 | Raise paw in front | One dog stands or sits in front of another one and raises a front paw in the direction of the other, making short grabbing movements in the air (Althaus, 1982). |
| 18 | Muzzle holding | One dog takes the snout of another dog into its mouth, showing a very inhibited nibbling or biting, sometimes interspersed with licking. Body posture is relaxed. |
| 19 | Active submission | Dog approaches opponent in a more or less submissive manner (ears flat at the back, submissive grin, tail may be under body, whole body slightly crouched and small. Dog |

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| | | may seek body contact with opponent and may lick snout. One hind leg may be slightly positioned to the side (Schenkel, 1967). |
| **B): <u>Imposing behaviour.</u>** Zimen (1971) differentiated between imposing and agonistic behaviour. According to Umlauf (1993) imposing behaviours are relatively fixed and ritualised. No confrontation with intense and prolonged body contact happens; each dog demonstrates its own supposed power and/or status. | | |
| 20 | Place paw on back | One dog places a front paw on the back of another (Althaus, 1982). |
| 21 | Mounting | Dog climbs with upper body and front legs on the back of another dog and wraps legs around hips, thrusts with the pelvis may follow (Althaus, 1982) |
| 22 | Raised bodily posture | Whole body is elevated with stiff straight legs, tense muscles (Feddersen-Petersen, 1978). |
| 23 | Raised tail | Tail is stiff and raised vertically above the back. The tip may be wagging at high frequency (Feddersen-Petersen, 1978). |
| 24 | Showing neck | Dog stands slightly erect near an opponent, head away from opponent, neck is presented. |
| 25 | T-position | This is a complex situation where dogs stand at right angles to one another, thus one forms the bar of the "T", the other one the line. When used in this paper, the number is given to the dog forming the bar, as this dog is regarded as the active partner, placing itself in a position where it is blocking the other's progress (Feddersen-Petersen, 1986). |
| 26 | Mounting at right angle | One dog stands at right angles to another dog and jumps with both front legs on the back of the other (Rottenberg, 2000). |
| 27 | Laying head on back | One standing dog lays its head on the back of another dog. Approach from different angles possible. |

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| **C): <u>Passive Submission.</u>** Passive Submission is not included in group A) as it is not shown in a socio-positive or neutral situation but always as a reaction to threat or danger, i.e. a reaction to imposing or agonistic behaviour from the partner in the interaction (Zimen, 1971; Umlauf, 1993). Rottenberg (2000) stated that, according to the situations it is shown in, it could belong to the group "agonistic behaviour"; but as it is not behaviour that actively increases the distance from a threat or opponent, it is listed here in its own group. | | |
| 28 | Passive submission | Dog laying on the back showing submissive display: tail under body, ears flat at the back, submissive grin, avoidance of eye contact with opponent. No active defensive behaviour. Opponent may be standing over dog or close to the side (Schenkel, 1967). |
| 29 | Submissive facial display | Flat smooth face, ears backwards, eyes wide open, long mouth-gap (submissive grin), eyes avoid contact with partner in interaction. Possible additional signs: licking of own snout, large pupils (Feddersen-Petersen, 1978). |
| 30 | Leg rotation | Dog stands slightly crouched and with submissive facial display; one hind leg is slightly rotated to the side (Feddersen-Petersen, 1978). |
| **D): <u>Agonistic behaviour.</u>** This term is collectively used for any behaviours directed against, or as a reaction to, conspecifics or any other opponent as an answer to conflict, threat, attack or just disturbance. Agonistic behaviour has both offensive and defensive elements. Thus it is used to gain/keep distance in space and time from the respective opponent (Gattermann, 1993). Agonistic behaviour is further divided into threatening behaviour, inhibited and uninhibited offensive (attacking) behaviours, and flight. Transitions between these subdivisions are fluid. | | |
| <u>D1): Threatening behaviour.</u> Behaviours not further specified can be shown either offensively or defensively, according to the emotional state of the dog. Threatening behaviour resembles aggressive communication and can for example develop from imposing behaviour in hardly noticeable transitional phases. Threatening behaviour incorporates no intention of direct physical harm though physical contact can happen and may result in minor injury, e.g. scratches or punctures. | | |

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| 31 | Laying on the back defending | Dog is laying on its back, showing active defensive behaviours i.e. intention to bite, snarling, raised hackles with ears more or less behind the head, long corners of mouth and may be showing teeth. Eyes focused on opponent. Dog kicks with legs at opponent. Opponent may be standing over dog or close to the side (Zimen, 1971; George, 1995). |
| 32 | Snapping | Dog shows biting intention, making snapping movements with the snout against opponent without contact of skin (Zimen, 1971) |
| 33 | Growling | Snarling sound directed at something or as a reaction to something in the living or non-living environment. Mouth may be open (Eisfeld, 1966); nose can be wrinkled (Zimen, 1971; Althaus, 1982). |
| 34 | Wrinkled nose | Skin on nose is wrinkled (Zimen, 1971; Althaus, 1982). |
| 35 | Raised hackles | Hair, on dorsal area of neck up to beginning of shoulder blades only, is raised. |
| 36 | Baring teeth | Lips are raised, showing display of teeth. Mouth can be open and gums may be seen. |
| 37 | Raising hair | Hair along the complete spine is raised vertically above the back, most prominently in the area between the shoulder blades (Althaus, 1982). |
| 38 | Barking | Barking sound as a vocal reaction to an environmental stimulus, can be directed at an object or other individual (Eisfeld, 1966). |
| 39 | Offensive facial display | Facial muscles tense, ears erect and pulled forward, eyes small and focused on partner, mouth slightly open (Feddersen-Petersen, 1978). |
| 40 | Lurking | Dog is lying on the ground, head low, visually fixing another dog or object. Front legs are stretched forward, hind legs are tucked under the abdomen, ready for standing up. |

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| 41 | Creeping along | Very slow approach to another dog; legs flexed, back may be slightly crouched. |
| 42 | Biting over the muzzle | One dog takes the snout of another dog into its mouth (either direction: from the side, top or from down under), closing the mouth with inhibited biting. This can be done in a rather quick movement for short duration or be done in slow motion. |
| 43 | Chattering with teeth | Fast biting-movements are done from a distance, directed at an opponent. Teeth make a loud chattering sound (Eisfeld, 1966). |
| 44 | Defensive threatening | Complex behaviour: dogs shows nose wrinkling and/or showing teeth in various intensities together with facial expression of fear (ears flat behind head, mouth wide open, widened pupils). Growling or snarling can be shown in high-intensity threatening. Possibly preceded by facial expression of fear: ears are erect with non-differentiated body posture (Schenkel, 1947). |
| 45 | Bite-threatening | Complex behaviour: erect body is shifted to the front, head may be held forward or is erect. Front teeth are shown, opponent is fixed visually, ears are erect. Can be accompanied by growling (Schenkel, 1947). |
| 46 | Standing over the opponent | Standing (parallel, anti-parallel or at right angles) over lying opponent. |
| 47 | Chase | One dog runs after another dog, which is retreating (Tembrock, 1958; Redlich, 1998). |
| D2): inhibited attacking behaviour | | |
| 48 | Mugging | Dog approaches fast, as if attacking. Head and tail are carried higher and legs not flexed. Movement can often be a pronounced gallop and often starts from lurking (Rottenberg, 2000). |
| 49 | Wrestling | Inhibited biting or snapping, where both dogs stand on the hind legs with occasional support from one front leg. One or both front legs are pressed against the opponent (Rottenberg, |

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| | | 2000). |
| 50 | Pressing down | Dog presses front legs or lays itself on top of another dog which is supine, thus holding this dog on the ground (Rottenberg, 2000). |
| D3): uninhibited attacking behaviour. Rottenberg (2000) called these behaviours "free aggressive behaviour" | | |
| 51 | Biting | The dog takes skin/body parts of another dog between its jaws and closes them. Bitten dog may show reaction of discomfort according to strength of bite. In the beginning of ontogeny biting can change into yawning, later puppy/dog might tear skin (Eisfeld, 1966). |
| 52 | Bite-shaking | One dog grabs the other with the teeth and shakes head (Zimen, 1971). |
| 53 | Attack | Dog runs straight up to another dog, head is slightly lowered down and held straight forward towards opponent; legs may be slightly flexed in knees and elbows. End of this movement is often a jump at the opponent (Rottenberg, 2000). |
| 54 | Serious fight | Two dogs try to severely wound each other with high intensity. Main targets for bites are head, snout and throat; the dogs may grab each other especially at the loose skin/fur of the throat area, and bite-shake (Rottenberg, 2000) |
| 55 | One-bite attack | A dog attacks another dog very fast and unerringly; the dog bites once, more or less uninhibitedly, and then retreats. |
| D4): Flight and behaviours for de-escalation. Though some behaviours listed here are not actively defensive behaviours, they are used in conflicts as a means for de-escalation, and to gain distance in time and space from an opponent in that they allow the opponent to leave. This applies especially to so-called displacement behaviours, that as such do not resemble intentional communication with an opponent, but rather a break in the interaction. In these, the dog shows a certain behaviour which, according to the individual situation/interaction, cannot be regarded as an appropriate reaction to the actual situation/communication. The behaviour shown can be any single behaviour from the ethogram; some that are shown quite often by dogs have been listed here (Feddersen-Petersen & Ohl, 1995). | | |

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|---|---|---|
| 56 | Going backwards | Dog moves slowly in backwards direction, rump first (Althaus, 1982). |
| 57 | Avoidance | Dog turns away from an object/situation or interaction with other dog either just with head or with whole body, without massive display of fear/shock but with some kind of submissive expression. The movement is neither sudden nor fast (Eisfeld, 1966; Althaus, 1982). |
| 58 | Flight | One dog runs away quickly from another dog. Face may show display of fear and/or submission. There may have been a longer social interaction beforehand or it may be only the approach of the other dog that is fled from (Althaus, 1982). |
| 59 | Leaving interaction | One dog leaves another dog it has been in a social interaction with in a controlled intentional movement, head moving away from other dog first (Althaus, 1982) . |
| 60 | Yawning - Displacement behaviour | Mouth wide open, slightly stretched neck, possibly persisting in this position for seconds. Behaviour can be accompanied by sound (Eisfeld, 1966). |
| 61 | Scratching - Displacement behaviour | During an agonistic encounter, using a leg to a) scratch own body, either sitting, standing or laying; b) showing scratching movement in the air (Feddersen-Petersen, 1992). |
| 62 | Shaking - Displacement behaviour | During an agonistic encounter, fast rotation from side to side either of the complete body (Eisfeld, 1966) or just of the head (Althaus, 1982). |
| 63 | Licking - Displacement behaviour | During an agonistic encounter, moving/wiping own tongue over own snout or other part of own body (Eisfeld, 1966). |
| **E): Behaviours to show distress, stress or arousal, other than the ones already named** | | |
| 64 | Panting | Breathing deeply and heavily with open mouth, tongue may be protruded (Althaus, 1982). |
| 65 | Uncertainty | Approaching or experiencing a novel stimulus / unknown individual. Body may be crouched, tail under abdomen, facial display of uncertainty (ears flat behind head, long corners of mouth, face muscles changing between tension and |

| | | |
|---|---|---|
| | | relaxation, eyes fixed on object), neck extension may be shown. Display alternates rapidly between approach and avoidance (Redlich, 1998). |
| 66 | Wagging | The tail is moved from side to side at different frequencies and different amplitudes. Angle to body may vary from straight up to partly pressed under the abdomen (Eisfeld, 1966). |
| **F): Play behaviour.** | | |
| 67 | Play bow | Dog lowers the thorax to the ground with stretched out front legs, bottom up in the air. Tail may be wagging (Zimen, 1971). |
| 68 | Play face | Facial expression typically shown in a play situation. Eyes are usually wide open without any direct focus and the face is partly relaxed and partly shows expressions that belong to various emotional states (e.g. fear) without showing the complete expression of the respective state. Ears may be up front or flat to the back with all variations in between. Mouth positions are also variable, although the corners of the mouth are usually relaxed and wrinkling of the nose is lacking. The expressions may change rapidly (Federsen-Petersen, 1978). |
| 69 | Bite playing | Dogs show play-face. Both solely use the mouth to get into contact with the opponent. Mostly inhibited biting is directed at head of opponent (Althaus, 1982). |
| 70 | Play fighting | Dogs show play-face together with an alternating exchange of variable submissive and offensive facial displays. Biting and snapping may be included, also flight and chase (Eisfeld, 1966, Redlich, 1998). |
| 71 | Mouse pounce | Jump directed at something (imaginary or real) on the ground with attention focused on this (imaginary or real) object. Front paws may show grabbing intention directly after landing (Tembrock, 1958). |

Table 3.2) Ethogram - listing and describing the additional single behaviours Nr. 72 to 79 for adult dogs and giving the respective ethogram-group per behaviour.

| Nr. | Name | Description |
|---|---|---|
| 72 | Sniffing at human | The hand or leg of an interacting human is sniffed. Belongs in group A): behaviours for social approach. |
| 73 | Approach | The dog approaches actively and calmly, showing interest and otherwise neutral or friendly display. Belongs in group A): behaviours for social approach. |
| 74 | Attention | The dog shows attention without approach or withdrawing, with otherwise neutral or friendly display. Belongs in group A): behaviours for social approach. |
| 75 | Startle | The dog shows a sudden alerting reaction to a stimulus. Belongs in group E): behaviours to show distress, stress or arousal other than the ones already mentioned. |
| 76 | Leaping out | Dog leaps out against human or non-human partner without making contact with body. Belongs in group E): behaviours to show distress, stress or arousal other than the ones already mentioned. |
| 77 | Sniffing on the ground | Dog sniffs intensively at the surrounding ground. Belongs in group D): flight behaviour and behaviour for de-escalation. |
| 78 | Fixing | Dog is fixing human or non-human partner in a subtest with its eyes. Belongs in group B): imposing behaviour. |
| 79 | Stiff body | Dog stiffens its body; movement, even breathing is halted for very short periods. Belongs in group D1): threatening behaviour. |

### 3.4.4 Data collection

Data collection has been described in detail in section 2.3.4. The videotapes were watched two to three times each on the computer-screen and, where necessary due to low quality, were further processed using Final Cut Pro 4® for Macintosh. For each dog, the first five behaviours from the ethogram shown in each test element as reaction to the stimulus (e.g. behaviour of the test-person or test-dog etc.) in the time specified were recorded on a present-absent basis, in the order they were shown by the dog. This could lead to less than five behaviours being recorded for an individual test element, e.g. if the dog performed one behaviour for a long time. The decision to restrict to the first five behaviours was based on research on dyadic interactions among Rhodesian Ridgeback puppies (see Chapter 5), which showed that the highest average number of behaviours per dog per dyadic interaction was four.

### 3.4.5 Data samples and statistical analysis

The set of data collected per dog consisted of the five single behaviours from the ethogram shown in each of the 39 test elements plus the obedience test were summed across all tests prior to multivariate analysis. Data files for statistical analysis were produced using the following programs: File Maker 5® and EXCEL®, both for Macintosh and Windows. Statistical analysis was done with SPSS® version 12 for Macintosh and version 12 for Windows. Data were inspected by crosstabulation, and examined for normal distribution. Parametric tests were applied where possible. Non-parametric analysis of variance and correlation was done with Kruskal-Wallis test, Mann-Whitney-U-test and Spearman Rank test. Cluster analysis (squared Euclidian Distance) and principal components analysis were used to group test elements.

## 3.5 Results

### 3.5.1 Single behaviours from the ethogram and behaviour groups

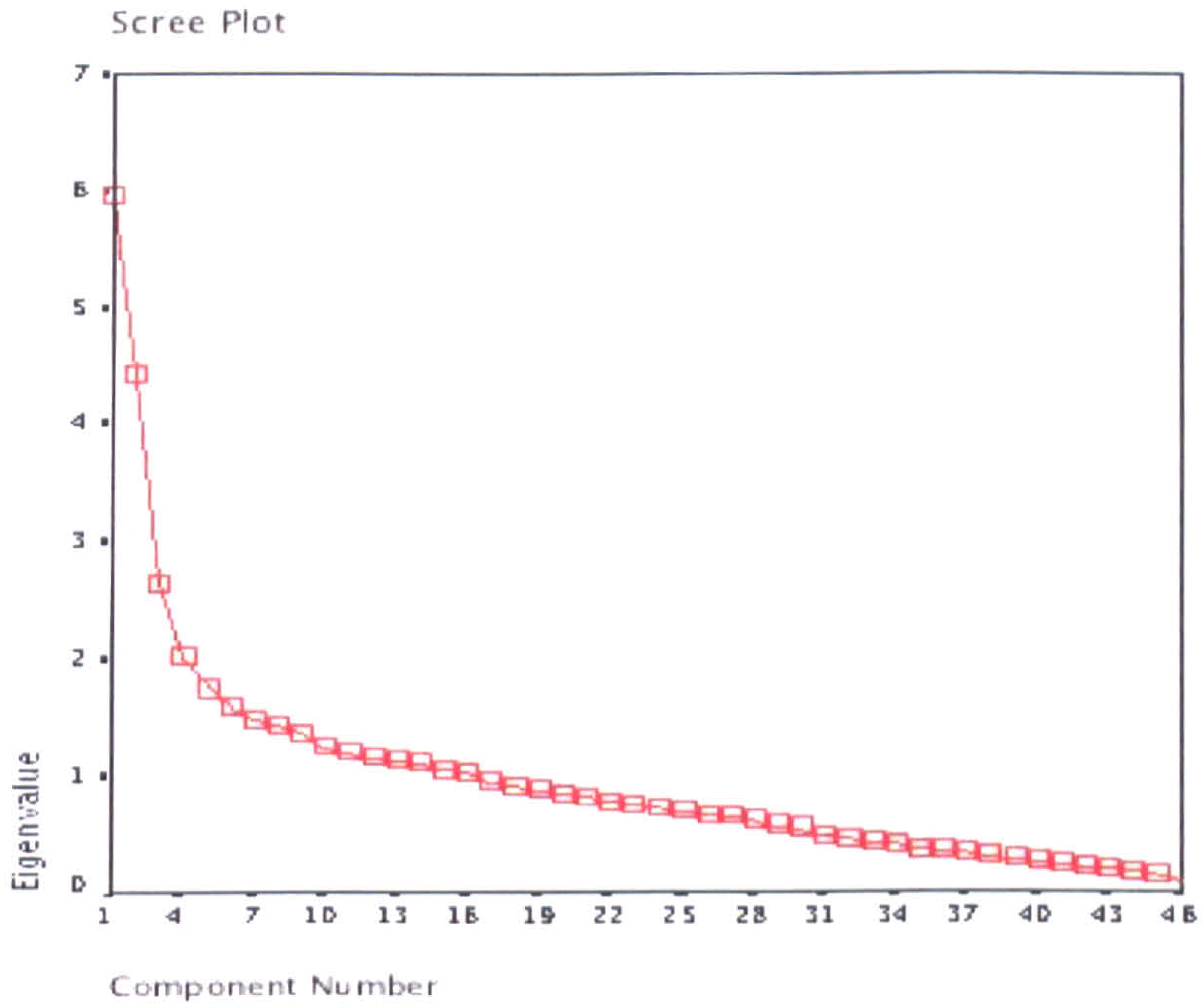
From the 79 individual behaviours presented in the ethogram (Table 3.1), only 67 were observed in two dogs or more. Twelve behaviours were never observed. Many behaviours were shown by all breed groups in only a few test elements. It was therefore decided to group behaviours for further analysis, particularly to compare results shown in test element T1-T10 (home) and T11-T39+obedience test (arena-part).

Principal components analysis (PCA) was used to examine whether the behaviour patterns performed by individual dogs did in fact fall into the groups indicated in the ethogram (Tables 3.1 and 3.2). Behaviours that were shown by dogs from two or fewer breed groups were excluded (i.e. Behaviours nr. 7-9, 12, 18, 20, 24-26, 31, 34, 36, 39, 47, 53, 55, 61, 63). Behaviours from group D2 (inhibited attacking behaviour, Table 3.1) were never shown during the test by any dog.

Unrotated PCA revealed 16 components with eigenvalues exceeding 1. Factorability of the correlation matrix (presence of coefficients of .3 and above) was supported by Kaiser-Meyer-Olkin value of .728 and Bartlett's test of Sphericity reaching statistical significance. The scree plot (Fig 3.1) suggested a break after the fourth or fifth component.

The first five components explained 12.9, 9.6, 5.8, 4.4 and 3.5 per cent of the variance respectively. Alignment of individual behaviours with components was not optimum for interpretation (see Figure 3.2), so Varimax rotation was performed; the results are given in Table 3.3.

Figure 3.1) Scree plot of eigenvalues for all components generated by PCA of numbers of test elements in which 254 dogs had performed 46 behaviours




In the first rotated component behaviours for social approach, play and passive submission had strong positive loadings (play bow, wagging, jumping at, play face, submissive facial display, bite playing, mouse pounce, pushing, licking, raise paw in front, active submission, nibbling). Strong negative loadings could be seen for flight behaviours (avoidance, flight, going backwards), “growling” and “uncertainty” (Table 3.3 and Figure 3.3).

In the second component agonistic behaviours (defensive threatening, snapping, biting, growling, barking), “leaping out”, “shaking” and “uncertainty” had strong positive loadings: “attention” was negatively loaded.

Positively loaded on component three were “uncertainty” with some agonistic behaviours (barking, stiff body),“panting” and “raised tail”. Negatively loaded on this component were “attention” again, together with other behaviours for social approach (fur-sniffing, nose nudge, muzzle licking) and “yawning”.

Play behaviour (play bow, mouse pounce) and imposing behaviour (fixing, raised bodily posture, mounting), “muzzle licking” and “going backwards” were positively loaded on component four. “Passive submission”, “rubbing” and “approach” had negative loadings.

"Attention", "fixing" and "stiff body" loaded positively in component five; the opposite was the case with "uncertainty", "avoidance", "flight", "going backwards" and "startle".

Figure 3.2) Principal component analysis for single behaviours from the ethogram (behaviours (B) from Table3.3 with behaviours nr. 7-9, 12, 18, 20, 24-26, 31, 34, 36, 39, 47, 53, 55, 61, 63 omitted) - unrotated component one and two are plotted against each other.

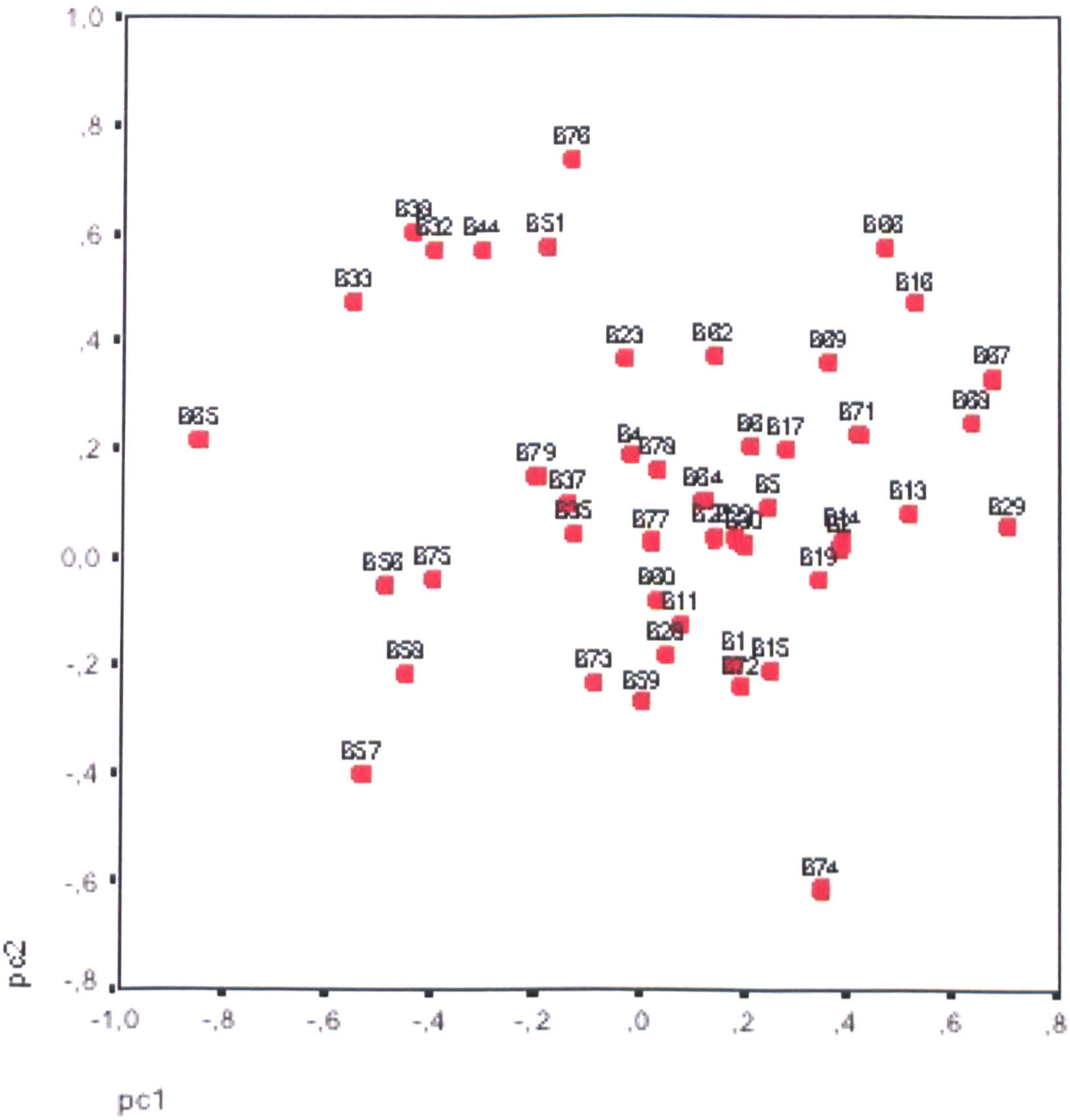
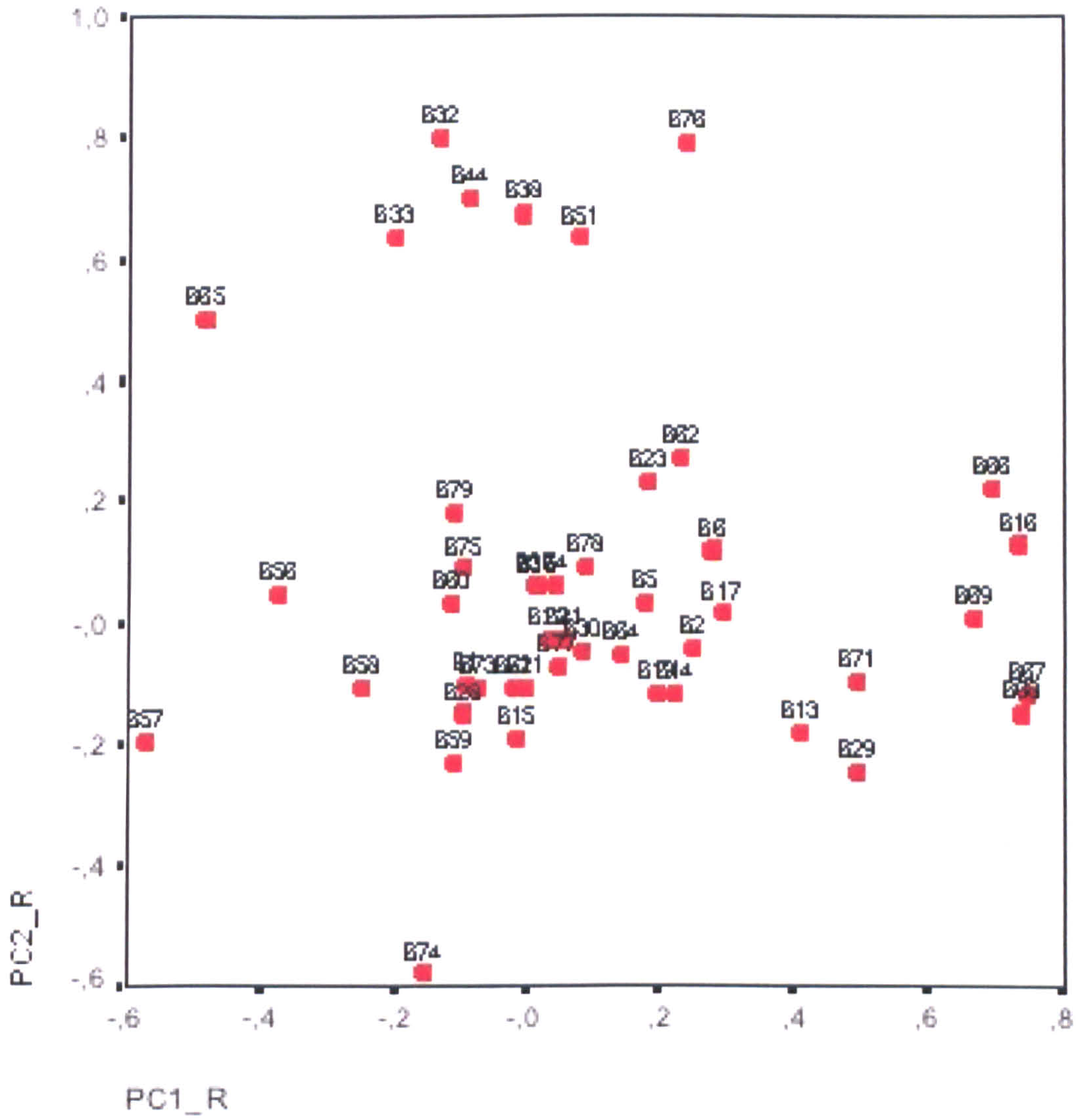


Figure 3.3) Loadings from varimax-rotated principal component analysis for single behaviours from the ethogram (behaviours (B) from Table 3.3 with behaviours nr. 7-9, 12, 18, 20, 24-26, 31,34, 36, 39, 47, 53, 55, 61, 63 omitted) - rotated components one and two.




The PCA results therefore confirm that the distinctions between behaviours for social approach and agonistic behaviours, and also between imposing behaviours and agonistic behaviours, are legitimate. This fits existing concepts of canine social behaviour and aggressive behaviour and their respective functions, summarised already in Chapter 1. The PCA results show also, that certain individual behaviours and behaviour groups (e.g. behaviours to show stress and play behaviour) fulfil several functions; they are equally likely to be used in a socio-positive or socio-negative context, in the latter used as a means for de-escalation or as a displacement activity. Some behaviours (i.e. leg rotation, raised hackles, muzzle nudge, licking intention, raising hair, leaving interaction) were not loaded at >0.3 on any of the five rotated components although they were shown by dogs from more than two breeds.

Table 3.3) Rotated component matrix for components 1 to 5 with coefficients of 0.3 or above..

**Rotated Component Matrix(a)**

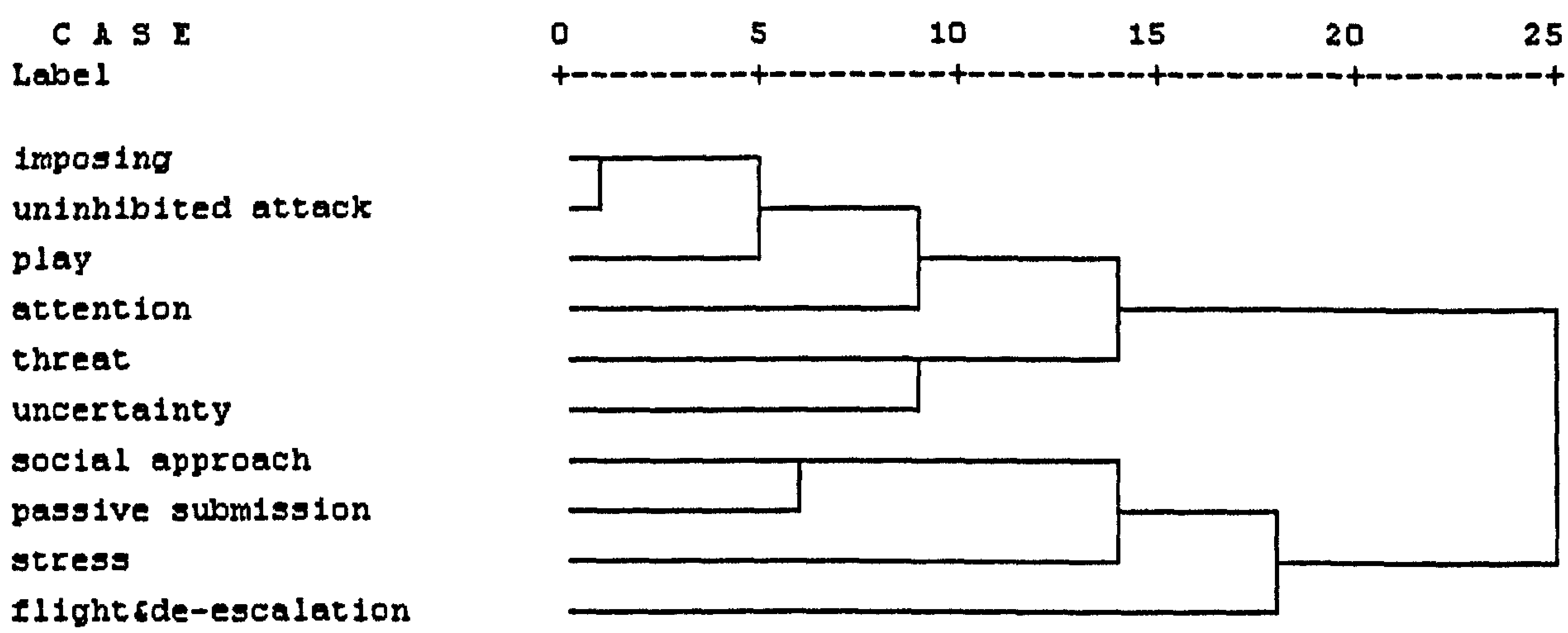
| Behaviour | Component | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Play bow | 0.723 | | | 0.350 | |
| wagging | 0.721 | | | | |
| jumping at | 0.718 | | | | |
| Play face | 0.699 | | | | |
| subm. facial display | 0638 | | | | |
| uncertainty | -0.576 | 0.403 | 0.428 | | -0.353 |
| avoidance | -0.568 | | | | -0.329 |
| bite playing | 0.499 | | | | |
| mouse pounce | 0.466 | | | 0.304 | |
| pushing | 0.462 | | | | |
| raise paw in front | 0.435 | | | | |
| licking | 0.353 | | | | |
| active submission | 0.319 | | | | |
| nibbling | 0.303 | | | | |
| leg rotation | | | | | |
| raised hackles | | | | | |
| leaping out | | 0.784 | | | |
| defensive threat | | 0.774 | | | |
| snapping | | 0.705 | | | |
| biting | | 0.684 | | | |
| growling | -0.326 | 0.577 | | | |
| barking | | 0.573 | 0.416 | | |
| attention | | -0.558 | -0.340 | | 0.528 |
| shaking | | 0.396 | | | |
| Muzzle nudge | | | | | |
| fur sniffing | | | -0.627 | | |
| sniffing human | | | -0.492 | | |
| raised tail | | | 0.463 | | |
| Stiff body | | | 0.427 | | 0.366 |
| nose nudge | | | -0.426 | | |
| panting | | | 0.381 | | |
| yawning | | | -0.332 | | |
| raising hair | | | | | |
| licking intention | | | | | |
| approach | | | | -0.594 | |
| rubbing | | | | -0.468 | |
| fixing | | | | 0.426 | 0.371 |
| raised body post. | | | | 0.423 | |
| muzzle licking | | | -0.389 | 0.416 | |
| passive submission | | | | -0.344 | |
| mounting | | | | 0.330 | |
| leaving interact. | | | | | |
| flight | -0.326 | | | | -0.577 |
| going backwards | -0.397 | | | 0.420 | -0.552 |
| startle | | | | | -0.517 |
| sniff ground | | | | | |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Since the PCA essentially confirmed the groupings within the ethogram, it was decided to leave the groupings as they were in Tables 3.1 and 3.2 for further analysis. The exceptions were behaviours 65 "uncertainty" and 74 "attention", which were analysed individually as they were always loaded opposite to each other and were associated with three or more components.

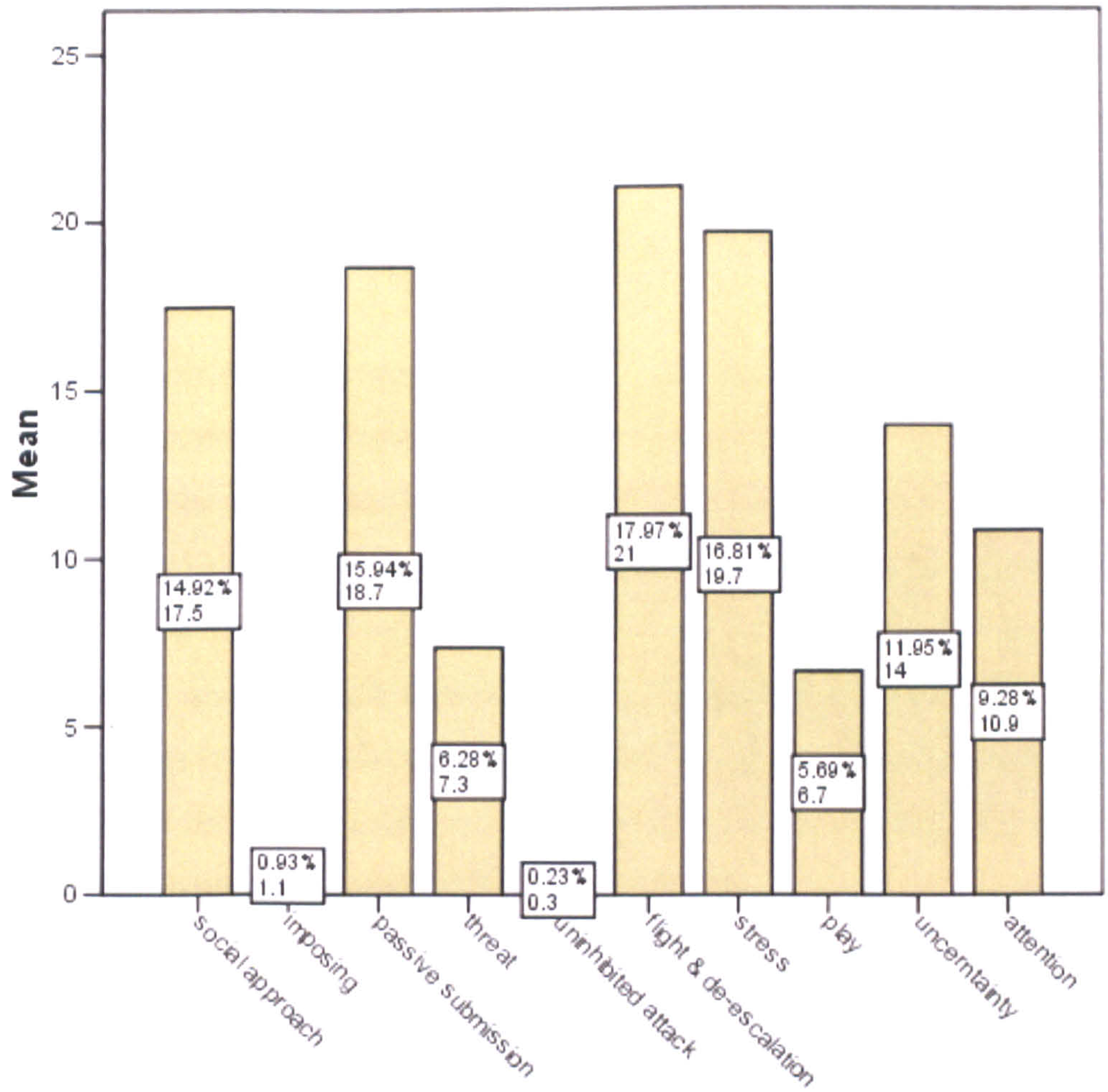
Cluster analysis was used to further look at connections between different groups. Two distinct clusters showed up (Figure 3.4). Behaviours for social approach, passive submissive behaviours, behaviours to show stress and arousal, and behaviours for de-escalation/flight behaviours formed one cluster. Imposing behaviour, threatening behaviour, uninhibited attacking behaviour, play behaviour and the single behaviours 65 (uncertainty) and 74 (attention) formed the other cluster

Figure 3.4) Hierarchical cluster analysis of the different behavioural groups and two single behaviours. Behaviours are named as labels; the dendrogram uses average linkage between groups. Total scores of all behaviours over all tests within each behavioural group were used.




The mean numbers of individual behaviours shown in the respective groups over the complete test differed extremely between counts of 0.3 and 21 (Figure 3.5).

Figure 3.5) Mean numbers and the respective percentage of behaviours (groups and two single behaviours "attention" and "uncertainty") shown by all dogs over the complete test.




3.5.2 Analysis: display of behaviour from the ethogram in relation to breed group, biting history, sex, neuter status and age; correlation between behaviours shown in individual test elements and the corresponding scoring

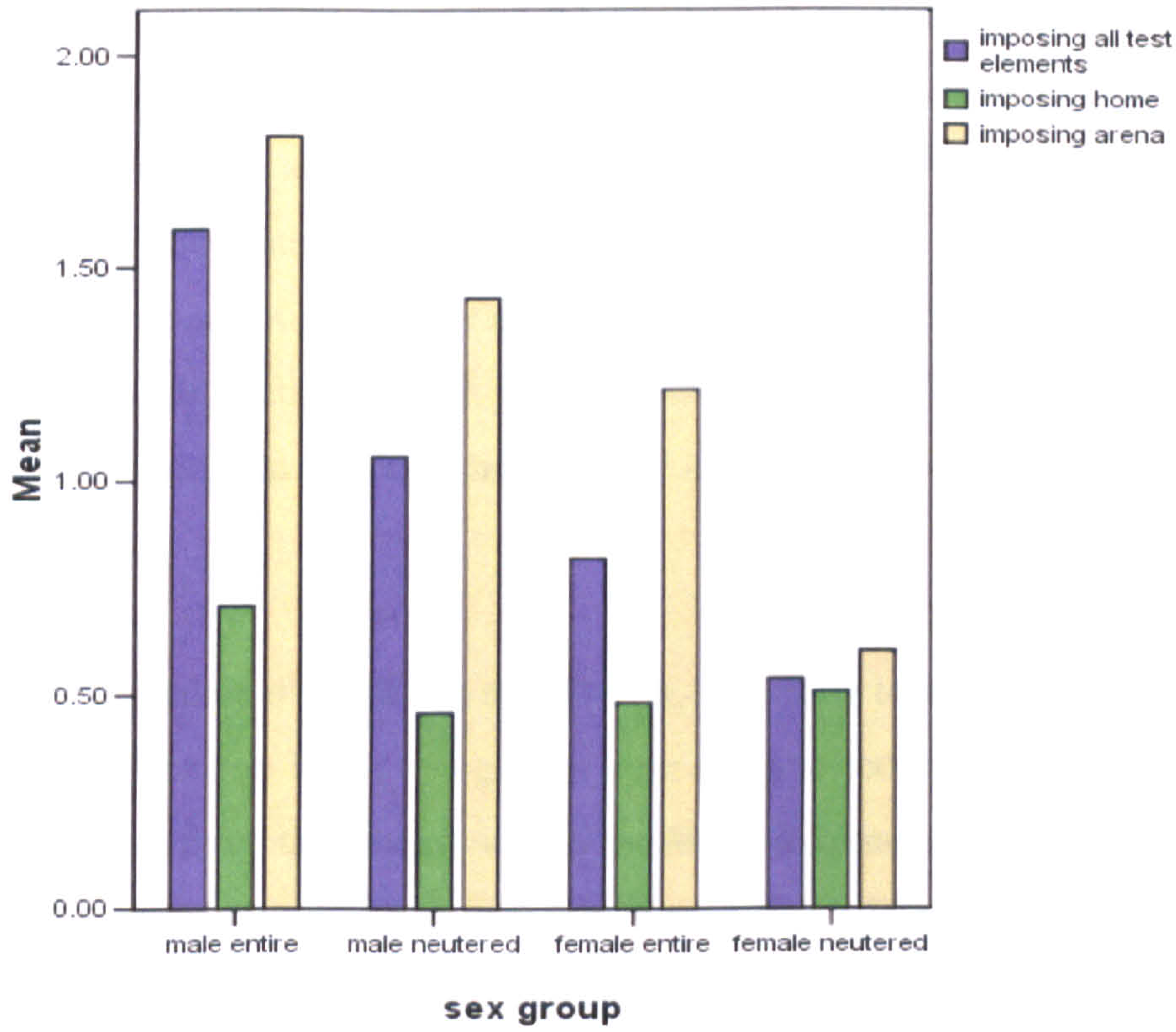
Total occurrences per dog for behaviours "uncertainty" and "attention" and the behaviour groups "social approach", "passive submission", "flight/de-escalation" and "stress" were approximately normally distributed. For groups "imposing", "threat", "uninhibited attack" and "play" the distribution was not normal, and did not become normal when log-transformed (Histograms are shown in Appendix 4). Thus non-parametric statistics were used in this chapter for all analyses.

For each behaviour group and the two single behaviours, comparisons were made between test elements T1-T10 (home) and test elements T11-T39+obedience (arena); total scores of all behaviours over all the respective within each behavioural group were used. For "uncertainty" and "attention" and for the groups "passive submission", "threat", "flight/de-escalation" and "stress", all correlations were positive (Spearman's rho: ranging from 0.969 to 0.211; significance: p ranging from <0.001 to 0.001).

For the other behavioural groups the results in the home and in the arena were not significantly correlated between each other: "social approach" Spearman's rho=0.084, p=0.181; "imposing" Spearman's rho=0.087, p=0.168; "uninhibited attack" Spearman's rho=0.085, p=0.176; "play" Spearman's rho=0.111, p=0.077. Thus for the following analysis the former behavioural groups were analysed combined across all test elements, but the latter were analysed separately for the home and arena tests.
The dog's age had no effect on quantity of behaviours from the ethogram shown in either part of the test (Spearman's rho correlation coefficient ranging between 0.005 and 0.116, significance between p=0.941 and p=0.066).

The sex and neuter status of the dogs played a highly significant role for showing imposing behaviour in the arena-part (K-W $chi^2$=24; df=3; p<0.001), but was of no relevance for the results in the dog's home. Intact males were the dogs most prone to show imposing behaviour (Figure 3.6). For all other behaviours or groups, the sex and neuter status appeared to be of little or no relevance. Table A3.1 in Appendix 3 gives the complete results.

Figure 3.6) Mean occurrences of imposing behaviour shown between the four sex-groups




Between the breed groups, considerably more significant differences in the counts shown per behaviour or behavioural group could be found. Table A3.1 in Appendix 3 gives the complete results. Progressive K-W tests were performed, omitting the highest-scoring breeds one at a time, to determine which breeds were displaying a certain behaviour/behaviours from a certain group most. The breeds with the highest mean score for each of these groups were (in ranking order):

Uncertainty (K-W $chi^2$=16; df=8; p=0.042): Dogue de Bordeaux

Social approach in the dog's home (K-W $chi^2$=17; df=8; p=0.029): Rhodesian Ridgeback.

Imposing behaviour in the dog's home (K-W $chi^2$=34.2; df=8; p<0.001): Pitbull Terrier, American Staffordshire Terrier, Bullterrier X, Rhodesian Ridgeback, DDA listed, DDA unlisted, Bullterrier.

Passive submission (K-W $chi^2$=34.9; df=8; p<0.001): Rhodesian Ridgeback, DDA unlisted, Pitbull Terrier, Bullterrier X, American Staffordshire Terrier, Bullterrier, DDA listed, Bullmastiff.

Threatening behaviour (K-W $chi^2$=20.6; df=8; p=0.008): Pitbull Terrier.
Uninhibited attack behaviour in the dog's home (K-W $chi^2$=16.4; df=8; p=0.036): Pitbull Terrier.
Flight behaviour and behaviours for de-escalation (K-W $chi^2$=21.6; df=8; p=0.006): Dogue de Bordeaux, Rhodesian Ridgeback.
Behaviours to show stress or arousal (K-W $chi^2$=48.3; df=8; p<0.001): Bullterrier, Bullterrier X, Pitbull Terrier, DDA unlisted.
Play behaviour in the dog's home (K-W $chi^2$= 22.9; df=8; p=0.003): Rhodesian Ridgeback.

Dogs were then divided into two groups, according to whether the breed was listed in any DDA or not. These two groups were again tested for any differences in showing behaviours from the ethogram with the Mann-Whitney-U test. DDA listed dogs displayed significantly more uncertainty (M-W-U=3901, p=0.004), and less social approach behaviour in the dog's home (M-W-U=4144, p=0.019), play behaviour in the dog's home (M-W-U=3725, p=0.001) and passive submission behaviour (M-W-U=3356, p<0.001).

Dogs that had bitten within the family showed significantly lower frequencies of behaviours for social approach in the home (M-W-U=1323; p=0.040) and a higher frequency of imposing behaviour in the home (marginally significant, M-W-U=1426; p=0.050). Significantly higher numbers of uninhibited attack behaviours were shown by these dogs in the arena (M-W-U=1576; p=0.036). Table A3.2 in Appendix 3 gives the complete results.

Dogs that had bitten strangers, showed uncertainty (M-W-U=583; p=0.050) and threatening behaviour (M-W-U=444; p=0.008) significantly more often in the complete test. The opposite applied to play behaviour within the dog's home (M-W-U=538; p=0.024); see Table A3.2 in Appendix 3.

Dogs that had bitten other dogs displayed imposing behaviour significantly more often in the home (M-W-U=5415; p=0.002) and the arena (M-W-U=5834; p=0.049). Threatening behaviour was shown by those dogs more often also (M-W-U=5729; p=0.035) as was uninhibited attack behaviour in the arena-part (M-W-U=5836;

p=0.001). Dogs that had bitten other dogs showed less flight behaviour and behaviour for de-escalation (M-W-U=5789; p=0.046) and a significant higher quantity of behaviours for stress and arousal (M-W-U=5673; p=0.027) and play behaviour in the arena (M-W-U=5796; p=0.047).

Dogs that had been bitten by other dogs, displayed behaviours for uninhibited attack in the home (M-W-U=7629; p=0.023), and in the arena (M-W-U=7279; p=0.016) significantly more often. See Table A3.3 in Appendix 3 for details.

In the previous Chapter, test elements were grouped into different subtest groups, based on the aggression scores the dogs got during the test. Correlations between those aggression scores and the quantity of the different behaviours shown, were examined using Spearman's rank correlation analysis. The same was done for the obedience scores. Table A3.4 in Appendix 3 gives all the details; a summarised overview will be given here with the following Table 3.4, showing the significant positive or negative correlations, also including the biting history of the dogs.

Table 3.4) Correlations between the mean frequency of behaviour, shown singly or combined into the respective group, and the biting history of the dog and the aggression scoring per dog in all subtest groups and the obedience test element. The direction of significant positive (pos) or negative (neg) correlations are shown, between high aggression scores / "good" obedience and biting history, and high frequencies of respective behaviour are shown.

| Behaviour/-group | Biting history | | Subtest group A | B | C | D | E | F | G | H | I | Good Obedience |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Attention** | Family | | | **neg** | **neg** | **neg** | **neg** | **neg** | **neg** | **neg** | **neg** | **pos** |
| | Stranger | | | | | | | | | | | |
| | Dog | | | | | | | | | | | |
| **Uncertainty** | Family | | | **pos** | **pos** | | **pos** | **pos** | **pos** | **pos** | **pos** | **neg** |
| | Stranger | **pos** | | | | | | | | | | |
| | Dog | | | | | | | | | | | |
| **Social approach home** | Family | **neg** | **neg** | **neg** | **neg** | **neg** | **neg** | **neg** | **neg** | **neg** | **neg** | |
| | Stranger | | | | | | | | | | | |
| | Dog | | | | | | | | | | | |
| **Social approach arena** | Family | | | **neg** | | **neg** | **neg** | | | | **neg** | |
| | Stranger | | | | | | | | | | | |
| | Dog | | | | | | | | | | | |
| **Imposing home** | Family | **pos** | **pos** | **pos** | **pos** | **pos** | **pos** | **pos** | | | **pos** | |
| | Stranger | | | | | | | | | | | |
| | Dog | **pos** | | | | | | | | | | |
| **Imposing arena** | Family | | | | **pos** | **pos** | | | | | | |
| | Stranger | | | | | | | | | | | |
| | Dog | **pos** | | | | | | | | | | |
| **Passive submission** | Family | | | | | | **neg** | | **neg** | **neg** | **neg** | |
| | Stranger | | | | | | | | | | | |
| | Dog | | | | | | | | | | | |

Table 3.4) continued

| Behaviour/-group | Biting history | | Subtest group | | | | | | | | | Good Obedience |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | D | E | F | G | H | I | |
| **Threat** | Family | | **pos** | **pos** | **pos** | **pos** | **pos** | **pos** | **pos** | **pos** | **pos** | **neg** |
| | Stranger | **pos** | | | | | | | | | | |
| | Dog | **pos** | | | | | | | | | | |
| **Uninhibited attack home** | Family | | | **pos** | | **pos** | **pos** | | **pos** | | | |
| | Stranger | | | | | | | | | | | |
| | Dog | | | | | | | | | | | |
| **Uninhibited attack arena** | Family | **pos** | **pos** | **pos** | **pos** | **pos** | **pos** | | | | | |
| | Stranger | | | | | | | | | | | |
| | Dog | **Pos** | | | | | | | | | | |
| **Flight / de-escalation** | Family | | | | | | | | **pos** | **pos** | **pos** | |
| | Stranger | | | | | | | | | | | |
| | Dog | **neg** | | | | | | | | | | |
| **Stress** | Family | | | **pos** | | **pos** | | | | | | **neg** |
| | Stranger | | | | | | | | | | | |
| | Dog | **pos** | | | | | | | | | | |
| **Play home** | Family | | **neg** | **neg** | | | **neg** | **neg** | **neg** | | **neg** | |
| | Stranger | **neg** | | | | | | | | | | |
| | Dog | | | | | | | | | | | |
| **Play arena** | Family | | | | | **pos** | | | | | | **pos** |
| | Stranger | | | | | | | | | | | |
| | Dog | **pos** | | | | | | | | | | |

Uncertainty was always positively correlated to high aggression scores, and apart from subtest groups A and D, the correlation was always highly significant. Uncertainty was also significantly linked with poor obedience. Attention behaviour correlated in the opposite direction to uncertainty; additionally there was a strong negative correlation with subtest group D (dogs): i.e. the aggression score was highest in dogs with the least attention behaviour. Dogs with a high count for attention showed significantly higher obedience levels.

High counts on behaviours for social approach were always significantly correlated with a low aggression score in the dog's home. In the arena part the correlation was only significant for subtest group B, D, E and I. Imposing behaviour in the dog's home was significantly positively correlated with high aggression scores in subtest group A–F and I. For the arena-part this applied to subtest group C and D only.

Passive submissive behaviours were always correlated with low aggression scores (significantly for subtest group E and G–I).
Threatening behaviour correlated positively with high aggression scores throughout all subtest groups and also with poor obedience results.

Uninhibited attack behaviour in the dog's home was significantly positively correlated with high aggression scores in subtest groups B, D, E and G; in the arena part the correlation was significant for subtest group A–E.
Flight behaviour and behaviour for de-escalation was significantly positively correlated with high aggression scores in subtest groups G–I. High counts for behaviour for stress and arousal was significantly correlated to high aggression scores in subtest group B and D and negatively to good obedience scores.

Play behaviour, finally, in the dog's home was significantly negatively correlated to high aggression scores in subtest groups A, B, E, F, G and I. A good obedience level was positively correlated to a high number of play behaviours shown in the arena as were, by contrast, high aggression scores in subtest group D (dogs).

## 3.6 Discussion

### 3.6.1 The ethogram, grouping of its behaviours and data sampling

The main goal of this chapter was to test the hypothesis that fear is the main emotional background for showing aggressive behaviour. Additionally differences were examined between whether breed groups differed in their behavioural reactions throughout the test elements and the individual subtest groups. In order to make the results as comparable with the existing literature as possible, an already widely utilised ethogram was used (see Chapter 1 and Rottenberg, 2000) to describe behavioural reactions to stimuli and to compare those reactions to the aggression scores in Chapter 2. Nevertheless this ethogram has never been explicitly used as an additional measure in an aggression test; thus no directly comparable data are available, nor is it clear whether this is the best means of sampling the behaviour.

Behaviours were recorded on a "presence-absence" basis, following an instantaneous rule of recording with each test element being one point to focus on. Nevertheless while a test element was performed the recording went on continuously (behaviour sampling: Martin & Bateson, 1996). Van den Berg et al. (2003) also recorded continuously while a test element was performed. Their test elements each lasted about five seconds longer and they focused only on the behaviours listed in the introduction to this chapter, counting their occurrence.
For comparing behavioural displays to scoring results more easily in this paper, it was decided to just count the first five behaviours shown in any test element and not to record durations or differences in intensity. Nevertheless it may be necessary in subsequent research to look for the duration of individual behaviours in a given time, and to evaluate which behaviours were shown in the beginning of a test element and which behaviours followed. When considering the reliability of the results obtained, the lack of repeated analysis for control purposes, should also be taken into account; this has also not been done in any of the cited literature. Thus comparison with existing results in this field is legitimate, but subsequent research should include tests of inter-observer reliability.

When evaluating results from the Lower Saxon aggression test, Bruns (2003) differentiated between non-aggressive and aggressive conflict-solving strategies and used some elements from Rottenberg's (2000) ethogram as a descriptive background. "Friendly approach", "active submission" or "play behaviour" were classed as non-aggressive conflict solving strategies; "fearful threats" and "self-assured threats" as aggressive conflict solving strategies. In this differentiation she roughly followed Feddersen-Petersen & Ohl (1995) but did not further discuss her definitions, for example why she classified snapping behaviour exclusively as a fearful threat.

Van den Berg et al. (2003) grouped single behaviours either as "aggressive behaviour" (including threatening behaviour) or "fearful behaviour". They noticed that some behaviours from both groups (e.g. raised hackles, trembling, lip smacking) were only shown incidentally, thus leading to exclusion from further analysis. Within the group of 254 dogs in this thesis, some behaviours from the ethogram were never shown by any dog and some only by a few dogs. Thus the analyses, e.g. looking for breed differences in behavioural display, could not be done straightforwardly using single behaviours. Behaviours therefore had to be grouped; this was also appropriate for allowing some comparison with the results from Bruns (2003) and Van den Berg et al. (2003). In the current literature on behavioural ontogenesis (see Chapter 1 and 5) grouped ethograms are often used.

Principal component analysis (PCA) showed that the grouping proposed by Rottenberg (2000) and other authors listed in Chapters 1 and 5, is roughly adequate. The distinction between behaviours for social approach and agonistic behaviours, as well as imposing behaviours and agonistic behaviours appears to be legitimate. Behaviours indicating stress, passive submission and play behaviour apparently fulfil different functions, reflected in the context they are shown in. These groups may not be mutually exclusive in respect of the behavioural elements in each, but this is compatible with what is known about the social behaviour of dogs. Further research on this point is necessary; especially on the comparison between inter-dog social communication and such communication between dog and man (e.g. Rooney et al. 2000).

Two behaviours (uncertainty and attention) were kept individually as they were always loaded opposite to each other and could be found in four and three of the five PCA-components respectively, loading alongside behaviours from several different groups. "Uncertainty" may be the single behaviour most characteristic of the emotion of fear, while "attention" may possibly only be expressed in the absence of fear.

Looking at the cluster analysis, behaviours for social approach, passive submission, behaviours to show stress and flight behaviour formed one broad cluster separate from imposing behaviour, threatening behaviour, uninhibited attack and play behaviour plus the two single behaviours "uncertainty" and "attention". This indicates some overlap between aggression induced by fear and by other motivations, which may be due to some motor patterns being used in both contexts. As the cluster results come from just 254 dogs, they will not be discussed here in depth but will be mentioned again in the general discussion. Again this shows that more research under standardised protocols is necessary, especially to look at behaviours that can be used for submission and de-escalation and are widely used in close social contacts, be they conflict, affiliative, or investigative (Bradshaw & Lea 1992).

### 3.6.2 Associations between behavioural display and breed, biting history, sex and age

Dogs did not show identical behaviour in some behavioural groups, comparing whether they were tested at home or in the arena. For example, behaviours for social approach were shown at higher frequencies in the test elements in the dog's home than outside; the same applied to imposing behaviour, uninhibited attack behaviour and play behaviour. One reason could be that, for the in-home situation, contact and possible conflict with the tester were subjectively more intense and thus stressful for the dog than outside. A difference would be expected depending on whether a dog is approached and eventually threatened by a stranger on its own territory, or on an unknown area. In its own home a dog might make social contact more readily, de-escalate via active submissive behaviour in close contact, use play behaviour for de-escalation, or engage in some status-indicating behaviours. Uninhibited attacking behaviour should also be more likely to occur on a place that is of ultimate importance for the dog, i.e. its own territory. Results for passive submissive behaviour, threat behaviour, flight behaviour and stress behaviour were significantly correlated, either performed in the dog's home and outside, indicating an identical subjective need for the dog to show those behaviours when threatened, irrespective of territory.

Age had no effect on quantity or quality of any behaviours shown. Sex and neuter status only played a significant role where imposing behaviour was concerned, with intact males being the most active imposers. But this influence was only apparent in the test elements performed outside, and when all subtests were looked at. Neither sex nor neuter status was important for imposing behaviour shown in the dog's home. This again stresses the point that the quality of interaction and conflict between dog and tester is a different one in the dog's home compared to outside. In the dog's home other subjective necessities might lead dogs of both sexes to show imposing behaviour. It can be assumed that imposing behaviour, social approach behaviour and play behaviour can have a slightly different quality and thus slightly different meaning in social communication in the dog's home compared to outside.
This could be one reason why the majority of biting dogs bite family members (Horisberger, 2002) and not strangers outside the house. "Misunderstanding" (i.e. wrong interpretation of a dog's behaviour with subsequent inappropriate behaviour of humans), leading to uninhibited attack, might happen more easily within the dog's own social group on its own territory, as social contact is probably more variable here, and conflicts over resources might arise more readily.

Considerable breed differences for performing individual behaviours could be seen. Dogs from the breed Dogue de Bordeaux for example showed a high amount of uncertainty and flight behaviour. With the Rhodesian Ridgeback it was rather the opposite. The Ridgebacks scored highest for social approach behaviour in the dog's home, passive submission behaviour, flight behaviour, and play behaviour in the dog's home.

Pitbull Terriers scored high on imposing behaviour in the dog's home, uninhibited attack behaviour and threatening behaviour in general. Pitbull Terriers also scored high for showing passive submission and behaviours to shown stress and arousal (though Bullterriers were here the breed showing the highest number of stress behaviours). Unfortunately Bruns (2003) did not differentiate between breeds when looking for the conflict-solving strategies of her dogs, and Van den Berg et al. (2003) only looked at Golden Retrievers.

So when comparing breeds, no general tendencies could be seen e.g. dogs that scored high on uncertainty did not necessarily score low on social approach behaviour or high on imposing or threatening behaviour. When the dogs were just split into two groups which might be presumed to be based on aggression (i.e. DDA-listed / DDA-non-listed), DDA-listed dogs displayed significantly more uncertainty and significantly less passive submission and social approach and play behaviour in the dog's home. This could indicate that the DDA-listed breeds were not only faster in developing a stressful state but then were less likely to go into low level conflict de-escalation (submission, displacement behaviour).

As stress can elicit aggressive behaviour in individual situations (see Chapter 1) a finding like "heightened display of uninhibited biting" might result from Terrier dogs being more easily stressed. A low tendency to show flight behaviours and behaviours for de-escalation in situations eliciting stress would not be surprising for terrier-type dogs, which comprise many of the DDA-listed breeds. The former usage of these dogs (hunting rats, foxes etc. or driving larger livestock) is unlikely to have resulted in selection for flight and behaviours for de-escalation under stress as a favoured trait. But altogether these data are insufficient for reliable deductions on breed specific traits, and it is not possible to definitely conclude that some breeds are more easily to be stressed than others and thus more readily display aggressive behaviour of any kind.

Dogs that had bitten within the family scored low on social approach behaviour within the dog's home, whereas dogs that had bitten strangers scored significantly higher for uncertainty and threatening behaviour in general. This fits the assumption that biting within the family and biting strange persons outside, though both might be shown out of perceived fear and stress, have different underlying motivations where resources are concerned. Especially within the family, misunderstandings in social communication, e.g. when status itself or resources to display status are concerned, will lead with higher chance of aggressive interaction.

When strangers are bitten, the resource "intact own body" or "territory" will play a more important role. Whether this is also the case with other dogs that have been bitten, cannot be differentiated sufficiently. Dogs that had bitten other dogs scored higher on imposing and threatening behaviour, stress behaviour and partly uninhibited attack behaviour whereas counts for flight behaviour were low. Dogs that had been bitten counted higher for uninhibited attack behaviour also. This stresses the point already mentioned, that dogs that have been bitten probably get injured while engaged in a fight with another dog they had bitten themselves.

### 3.6.3 Correlation between aggression scores and behavioural display

The aggression scores described in Chapter 2 give no hint of underlying motives (emotions) eliciting aggressive behaviour as reactions to individual stimuli in individual situations. To prevent incidents and try to give some prediction on quantity and quality of aggressive display in the future, it should be important to look for emotions displayed in an aggression test, thus giving hints as to the tolerance levels of the dog. Emotional states can be deduced from the behavioural display. No single element in the ethogram was described as "fear behaviour". Such an element is unlikely to be found in any canine ethogram, as dogs show the state of fear with a wide range of different behavioural displays (Feddersen-Petersen, 2004).
Van den Berg et al. (2003) subsumed behaviours like e.g. shrinking back, avoidance of eye contact, lifting front paw, smacking lips or attempting to flee as fearful behaviour. Included were thus behaviours that belong in the groups of social approach behaviours (e.g. lift front paw), passive submission (e.g. smacking lips) or flight behaviour (e.g. shrinking back, attempting to flee) from the ethogram used in this thesis. Bruns (2003) looked at facial display and body posture while differentiating for aggressive and non-aggressive conflict-solving strategies in her dogs. Her facial displays and body postures used as indicators for insecurity or fear resemble postures/displays described in the ethogram used here in the behavioural groups for passive submission, flight behaviour and behaviours to show stress. Bruns stated that much of the aggressive behaviour in her investigation arose from a state of uncertainty; Van den Berg et al. (2003) did not discuss any correlation between fear and aggressive display of their Golden Retrievers.

The behaviour "uncertainty" resembles an expression of fear, out of which aggressive behaviour might be shown, based on the associations between high counts of uncertainty and high aggression scores in some test elements. Such causal interpretation seems justified from the literature (Chapter 1, e.g. Archer, 1976), though these associations as such do not distinguish cause from effect. Further evaluation of the data, putting individual behaviours from the ethogram in a time-line of occurrence, would be helpful to show that other possible relationships (e.g. uncertainty as a result of the stressor not diminishing as a reaction to e.g. threats) are unlikely.
A high count for uncertainty correlated positively with a high aggression score in the following subtest groups: threats in the arena, noise, play, strange persons, threats in the dog's home and manipulation in the home. The behaviour "attention" gave just the reverse picture; in the same subtest groups as for uncertainty, a high count for attention was significantly correlated with a low aggression score. Additionally a negative correlation with attention could be found in subtest group D, dogs. In parallel, dogs with a high count for uncertainty showed a bad obedience level and vice versa for attention. These findings could point towards a scenario within which many biting incidents with humans might happen accidentally. Without acting deliberately, but rather by accident, people might challenge or threaten the dog and might not even recognise this fact. The decisive factor then for whether a dog might bite or not, will be the level of fear, influenced by the individual dog's tolerance against stress eliciting stimuli.

The correlation between high counts for uncertainty and high aggression scores was not significant for test elements involving dogs, and where people passed by in an everyday manner on the street. It can be assumed that "everyday situations on the street" are probably able to elicit aggression in dogs via individually eliciting fear. However, in general this probably happens too rarely to find a significant correlation between the display of uncertainty (i.e. resembling a dog that is easily stressed/fearful) and showing high aggression scores in those groups. The dog-dog-situations are probably, out of all the situations, among those most likely to involve behaviours learned in previous similar situations. This is consistent with the observation that uncertainty or fear can be masked in these test elements. But the emotion of fear is elicited in this subtest group also, as the correlation between "attention" and aggression scores shows. The behaviour "attention" is defined as „showing attention without approach or withdrawing, with otherwise neutral or friendly display". Dogs that are not easily stressed or frightened might rather show attention against other dogs – thus a negative correlation between attention and high aggression scores occurs, and it can be deduced from this that fear is most likely involved in those dogs showing higher aggression scores, but might just not be displayed.

High counts of behaviours for social approach in the dog's home were significantly correlated with low aggression scores in all subtest groups. High counts for social approach behaviours shown in the arena were significantly correlated with low aggression scores in subtest groups comprising friendly interaction in the dog's home. Dogs that showed a high frequency of social approach behaviour during a fear and stress eliciting situation, appeared not to need to try solve the conflict by using aggressive means. This differences in the significant correlations between the in-home tests and the arena part stresses the point that there are subjectively different needs for the dogs to show social approach behaviour in-home and in the arena, with the latter giving more possibilities for behavioural variations in conflicts.

This fact is further stressed by the observation that passive submissive behaviour was significantly correlated to low aggression scores in subtest groups with "high-level" threats (threat at home, manipulation) – but only in the dog's home.

Dogs that showed a high amount of imposing behaviour in their homes scored high on aggression in the arena-situations "accidental interaction, threats, dogs and play". Dogs showing imposing in the arena only scored high on aggression in the subtest groups "dog". For the complete test results there was a significant correlation between high imposers and high aggression for the groups "dog" and "noise". As the sex only played a role for imposing been shown against other dogs, this results stress the point mentioned before, that the quality of interaction and conflict between dog and tester is a different one in the dog's home compared to outside. In the dog's home other subjective necessities might lead dogs of both sexes to show imposing behaviour. The correlation between threatening behaviour, stress behaviour and uninhibited attack behaviour to high aggression scores followed the correlation of "uncertainty" and partly, in a converse way, "attention" and "play".

From the results it can be said that, in concordance with other cited papers, "the main emotional background for aggression is uncertainty and fear".

The correlations between biting history and the significantly higher or lower display of certain behaviours further stress the point that aggressiveness is not a personality trait as such but comes to be influenced by many factors that influence each other also. Here also the difficulties in validating such aggression tests as an instrument to predict in the future become apparent. E.g. dogs that had bitten other dogs scored high on uninhibited attack behaviour in some situations, but not others; and dogs that had bitten strangers scored high on threats. Both are in contrast to Netto & Planta (1997), who stated that only aggressive biting (i.e. uninhibited attack behaviour) should be used for validation of the test, without regarding threatening behaviour and without looking for emotions such as fear etc. Svartberg & Forkman (2002) also did not use an explicit ethogram, but looked in each of the test situations for special behaviours directly shown as a consequence of the respective stimulus. Elements from aggressive behaviour as well as fear behaviour, attention or play behaviour etc. were thus counted.

PCA in Svartberg & Forkman's study revealed five personality factors which partly resemble some of the ethogram groups used here. "Playfulness" would resemble play behaviours, "curiosity/fearlessness" would resemble, based on their loadings of individual behaviours, the behaviours "attention" and "uncertainty". "Chase-proneness" is a factor with no counterpart in the ethogram used here. The factor "sociability" has counterparts in the group of behaviours for social approach, passive submission, and partly play behaviour also. The factor "aggressiveness" in the end is derived from behaviours having counterparts in the threat- and attack behaviour groups of the ethogram used here. Svartberg & Forkmann have been able to show that their personality factors were common to dogs in general, and could be found in every breed group (FCI standard), with "aggressiveness" unrelated to a broader personality factor gained from the other four factors. It will be interesting to further examine breed group differences, using more dogs, and especially look for emotions such as fear. With the help of an ethogram, it should also be possible to confirm or otherwise, the composite "shyness-boldness" characterisation of any dog and its lack of correspondence with "aggressiveness". From a theoretical perspective, this discrepancy is unexpected, because from the literature reviewed in Chapter 1, a connection should be expected between an individual's readiness to display fear, and its tendency to show aggressive behaviour.

Again, as in Chapter 2, the data gave no substantial and valid results to support definite breed differences in the behavioural reactions throughout all test elements. The basis for, and the use of, "prospective aggression tests" has to be examined critically. Will dogs that show less flight behaviour in an aggression test, be the same dogs that bite another dog with high probability later on in their life? Will dogs that show low counts for social approach behaviour, automatically bite their owners or within the family later on in their life? These findings, though coming from a small group of dogs, rather emphasis that aggression tests should not be a single prospective tool, but may be more useful as a retrospective method to help in deciding on measures following a biting incident. The test used here can be one possible prospective tool as long as it concentrates on the overall picture a dog gives in the test in respect to its reactions to stressful, challenging and threatening stimuli.

# Chapter 4:

## Owner influences on the aggression scores and behaviour shown in the aggression test.

## 4.1 Aims

There is little published research on the role the owner might play in the development of social and aggressive behaviour in their dogs, or owner-effects on the actual display of aggression. However, it is generally presumed that the owner's influence is great and should never be neglected when looking at problems created by any dog's behaviour (McConnell, 2002). In this chapter, information on the dog's training background, attention seeking behaviour directed at the owner, and the owner's judgement of the dog's character, are compared to biting history, aggression scoring, obedience level and behaviour derived from the ethogram.

This will indirectly address Hypotheses 2 to 4, by looking into some aspects of how the owner might directly or indirectly contribute to the development and display of aggressive behaviour in his or her dog.

## 4.2 Introduction

Owner/handler influences can be divided into influences on the development of the dog's character, and direct influences on individual aggressive incidents. Environmental influences, including the owner, on the dog's development during the socialisation period have already been described in Chapter 1. Dodman et al. (1996) compared owner-personality-profiles of dogs showing dominance aggression with non-dominant aggressive dogs. Owner personality was not significantly different between those two groups, nor did it affect the outcome of behaviour modification treatment. There was a significant positive effect on the outcome of treatment, whether owners changed from harsh correction methods to non-confrontational means in the treatment programme.

This agrees with Roll (1994), who found that owners indirectly reinforced and increased aggressive behaviours of their dogs in inter-dog conflicts through attention of any kind, including harsh manipulation. Punishment especially increased the likelihood that dogs would show aggressive behaviour. Feddersen-Petersen (2004) also noted that punishment increases stress in dogs, thus leading to a higher probability for aggression to be shown in some situations. A significant correlation exists between the use of punishment and problem behaviour, according to Hiby et al. (2004).

Bruns (2003) mentioned a correlation between punishment (harsh leash correction), heightened stress level, fear and aggression in temperament-tested dogs. She warned that the leash-jerk can become a predicting signal for stress and thus become an aggression-eliciting trigger (see also Böttjer, 2003). Bruns also described qualitative differences in general obedience between dogs that showed attacking behaviour (dogs with "bad" obedience) in the test and dogs that at most showed threats, e.g. growling (dogs with "good" obedience). The "attacking dogs" were distinctly more stressed than the "threatening dogs" in the course of the obedience test. She also reported quite a high level of insecurity and submissive behaviour in all dogs in response to owners giving commands.

Böttjer (2003) observed that many dogs showing attacking behaviour had received a jerk on the leash from their owners immediately beforehand. Böttjer looked at other factors potentially influencing the development of aggressiveness: e.g. when the dog was obtained by the owner and where from, whether it was kept alone or with other dogs, and how it had been trained. She could not find any significant correlations but there was a tendency for answers on training methods (reinforcement or punishment) in the owner-questionnaire not to correlate with the actual behaviour of the owners (e.g. giving harsh leash corrections) in the test.

Borchelt & Voith (1986) found no significant correlation between the experience of the owner and the prevalence of behaviour problems in dogs. Voith et al. (1992) could not find any links between anthropomorphic attitudes of the owner and behaviour problems either. They also could not find any distinct correlation between behaviour problems and training for obedience. Jagoe & Serpell (1996), on the contrary, found a significant correlation between training for obedience and a reduced prevalence of competitive aggression and some other problems (e.g. separation related problems) in their dogs.

Svartberg (2002) found a relationship between the success of a dog in working trial tests and the handler's experience. Dogs from experienced handlers scored "better" in the complete test. "Better" has to be put in parentheses, as no direct biological measures are judged in these tests (see Chapter 2).

No evaluation has been published on the direct influence of the owner's knowledge of dog behaviour and training, on the prevalence of behaviour problems or biting incidents. Although this topic was not the direct aim of this study, links have been explored between owner assessments of their dog's character and the hierarchical structure between them and the dog, and the method of training, and these have been compared to the biting history and the scoring and behaviour shown in the aggression test.

## 4.3 Materials and methods

### 4.3.1 Dogs

The dogs have been described in detail in section 2.3.1.

### 4.3.2 Data collection and statistical analysis

The questionnaire used was in concordance with official regulations in the course of testing dogs following DDA legislation. For this thesis the following questions were utilized in addition to those already mentioned in Chapter 2. The complete questionnaire can be found in Appendix 1.

- Had the dog undergone any special training/education: hunting dog, schutzhund, search and rescue, agility, guide-dog, service-dog, German "Begleithundprüfung" (companion dog test "canine good citizen" including reaction to shot (CGC-shot)), German "team-test" (companion dog test "canine good citizen" without reaction to shot (CGC-no shot)), dog-dance.

- Method of reinforcement and/or punishment during education, and tools used: verbal reinforcement, treat, play, stroking, verbal correction, verbal punishment, physical punishment, flat collar, choke-collar, prong collar, electronic collar, Halti®, other.
- How often the dog begs for attention from the owner and how often is this begging given in to by the owner; both measured on a scale from 1 (= never) till 5 (= permanently, always).
- Estimate by the owner of the social hierarchy between owner and dog, on a scale from 1 (= owner above dog in status) till 5 (= dog above owner in status).
- Dog's character as described by the owner: fearful, timid, friendly, curious, brave, calm, active, hectic, playful, aggressive (character traits taken from FCI-standards).

Apart from the type of collar no other tools were mentioned, e.g. clicker or Fisher-disks. This was decided because these were fairly new tools (one used as a positive reinforcer, the latter used as a punisher) and there was little scientific literature, apart from laboratory studies, on secondary reinforcers or punishers. Just recently Williams et al. (2004) have stated that there was no difference in training time and training efficacy between horses trained with a clicker and those receiving only a primary reinforcer.

Statistical analysis was done with SPSS® version 12 for Macintosh and version 12 for Windows. Data files for statistical analysis were produced using the following programs: File Maker 7® and EXCEL®, both for Macintosh and Windows. Data was inspected by crosstabulation, and examined for normal distribution. Parametric tests were applied where possible. Non-parametrical analysis of variance was done with Kruskal-Wallis-test, Spearman Rank test and Mann-Whitney-U-test. Cluster analysis (binary data, squared Euclidian Distance followed by average linkage) was used to place training methods into groups.

## 4.4 Results

### 4.4.1 Training (formal and by owner)

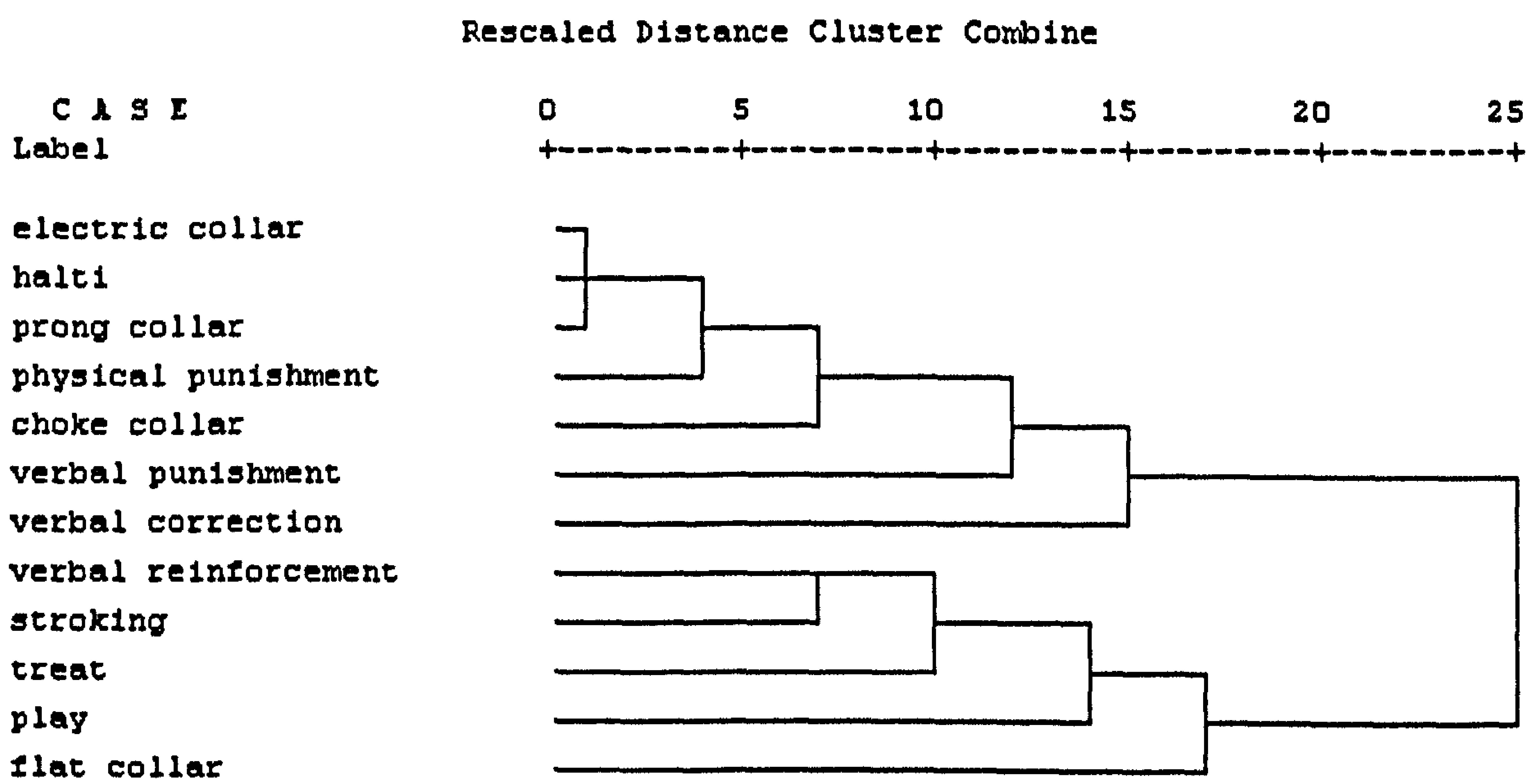
Special training had been undergone by 37 dogs (canine-good-citizen (cgc)-shot: 27 dogs; cgc-no shot: three dogs; schutzhund: five dogs; hunting-dog: one dog; agility: one dog). As all but one of these frequencies were too small for statistical analysis, the dogs were grouped in those having any formal training and those having none.
Table 4.1 gives an overview on the methods of reinforcement and the methods/tools used in training. Many owners had ticked more than one method of reinforcement and no dogs at all had been trained solely with punishment. Thus two groups were constructed; dogs that had only been trained with the help of positive reinforcement (N=119) and dogs that had experienced both punishment and positive reinforcement during training (N=135). Frequencies for individual methods/tools of education were, apart from the flat collar, quite low. Thus choke-, prong- and electric collars were grouped together (51 dogs) for some statistical evaluations, as all are advertised as inflicting aversive sensations and are claimed to give the owner an easy and effective control in the case of unwanted behaviour/disobedience (Myles, 1991).

Table 4.1) Numbers of dogs reported by their owners to have received individual methods of reinforcement and training methods/tools. Owners could tick more than one.

| Method of reinforcement | number | Means/Tools for training | number |
|---|---|---|---|
| Stroking | 196 | Flat collar | 143 |
| Verbal reinforcement | 194 | Choke collar | 40 |
| Treat | 180 | Prong collar | 9 |
| Play | 132 | Electric collar | 2 |
| Verbal correction | 94 | Halti | 7 |
| Verbal punishment | 74 | | |
| Physical punishment | 21 | | |
| Dogs trained solely with positive methods | 119 | Dogs trained with tools inflicting aversive sensations | 51 |
| Dogs trained with positive and negative methods | 135 | | |

Cluster analysis of methods of reinforcement and methods/tools used revealed two distinct groups (Figure 4.1): one group consisting of punishment plus aversive tools, the other consisting of positive reinforcement plus flat collar. Interestingly, because it is not designed to be associated with aversive techniques, the Halti was linked with the first group. The questionnaire did not gather information on when the different methods and tools had been used. Thus it is possible that owners had changed to a tool promising more control (as the Halti does) after identifying a problem with their dogs; they may have started to use punishment for the same reason. Interestingly, 56 owners did not tick any collar at all, which agrees with Böttjer's idea (2003) that apparently some dog owners did not see the leash as a distinct tool for education or training.

Figure 4.1) Dendrogram from hierarchical cluster analysis of owner-reported combinations of methods of reinforcement and methods/tools used for training. Method: squared Euclidian Distance followed by average linkage between groups. Each owner's total scores for all methods/tools were used.




The clusters (Figure 4.1) were generally supported by crosstabulations of pairs of methods and/or tools (Pearson $Chi^2$; Fisher exact test for small numbers; see Table A 4.1 in Appendix 4). Owners that used verbal reinforcement, had a high probability of using most other educational means, and flat- and choke collars ($Chi^2$ ranging from 73.122 to 8.483; significance p ranging from <0.001 to 0.004). They rarely used physical punishment ($Chi^2$=4.513; p=0.031). Physical punishment was strongly linked to verbal correction ($Chi^2$=15.077; p<0.001) and verbal punishment ($Chi^2$=15.620; p<0.001). Using the choke collar was associated with using a Halti ($Chi^2$=16.820; p=0.001); usage of electric collar and Halti was marginally associated (Fisher's exact test p=0.054). This further strengthens the suggestion that all three tools might be used by owners as easily accessible means of last resort, when confronted with a problem.

### 4.4.2 Aggression scores, behaviour, breeds, education characteristics and biting history

Scores in the nine aggression subtest groups (see Chapter 2) were then compared according to whether the dog had received formal training or not. As expected, there was a highly significant association between a "good" obedience score and formal training (MWU=1823, p<0.001; for complete data see Table A4.2 in Appendix 4). In the aggression subtest group (D) comprising test elements with other dogs, dogs with formal training showed marginally significant lower aggression scores (MWU=3256, p=0.046). The use of punishment had no significant influence on the aggression scores in the subtest groups, but "bad" obedience was significantly linked with the use of punishment (MWU=6377, p=0.004; for complete data see Table A 4.3 in Appendix 4). The use of choke-, prong- or electric collars was also significantly associated with "bad" obedience levels (MWU=3774, p=0.010; see Table A 4.4 in Appendix 4).

Breeds were grouped according to whether they were listed in any DDA in Germany (group 2: American Staffordshire Terrier, Bullmastiff, Bullterrier, Bullterrier X, Dogue de Bordeaux, Pitbull Terrier, DDA listed) or not (group 1: DDA unlisted, Rhodesian Ridgeback) and compared to each other according to education and training etc. The groups did not differ significantly in whether punishment (Pearson $Chi^2$=.180; p=0.678) or the named aversive collars (Pearson $Chi^2$=2.784; p=0.097) were used. DDA unlisted breeds were more likely to have received formal training (Pearson $Chi^2$=17.261; p<0.001).

Finally it was examined whether formal training, use of punishment or type of collar used was linked to behaviours or behavioural groups from the ethogram (see Chapter 3). The frequencies of behaviours for stress and arousal in the complete test (MWU=2723.5, p=0.002) and in the arena test elements (MWU=2760, p=0.002) were higher in the "formally trained" group. This was also the case for play behaviour shown in the dog's home (MWU=3072.5, p=0.018).

Dogs that had experienced punishment during training had significantly higher counts for threatening behaviour in the complete test (MWU=6791, p=0.033). The usage of choke-, prong- or electric collars was not significantly associated with any of the behaviours or behavioural groups.

There was no significant association between the biting history of the dog and either special training or usage of punishment. But there was a marginally significant positive link between whether dogs wore a choke-, prong- or electric collar, and had bitten within the family (Pearson $Chi^2$=3.855; p=0.050) or had been bitten by other dogs (Pearson $Chi^2$=5.397; p=0.020). Dogs that had bitten other dogs had experienced a significant amount of physical punishment (Pearson $Chi^2$=5.053; p=0.025).

### 4.4.3 Attention- seeking behaviour (initiating contact) and social status of the dog as perceived by the owner

The following table (Table 4.2) gives the frequencies of answers to the questions on how often the dog initiated contact between dog and owner, the reaction of the owner to this attention begging and the perceived hierarchy between dog and owner. Figure 4.2 shows the distribution of answers for the perceived hierarchy. In general most owners saw themselves as above the dog.

Table 4.2): Frequencies for answers to the questions on how often the dog initiated contact between dog and owner, the reaction of the owner to this attention-seeking and the owner's perception of the hierarchy between dog and owner

| | Always | Almost always | Equally | Almost never | Never |
|---|---|---|---|---|---|
| Dog initiates contact | 82 | 73 | 87 | 11 | 1 |
| Owner reacts to contact initiated by dog | 110 | 55 | 70 | 15 | 4 |
| | **Owner higher than dog** | **Owner nearly on top** | **Owner and dog on equal levels** | **Dog nearly on top** | **Dog higher than owner** |
| Perceived hierarchy between dog and owner | 208 | 18 | 16 | 2 | 10 |

Dogs which initiated more contact were reacted to by the owner significantly more often (Spearman rho=0.346, p<0.001). The correlation between the owner's statement on status difference, and how often they gave in to the contact initiation of the dog, was not significant (Spearman rho=-0.040, p=0.523). Also non-significant was the correlation between the perceived hierarchy and how often the dog initiated contact (Spearman rho=-0.104, p=0.098).
Mann-Whitney-U tests revealed no significant associations between biting history and these three variables. The complete data are shown in Appendix 4, Table A 4.5.

Dogs with a "bad" obedience level initiated contact with the owner significantly more often than those with good obedience (Spearman rho=0.135, p=0.031). High aggression scores in subtest group B (threatening situations) were marginally positively correlated with the dog's frequency of initiating contact (Spearman rho=0.129, p=0.040). Apart from this there were no correlations between frequency of initiating contact or being successful with it, and the mean aggression scores in the subtest groups. No significant correlation between the supposed status of the owner and the aggression scores of the dog or its obedience level could be seen.

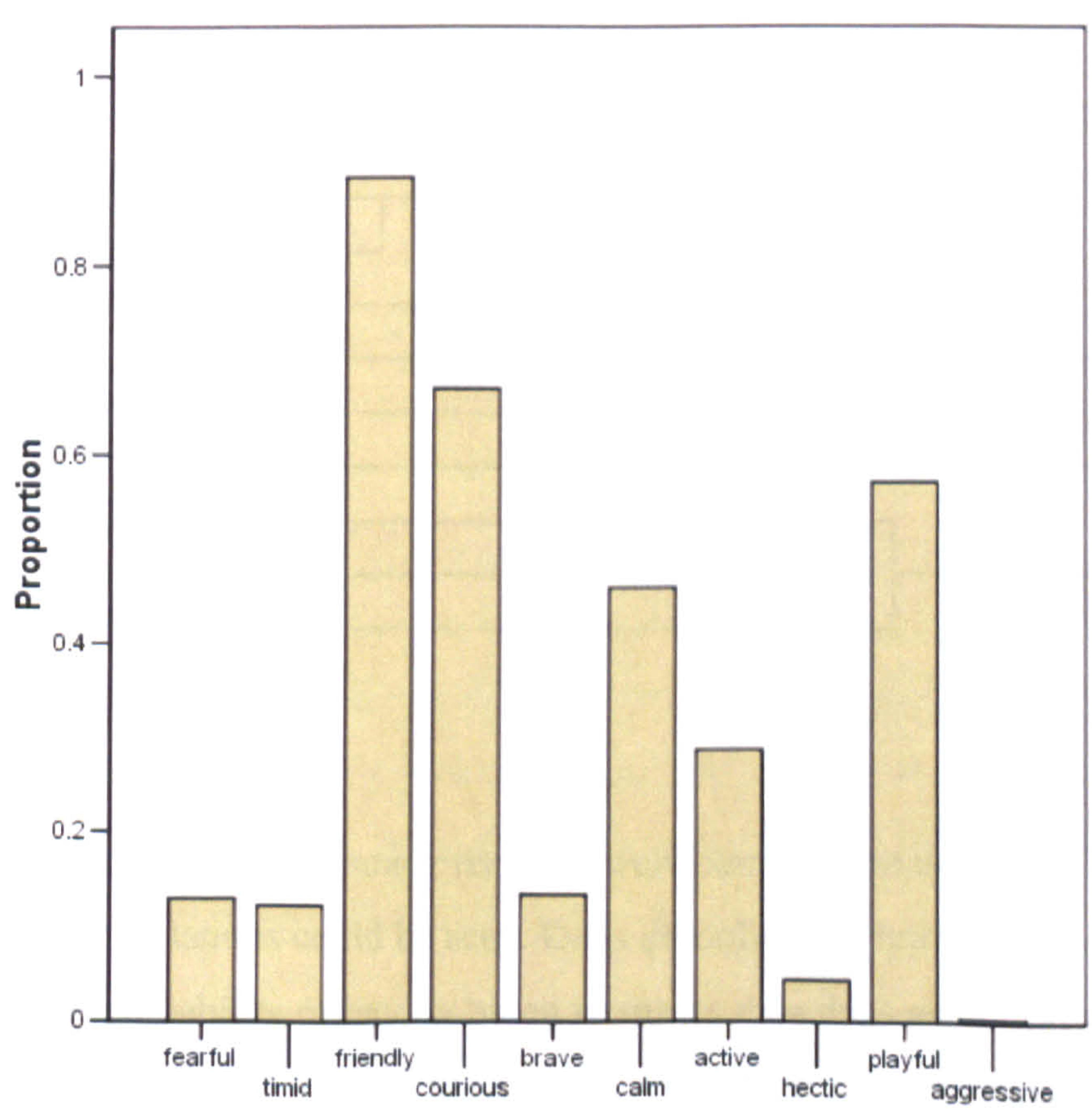
From the ethogram, high counts for uninhibited biting were significantly correlated with "always initiating contact" (Spearman rho=0.128, p=0.041) as were high counts for stress and arousal (Spearman rho=0.170, p=0.007). Dogs showing much "uncertainty" in their own home during the test initiated contact with the owner significantly more

often (Spearman rho=0.163, p=0.009). Owners who saw themselves high in status had dogs showing significantly more play behaviour in the arena test elements (Spearman rho=0.138, p=0.028).
No breed differences could be detected for these three variables.

### 4.4.4 Characterisation of the dog by the owner

Owners could tick more than one item to characterise their dogs (Figure 4.3). Most (227) owners stated their dogs to be friendly and 170 owners had a "curious" dog. Another 117 owners claimed their dogs to be calm, compared to 73 who said they had an active dog, and 145 owners said that their dogs were playful. Thirty-three dogs were characterised as fearful and 31 as timid; 34 were said to be brave; 11 were termed hectic and one dog was said to be aggressive.

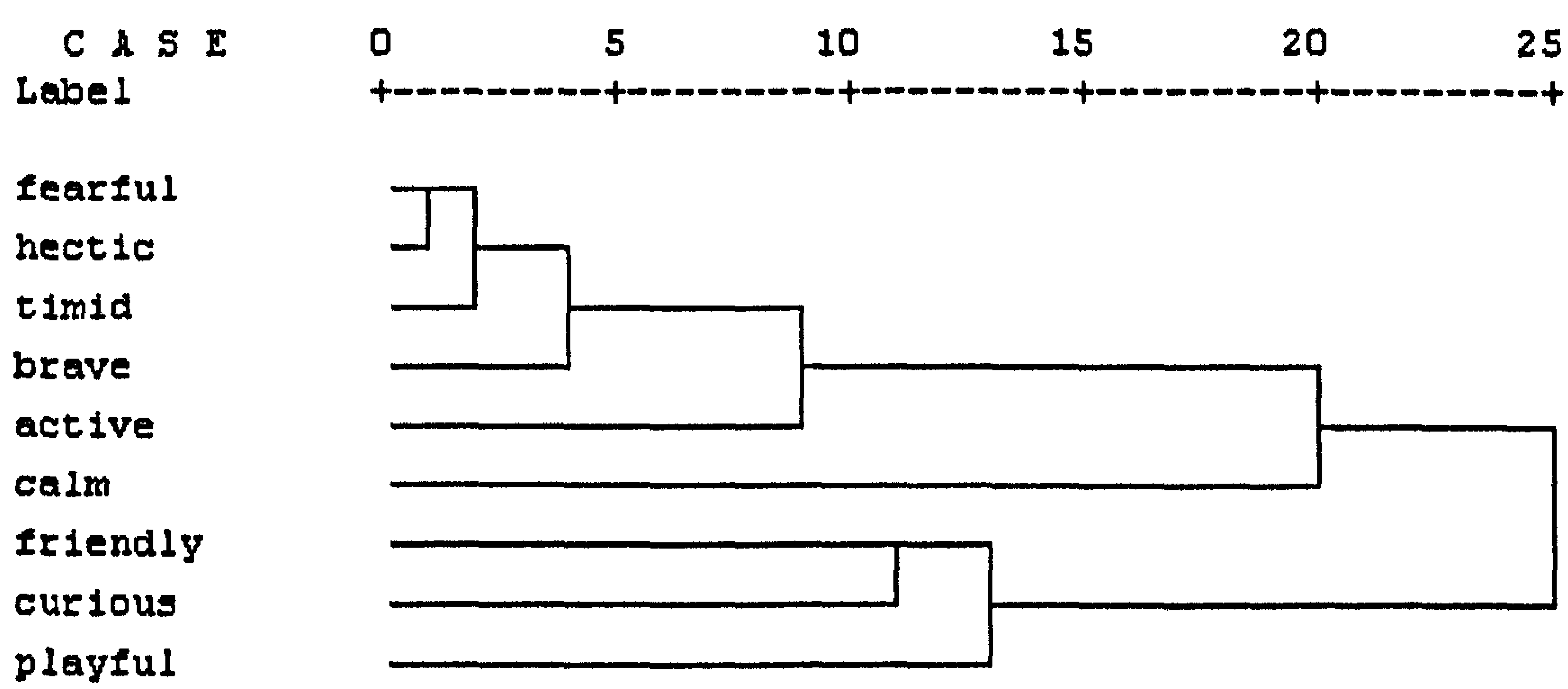
Figure 4.2) Proportions of the sample given the different characterisations by their owners



Pearson Chi$^2$ was used to look for any significant associations between each of the characterisations. Fearful dogs were unlikely to be described as friendly (Pearson Chi$^2$=11.058, p=0.001) or calm (Pearson Chi$^2$=7.269, p=0.007) but were likely to be hectic (Pearson Chi$^2$=5.556, p=0.018). Timid dogs were not described as friendly (Pearson Chi$^2$=5.308, p=0.021). Friendly dogs were usually described as playful (Pearson Chi$^2$=4.957, p=0.026). Curious dogs were also termed "active" (Pearson Chi$^2$=14.999, $p<0.001$) and playful (Pearson Chi$^2$=18.478, $p<0.001$) but not calm (Pearson Chi$^2$=4.940, p=0.026) and active dogs were rarely described as calm (Pearson Chi$^2$=32.917, $p<0.001$). Aggressiveness could not be analysed as it was used to describe just one dog.

Cluster analysis (Figure 4.3) showed that friendliness, curiosity and playfulness formed a distinct group against being brave, hectic, fearful and timid. Being active was loosely linked to the group comprising fearfulness etc. Calmness was not particularly associated with any other characteristic.

Figure 4.3) Dendrogram from hierarchical cluster analysis; descriptors used by owners to characterise their dogs. Clustering by squared Euclidian Distance method followed by average linkage between groups. Each owner's total scores for all characterisations were used.




When the different characterisations were compared to the biting history of dogs, only some correlations could be seen. Dogs described as "brave" by their owners had a higher probability of having bitten strangers than dogs not described as "brave" (Pearson Chi$^2$=4.143; p=0.042), were more likely to have bitten other dogs (Pearson

$Chi^2$=9.119; p=0.003) and also to have been bitten (Pearson $Chi^2$=7.576; p=0.006). Dogs described as "friendly" had rarely bitten strangers (Pearson $Chi^2$=6.278; p=0.012); "fearful dogs" giving the opposite picture with marginal significance (Pearson $Chi^2$=4.389; p=0.036). Timid dogs had rarely been bitten by other dogs (Pearson $Chi^2$=5.275; p=0.022).

Associations were then examined between these descriptors and the aggression scores per dog in the different subtest groups and at the obedience level. Dogs described as fearful had significantly higher mean aggression scores in all subtest groups. Subtest group D (dogs): MWU=2855, p=0.029. All other groups: MWU from 1982 to 2617, p<0.001. There was no association between fearfulness and obedience level (MWU=3584, p=0.873).

For dogs described as timid the link with high aggression scores was only significant in subtest group F (strange person) (MWU=2709, p=0.016) and subtest group G (threats at home) (MWU=2732, p=0.026). "Friendly" dogs gave high aggression scoring in subtest group B (threats) (MWU=2283, p=0.019), E (play) (MWU=2361, p=0.003); G (threats at home) (MWU=1751, p<0.001), H (manipulation) (MWU=2090, p<0.001) and I (friendly people) (MWU=2267, p<0.001).

Dogs stated to be calm, showed significantly high aggression scoring in subtest group D (dogs) (MWU=6775, p=0.021) and F (strange person) (MWU=7029, p=0.038). Active dogs had a significantly bad obedience levels (MWU=5133, p=0.005) and gave high aggression scores in subtest group C (noise) (MWU=5415, p=0.003).

When the different behaviours/groups from the ethogram were examined, playful dogs showed a significant high number of behaviours for social approach (MWU=6111, p=0.002), passive submission (MWU=6540, p=0.019), flight- (MWU=6562, p=0.021), play- (MWU=5644, p<0.001) and behaviour for stress and arousal (MWU=5587, p<0.001). Uncertainty was also significantly higher than in dogs not described as "playful" (MWU=6689, p=0.036).

Active dogs showed a significantly high number of submissive behaviours (MWU=5516, p=0.039), flight behaviour (MWU=4826, p=0.001) and play behaviour

(MWU=5155, p=0.006). In the subtests performed in the dog's home only, active dogs showed a high frequency of imposing behaviour (MWU=5206, p=0.002).

Calm dogs showed a high frequency of submissive-(MWU=6067, p=0.001), flight-(MWU=6397, p=0.006) and play behaviour (MWU=6200, p=0.002) also. Additionally they expressed a high amount of uninhibited attack behaviour (MWU=7038, p=0.003) and behaviour to show stress and arousal (MWU=6020, p=0.002). Uncertainty was shown at a high frequency also (MWU=6383, p=0.005).

Behaviour for social approach was shown significantly more often from brave dogs (MWU=2929, p=0.042) as was play behaviour in the dog's home (MWU=2896, p=0.028) and flight behaviour in the arena (MWU=2957, p=0.049).
Curious dogs showed threatening behaviour quite often (MWU=6002, p=0.038) and behaviour for stress and arousal in the dog's home (MWU=5594, p=0.005).

Friendly dogs displayed a high number of behaviours for social approach (MWU=2158, p=0.012), passive submission (MWU=1975, p=0.003), threatening behaviour (MWU=2157, p=0.012), flight behaviour (MWU=1961, p=0.002) and play behaviour (MWU=1896, p=0.001). Uncertainty (MWU=1602, p<0.001) and attention (MWU=1923, p=0.002) were both shown in high frequency.
Timid dogs showed significantly high frequencies of imposing- (MWU=2667, p=0.027), flight- (MWU=2008, p<0.001), play- (MWU=2705, p=0.049) and behaviour for stress and arousal (MWU=2247, p=0.002). Fearful dogs showed threatening behaviour significantly more often (MWU=2759, p=0.024) as well as uninhibited attack behaviour (MWU=3124, p=0.018) and play behaviour (MWU=2842, p .040).

Owner's characterisations of the dogs were then compared to which training methods and schemes the owners had used. Owners naming their dogs as fearful were significantly more likely to have used aversive collars on the dog (MWU=3041, p=0.023). Calm dogs were significantly more likely to have received formal training (MWU=7258, p=0.034). None of the other possible correlations were significant.

There were a few significant differences between breed groups in how the owners had characterised their dogs. Characterisation as "calm" differed significantly between breeds (Pearson $Chi^2$=38.483; df=7; p=0.022) with Dogue de Bordeaux, DDA listed dogs and Bullmastiff being the calmest. A difference was also evident for "active" (Pearson $Chi^2$=21.703; p=0.005) and "playful" (Pearson $Chi^2$=21.694; p=0.006); the most "active" dogs were Bullterrier, DDA unlisted and DDA listed dogs, most playful dogs were Bullterrier, DDA listed dogs and Bullterrier X. Most "curious" dogs were DDA listed dogs, followed by Bullterrier and Bullterrier X (Pearson $Chi^2$=16.611; p=0.034).

## 4.5 Discussion

### 4.5.1 Does training/education affect aggression shown in an aggression test?

Information on the dog's training background and attention seeking behaviour towards the owner, as well as the owner's judgement of the dog's character, were compared to biting history, aggression scoring, obedience level and behaviours shown from the ethogram.
Altogether 14.5 % of the sample had received formal training. It is difficult to ascertain whether this is a typical proportion; for example, data from kennel clubs on dog numbers does not differentiate by education. Even Horisberger (2002) who did a thorough examination of her "biting" dog population concerning age, sex and neuter status, breed etc. did not look at their education/training status.

As expected, dogs that had received formal training scored high for obedience. In the aggression scores, formal training was apparently only beneficial for the test elements concerning other dogs. Overall, high scores for obedience correlated with low scores for aggression for all five subtest-groups (including other dogs). The test elements comprising dog-dog interaction are the least standardised and controllable by the tester; and they are test elements that resemble "everyday" occurrences for the test dog, as owners probably have to control dog-dog encounters on a regular basis. The influence of formal training could therefore be higher in dog-dog than in all other test elements; this might explain why measured obedience affected five out of nine subtest-groups for aggression, but only one subtest-group was affected by formal training.

Netto & Planta (1997) state that dogs with Schutzhund-education should be more likely to show aggressive biting. As Schutzhund-training in Germany includes intensive training for obedience (Raiser, 1979), the opposite would be expected. Netto & Planta, though, do not back up their statement with statistical data and as far as the author knows, this correlation has never been intensively investigated with a large sample of dogs.

Training with punishment and "aversive collars" had no significant influence on aggression shown in any subtest group, but there was a significant correlation to "bad" obedience levels. Hiby et al. (2004) found a significant correlation between the use of reward and "good" obedience and no correlation between obedience level and the use of punishment. They differentiated between one and the other whereas here all dogs had experienced "reward training" with some additionally having experienced punishment. However, overall the trends in the two studies are similar.

It cannot definitely be concluded whether the dogs here were trained with punishment/ aversive tools because of bad obedience levels, or conversely, whether the bad obedience level was a result of that training. Apparently the use of these methods had no direct influence on the quality of aggressive display in the test elements, in contrast to some statements in the literature (Roll, 1994; Feddersen-Petersen, 2004). Again a much larger number of dogs will be needed to disclose any significant correlation between the previous use of punishment/aversive means in training and the display of aggressive behaviour in an aggression test.
Bruns (2003) and Böttjer (2003) looked directly at how the owner handled the dog in some test elements and found a positive correlation between harsh leash correction and heightened stress level, fear and aggression in these dogs. This fact was considered here to be too high a source of errors due to small sample size. "Harsh leash correction" would have needed to be defined as a distinct factor beforehand, preferentially with a much larger number of dogs.

There was a significant correlation between the use of punishment and a high display of threatening behaviour in the test, but there was also an unexpectedly high correlation between the display of stress behaviour and play behaviour and formal training. The finding that dogs trained with aversive collars tend to bite family members and are also more likely to be bitten by other dogs, is also not easy to interpret. In conclusion, it can be said that associations between education and history of biting, aggression scores and behaviour do exist, but that the underlying mechanisms are still unclear.

### 4.5.2 Do "dominant" dogs show more aggressive behaviour in an aggression test?

It is generally agreed that to gain information on status differences between members of a social group, all social interactions should be examined, not only aggressive displays. In particular, dyadic interaction on a subtle, non-overtly offensive level gives valuable information on the actual status difference between individuals (see section 1.2.2.3 and 1.3.2.3). In encounters between a pair of dogs (or wolves) a wide variety of outcomes are possible (e.g. aggressive reaction or submissive display) that give information on status differences. Turning to human-dog relationships, it was assumed that the majority of owners presented here had no problem in approaching and touching their dogs (i.e. no aggressive reaction from the dog). Thus it was decided to ask for information about the dog's initiations of social contact, the owner's reaction to these attempts and the owner's own idea of the dog's status in relation to themselves.

Dogs which almost always initiated contact were also reacted to by the owner significantly more often. This could lead to dogs subjectively perceiving their status as above the owner. However, the owner's perception of status difference was neither significantly correlated to how often the dog initiated contact nor how often the owner gave in. The fact that significantly more dogs from the group with self-rated "high ranking" owners bit within the family, could indicate that many owners still do not have much actual knowledge of dog behaviour. Dogs initiating contact quite often showed significant levels of uninhibited biting, stress behaviour and uncertainty, similar to the trends found by Rooney et al. (2003). Overall, these associations provide further support for further research in the complex field of dog-human social interaction when looking at biting incidents and "dangerous dogs"

Also interesting was the correlation between bad obedience levels and how often the dog initiated contact with and was reacted to by the owner. It can be assumed that attention by the owner (social contact) plays a relevant role as a positive reinforcer in training. For dogs that get attention "for free" (i.e. whenever they want) this reinforcer might not be of high value, thus leading to bad performance/slow learning in training.

The few points looked at give no distinct information on the general hierarchy between dog and owner and no complete picture as to whether a "dominant" or "dominance-seeking" dog in an owner-dog dyad would actually tend to react more aggressively in an aggression test or in general. However, no evidence has been found to support this widely-supported dogma (even by the professional dog training community). Nevertheless it has to be stated, that the correlations mentioned above were quite weak in certain cases and due to small numbers no statistical correction for multiple testing was undertaken. Again this implies that further research in this field, using larger samples, is necessary.

### 4.5.3 Correlation between owner's characterisation and aggression scores and behaviour in the test

Owners were given certain characterisations to choose, taken from the FCI-standards of some breeds dealt with here (Rhodesian Ridgeback, Bullterrier, American Staffordshire Terrier, Doberman, Bullmastiff, Dogue de Bordeaux). Characterisations could be grouped in a "nice-dog" group (friendly, curious, playful) and a "bad-dog" group (fearful, hectic, timid, brave) with the characterisation "active" rather belonging to the latter, and "calm" being somewhere in the middle. The two groups were almost mutually exclusive for the features in brackets. The close association between "timid" and "brave" in the owners' perceptions is interesting. This could be interpreted as suggesting that both a timid dog and a brave dog show behaviours that are unwanted by human society overall, although an individual owner might appreciate them to some extent. Whereas a timid dog might withdraw from an object or individual ("it is Ok when my dog does not like to be touched by anybody"), the brave dog might show aggressive communication or offensive aggression ("it growls at every stranger entering the premises"). The owners were not asked for descriptions for individual characterisations, and this is again another important point to be investigated further.

Looking at biting history, no characterisation was correlated to biting within the family, but "brave" dogs tended to bite strangers and other dogs and also got bitten. Friendly and fearful dogs had both bitten strangers, while timid dogs had mostly been bitten by other dogs. As expected, dogs described as fearful showed high aggression scores in all subtest-groups, whereas dogs described as timid showed high aggression scores only in the test elements involving strange persons and involving threats at the dog's home. Dogs described as "friendly" gave high aggression scores also, but in fewer subtest-groups than fearful dogs. The "friendly" dogs reacted with aggression in test elements involving threats (arena and dog's home), play, and manipulation and friendly contact in the dog's home. This suggests that some of the descriptions given by owners may have been motivated by trying to give a good impression of their dog's character, knowing that it was about to be tested for aggression.

When the different characterisations were compared to the behaviours from the ethogram, no distinct picture could be seen, apart from the fact that "bad dogs" showed a tendency to display higher levels of uninhibited attack behaviour, threatening behaviour and imposing behaviour. But play behaviour, flight behaviour, passive submission and stress behaviour were shown by them also, and the "brave" dogs did show a high number of behaviours for social approach. Friendly dogs showed higher levels of social approach than the brave dogs, but also showed all other behavioural groups to a greater extent, apart from uninhibited attacking behaviour and stress behaviour.

Serpell & Hsu (2001) concluded that the assessment of candidate guide dogs by puppy walkers was a valid means of predicting their suitability for work (for example, using fear of certain objects of a certain type as a criterion for excluding the dog from further training). Stephen & Ledger (2003) stated that owners were reliable observers of their own dog's behaviour, providing a more reliable external reference for the validation of temperament tests than an independent tester. Both of these sets of authors did not ask their owners for any direct characterisation as done here, but asked them to tick certain descriptions of the dog's behaviours for certain situations. This seems a better way to get a description of the dog's character by the owner and could prove a valid tool in aggression tests also. Just asking for some "nice dog" and some "bad dog" characterisations could lead to wishful thinking or attempts at deception.

# Chapter 5:

## Development of social behaviour in the Rhodesian Ridgeback

## 5.1 Aims

Comparison between puppy and adult dog is necessary in order to answer whether a puppy's social and, in particular, its aggressive behaviour predict how it will behave socially when adult, and also whether aggressive traits are inherited in certain breeds. This chapter will deal with the development of social behaviour in puppies from the Rhodesian Ridgeback breed. In the following chapter the information gained here will be compared with data on the social behaviour of the same sample of dogs when adult.

Emphasis is placed not only on the puppy as an individual but also on how the individual puppy behaves in dyadic interactions. Quality and quantity of social interaction were recorded using an ethogram derived and modified from Schöning (2000a) and Rottenberg (2000). The development of the social behaviour of the puppies will be compared to analogous data already existing for other breeds.

## 5.2. The Rhodesian Ridgeback

The typical Rhodesian Ridgeback is described as a handsome, strong, muscular and active dog; symmetrical in outline, capable of great endurance with a fair amount of speed. The standard for the mature dog is that it should be handsome and upstanding, dignified, intelligent and aloof with strangers, but showing no aggression or shyness (FCI-Standard Nr. 146, cited in Carlson, 1995). The usefulness of the standard as a practical concept for examining a breed and the behaviour of its individuals will be discussed later.

The Rhodesian Ridgeback was first mentioned in 1891, when the Kennel Union of Southern Africa was founded (Gallant, personal communication). In 1922 the breed standards were described and set for the first time (Hawley, 1957; Carlson, 1995, 2000). "Ridged dogs of the Hottentots" were already described by the first European settlers in the Cape area in the 17$^{th}$ century and the modern Rhodesian Ridgeback was developed by crossing these "Hottentot Dogs" with the dogs of the settlers (Hawley, 1957). It is supposed that these native ridged dogs of southern Africa sprang from Pariah Dogs originating in the Middle East which started migrating south around 5000 BC (Gwatkin, 1934; Jeffreys, 1953; Hawley, 1957).

At the end of the 19th and beginning of the 20th century the Ridgeback was mainly used for hunting purposes. They were usually kept in small groups of two or three dogs. They were used to locate, follow and corner the prey, thus allowing the hunter to shoot. As lions were a popular prey for human hunters in those days, and as the dogs sometimes got attacked by the cornered prey, the legend of the "lion fighting dog" came to life. The Ridgeback as a hunting dog usually underwent no special training by humans to serve that purpose, as other hunting dog breeds do. From the beginning of the 20th century the Ridgeback was used more and more as a guarding dog for farms and houses and more recently has become something of a companion dog in North American and European society (Carlson, 1995, 2000).

In Germany, the Rhodesian Ridgeback has become a popular breed during the last two decades. In 1998 roughly 1265 breeders and owners incorporated the three Rhodesian Ridgeback Clubs under the umbrella of VDH (Verein für das Deutsche Hundewesen, the German equivalent to the British Kennel Club). In 2001 the number of breeders and owners had dropped slightly.

Although there are still three registered clubs within the VDH, there have been some changes in club structure in the last 24 months. For a short time in 2000/2001 a fourth club existed, which was recently disbanded. One existing club changed its name, in order to demonstrate that the emphasis of this club's work is on promoting the Ridgeback as an acknowledged hunting dog breed in Germany. In the FCI nomenclature the Ridgeback currently runs in group 6 (Gundogs and Hounds) but is not an acknowledged hunting dog breed in Germany. In 2002 all the clubs together registered 649 puppies, in 2004 691 puppies (VDH Welpenstatistik, 2003, 2004). The numbers of owners/breeders who are not connected to the VDH is unknown, nor is the number of puppies they produce each year. The VDH (2003) estimates that just 25 % of all puppies (of all breeds) purchased per year come from a VDH breeder. Twenty percent are imported and about 55% come from uncontrolled breeding.

In Germany the Rhodesian Ridgeback was under intensive discussion (and still is to some extent) as to whether it should be classified as a dangerous breed, together with breeds like the Bullterrier, American Staffordshire Terrier or Pitbull Terrier. Up to the spring of 2003 the Rhodesian Ridgeback was listed in the Dangerous Dog Act (DDA) of the German state of Bavaria (Verordnung über Hunde mit gesteigerter Aggressivität und Gefährlichkeit vom 10. Juli 1992). Bavaria was one of the first states ever to define a list of so called dangerous dog breeds, and the German DDAs established subsequently mainly followed Bavaria in their lists of breeds. At the present moment (winter 2005) 13 of the 16 German states list certain breeds as being per se dangerous in their respective DDAs. The differentiation into dangerous and non-dangerous breeds was done following a vague concept. Usually breeds were named as dangerous when they either led the statistics of biting-incidents by dogs, or when, though not leading the statistics, these incidents had been reported over-proportionally to lead to severe wounds or fatalities. The purpose the dogs were originally bred for was slightly taken into consideration as well.

In the average year for the period 1992-1997, 507 incidents with crosses were listed (excluding Pitbull crosses or Bullterrier crosses). German Shepherd Dogs followed with 391 incidents, subsequently followed by Rottweilers (108 incidents), Pitbull Terriers (64 incidents, crosses included) and Bullterriers (34 incidents, crosses included). For the Rhodesian Ridgeback 1.5 incidents were reported per year to the authorities (Deutscher Städtetag, 1997). From 1998 data is scarce, and exists from only some German states. Berlin lists 2.6 incidents per year for the period 1998-2004 (Kuhne & Struwe, personal communication). Hesse lists one incident with a Rhodesian Ridgeback for the period 24.8.2000 - 29.10.2000 (letter of the Hessian Ministry of Inner Affairs to the German Ministry of Inner Affairs from November 2000).

Despite these numbers, the Rhodesian Ridgeback had found its way into the Bavarian Dangerous Dog Act, due to the fact that it is a large and strong dog that is "not native in Germany and therefore not known to the German population". This makes, according to the judge's verdict, "conflicts more possible than conflicts with other large and strong breeds like the German Shepherd or Rottweiler, which altogether have a greater acceptance in Germany" (Verdict: Bayrischer Verfassungsgerichtshof, 12. Oktober 1994, Nr. Vf. 16-VII-92 und Vf. 5-VII-93).

A highly emotional discussion is still running as to whether certain breeds belong within a Dangerous Dog Act or not, and indeed whether there should be a list of breeds at all, as behaviour is always a mixture of inborn traits and learned responses to environmental stimuli. Although each owner gives his or her dog a specific direction in its individual behavioural development, the owner can only use what potential is already there when starting. This potential is what is set, up to a certain but as yet unknown point, by inborn traits, and can be characterised in each breed by giving it its own ethological profile (Feddersen-Petersen, 1994a, 2004; Schöning, 2000a).

## 5.3 Ontogeny of social behaviour in the Rhodesian Ridgeback

For the Rhodesian Ridgeback some research has already been undertaken to look whether there might be differences in development of aggressive behaviours due to some inborn traits when compared to other breeds. This was examined under the premise that individual breeds differ in the onset of certain behaviours in the ethogram, according to the purpose the breed was originally developed for. Two hypotheses were tested: (1) whether the Ridgeback differed in its behavioural development from the average in the other breeds examined so far, taking into account its dual function as a guarding and hunting breed, and (2) whether so called "aggressive breeds" showed a difference in behavioural development compared to other breeds that were supposed to be less aggressive. These questions could not be answered sufficiently with the data available then. The Ridgeback did not develop significantly faster in behaviours necessary either for a hunting or guarding breed or a breed that was bred for increased levels of aggression (for example, biting or bite-shaking, scenting, fixing, behaviours for threat or submission) but, as discussed in the cited study, the sample size then was small (Schöning, 2000a).

So far, 13 dog breeds and the European Wolf have been monitored in their social development during the first eight weeks of life, following approximately comparable methods: Siberian Husky (Althaus, 1982), Beagle (Venzl, 1990), Bullterrier (Schleger, 1983; George, 1995), Weimaraner (Dürre, 1994), German Shepherd Dog (Feddersen-

Petersen, 1992), Labrador-Retriever (Feddersen-Petersen & Hoffmeister, 1990; Feddersen-Petersen, 1992, 1994a/b), Golden Retriever (Feddersen-Petersen & Hoffmeister, 1990; Feddersen-Petersen, 1992, 1994a/b), Standard Poodle (Feddersen-Petersen, 1992, 1994a/b), Miniature-Poodle (Feddersen-Petersen, 1992, 1994a/b), American Staffordshire Terrier (Redlich, 1998), Fila Brasileiro (Gramm, 1999), Rhodesian Ridgeback (Schöning, 2000a), Border Collie (Heine, 2000).
Heine (2000) has made the most recent comparison of developmental data among the breeds mentioned (missing out the Ridgeback). She stated that most of the behaviours listed in the ethogram had an earlier onset in most of the breeds compared to the wolf. Her Border Collies showed an earlier onset in a total of 63% of all behaviours from the ethogram. Looking at behaviours within the social interaction between puppies only, the proportion came to 66%. For the Rhodesian Ridgeback, the same comparisons come to 30 % and 25 % respectively. When looking at the median, quartile and extreme values for behaviours from the ethogram (first day of onset of any behaviour within the different dog breeds), the Ridgeback overall showed no significant earlier or later onset than the other dog breeds; though being slightly later than the average of the other dogs in the onset of about 75 % of its social behaviour (Schöning, 2000a). The Border Collie was not included in this last comparison.

Overall, behavioural development in the breeds examined so far follows the phases already mentioned by Scott & Fuller (1965). The socialisation phase was claimed to start early (around day 20) for breeds like the Border Collie (Heine, 2000) or Siberian Husky (Althaus, 1982) and late (around day 30) for breeds like Golden Retriever and Labrador Retriever (Feddersen-Petersen & Hoffmeister, 1990; Feddersen-Petersen, 1992, 1994a/b). The Ridgeback started this phase around day 29, when the puppies suddenly showed many new behaviours from the ethogram (see Chapter 3), and started an intensive interaction with the living and non-living environment (Schöning, 2000a).

So far just the day of first occurrence of individual behaviours from the ethogram has been analysed for the Rhodesian Ridgeback (Schöning, 2000a). For some other breeds, like the Border Collie (Heine, 2000) or American Staffordshire Terrier (Redlich, 1998), the further development of single behaviours, e.g. in social interactions, has already been described. Doing this for the Ridgeback and comparing the data to the data already existing from other breeds is one aim of this chapter.

## 5.4 Materials and Methods

### 5.4.1 The Ethogram

The ethogram has been described in detail in Chapter 3.

### 5.4.2 Dogs

Four litters of Rhodesian Ridgeback puppies (altogether 37 puppies) were monitored. Each litter is described in detail further down; puppies are numbered sequentially per litter; puppies were differentiated according to sex and the various white fur-marks. In order to keep the data on individual dogs as anonymous as possible (data-protection – most dogs are still alive and privacy of the owners has to be respected) no detailed phenotypic description of any individual dog will be given here. The following Table (5.1) gives an overview of the litters and their rearing background.

Table 5.1: Overview of litters and rearing background

| **Details bitch** | **Details puppies** |
|---|---|
| Litter A: Eleven puppies (6 females A1-A6, 5 males A7-A11) | |
| ➢ Primiparous<br>➢ Owned by the breeder; lived together with three other Rhodesian Ridgeback bitches (one spayed) and one male. Dogs lived in the house with the owner's family and had access to every room as well as to a large garden. Breeders lived in slightly remote location in northern Germany near Hamburg<br>➢ Dry food for adult dogs (Waltham).<br>➢ Vaccinated against distemper, rabies, parvovirosis, hepatitis and leptospirosis; wormed regularly.<br>➢ On day 26 the mother became ill with mastitis which marked the end of nursing | ➢ Up to day 31 together with mother in the breeder's living room. Three-sided wooden whelping box, carpet floor covered with towels; 2 x 1.5 m, height of walls 40 cm. Mother had free access to puppies, could come and leave as she wanted. Approach by other dogs was controlled by breeder. As long as the puppies were kept indoors, at least one person of the breeder's family was in the room at any time<br>➢ After day 12: mother started leaving the puppies for short periods to sleep somewhere outside the box. These periods progressively increased in duration.<br>➢ Day 23: start semi-solid food (canned puppy-food, Waltham, mixed with warm water); fed five times per day.<br>➢ Day 35: start canned puppy food (Waltham). The canned food substituted one of the then four semi-solid meals. Subsequently more and more semi-solid meals were substituted. Four meals were kept until the end of observing time.<br>➢ From day 31 on: puppies kept in an outdoor kennel: 7 x 5 m running area (3/4 sand ground, 1/4 wood) plus a wooden shelter (4 x 1,7 m); completely covered with meshed wire. Combined with the shelter was an indoor sleeping area, which could be heated. Puppies had free access to any area during the day and were kept in shelter and indoor area during the night. Mother had free access whenever she wanted during the day and was kept in the breeder's house during the night. |

| | |
|---|---|
| | Kennel contained toys (plastic balls, plastic bones) of different sizes.<br>➢ From day 41 on: puppies during the day in a 260m$^2$ grassed area, completely fenced. The area contained a 5 x 3 m awning under which stood two smaller wooden dog shelters (1 x 1,5 m) which the puppies had free access to. Toys in various sizes, wooden trunks, water bowls. During the night the puppies were returned to the meshed wire kennel. The fence around this grassed area was easily jumped over by the adult dogs, which kept coming and going regularly.<br>➢ Lots of human visitors of different ages and shapes from day 21 on<br>➢ Puppies wormed on day 9, 16 and 24 with Flubendazol (Flubenol ®, Janssen-Cilag), 20 mg / kg body weight. |
| <u>Litter B:</u> Nine puppies (6 females B1-B6, 3 males B7-B9) | |
| ➢ Pluriparous<br>➢ Further details see litter A<br>➢ Day 14: became ill with mastitis which marked the end of nursing | ➢ One puppy born dead; two other puppies died on day 6 (male) and day 10 (female) due to an *Escherichia coli*-infection<br>➢ From day 14 on: artificial feeding with puppy-milk (Waltham)<br>➢ From day 19 on: semi-solid food.<br>➢ Born four days later than litter A at the same breeder. Living conditions of puppies resemble those of litter A, except that the puppies moved to the kennel and the grassed area four days earlier than those from litter A. |

| <u>Litter C:</u> Ten puppies (5 females C1-C5, 5 males C6-C10) | |
|---|---|
| ➢ Primiparous<br>➢ Owned by the breeder and lived together with the puppy's father in the breeders family. The dogs had full access to the house and a large garden. The breeders lived in a Hamburg suburb.<br>➢ Dry food for adult dogs (Waltham).<br>➢ Vaccinated against distemper, rabies, parvovirosis, hepatitis and leptospirosis, wormed regularly | ➢ Kept in a separate room in a wooden whelping box, carpet floor, covered with towels. Approximately 1,7 x 1,5 m. Height of walls 40 cm. Mother and father had free access to the puppies and could come and leave as they wanted. As long as the puppies were kept indoors, at least one person of the breeder´s family was in the room at any time.<br>➢ From day 28 on: puppies could leave whelping box.<br>➢ From day 21 on: puppies had access to all ground floor rooms as well for shorter periods of the day. After day 12 the mother started leaving the puppies for short periods to sleep somewhere outside the box. These periods increased with time. Lots of human visitors of different ages and shapes from day 21 on<br>➢ From day 32 on: puppies had restricted access to the garden.<br>➢ Day 26: semi-solid food (canned puppy-food, Waltham, mixed with warm water)<br>➢ Day 35: canned puppy food (Waltham). The canned food substituted one of the then four semi-solid meals. Subsequently more and more semi-solid meals were substituted and subsequently the mother showed less and less willingness to feed the puppies herself. Five meals were kept until the end of observing time. |

| Litter D: Seven puppies (3 females D1-D3, 4 males D4-D7) | |
|---|---|
| ➢ Pluriparous<br>➢ Same breeder as litter A and B<br>➢ Five other Rhodesian Ridgeback bitches (two spayed) and one male<br>➢ Living conditions as in litter A and B | ➢ Rearing conditions see litter A and B<br>➢ Puppies stayed indoors until day 25. As it was very good weather they were then allowed outside for some hours in the grassed area each day while staying otherwise in the house. From day 35 on they were kept in the kennel and during the day in the grassed area. Semi-solid food was first fed on day 24. |

### 5.4.3 Data collection

Data collection was done following Altmann's (1974) focal animal sampling method. Monitoring took place with a video camera and additional written notes. Cameras: Canon UC9, 8 mm Video Camcorder Hi8; Panasonic Digital Video Camera, NV-DS35EG. Puppies were monitored daily from day 23 up to day 56, following which they left the breeder and were given to their new homes. Recording of the puppies earlier than day 23 was omitted as earlier investigations on Ridgeback puppies had shown that the development of social behaviour did not start before three and a half weeks of age (Schöning, 2000a). All puppies were video taped for three minutes each for one video sequence. Two sequences were recorded each day, done more or less consecutively. Monitoring was done at times during the day when the puppies were known to be active, mostly in the late morning or afternoon until early evening. The filming started when at least 50% of the puppies showed any kind of action - which did not necessarily mean social interaction. The order of focal puppies in a sequence was randomised as far as possible, starting each new sequence with a different puppy than the one before and then choosing puppies randomly. The one closest to the actual focal puppy at the end of each sampling period, that had not been already sampled that day, was the next focal puppy. Video taping was stopped and/or data not counted when the breeder or visitors handled the puppies in the house, because this usually included displacement from the group for more than one puppy, e.g. for weighing purposes or investigation by a potential buyer. When the puppies were in a kennel, garden or grassed area, reaction to and interaction with human visitors was monitored, as were their reactions to or interaction with any other stimulus in the environment. The person taking the videos did not interact with the puppies though she was sometimes the target of interaction (mainly gnawing at shoes etc.). Data gathering and methods of sampling used thus followed the methods used with the other breeds examined as puppies so far (for an overview see Heine, 2000).

### 5.4.4 Data samples and statistical analysis

The video recordings were watched two to three times each. Videos were watched on the computer-screen and, where necessary due to low quality, further processed using Final Cut Pro 4® for Macintosh. For each focal puppy, during two periods of three minutes, the behaviours shown in dyadic interaction with another puppy were recorded. One set of data consists of the following details: litter number, day, focal puppy; number of reactors per sample time, number of dyadic interactions (sequence-number), mean number of behaviours from the ethogram per dyadic interaction (sequence-length), number of behaviours from the ethogram shown by the focal puppy. A dyad was considered to be terminated when contact between the partners broke off (either or both puppies left interaction) or one or more other puppies mingled in. Statistical analysis was done with SPSS® version 12 for Macintosh and Windows. Data files for statistical analysis were produced using the following programs: File Maker 5® and EXCEL®, both for Macintosh.

As individual data samples for each puppy contained too many zeros (i.e. behaviours not shown in the focal-period) to apply statistical tests, they were pooled by week and litter. Some variables were not normally distributed, and were log-transformed in order to use parametric statistical tests (Bortz, 1999). In some cases the distribution was so skewed, due to too many zeros, that transformation was ineffective; here, statistical analysis was done with non-parametric alternatives, despite their being less powerful. Parametric statistical tests: two-way ANOVA with two-sided Dunnett test as post hoc test; Non-parametric tests: Friedman-test, Mann-Whitney-U-test, Kruskal-Wallis test. Whether or not log-transformation took place, and which of these statistical tests was used, is described for each variable in the results section.

## 5.5 Results

### 5.5.1 Number and length of dyadic interactions among puppies and number of reactors

Altogether 3310 samples of dyadic interactions were recorded. The number of dyadic interactions per puppy varied between none and ten per focal time; the number of reactors varied between none and six; the individual dyadic interactions varied in composition between none and sixteen of the interactive behaviours from the ethogram. The mean number of dyadic interactions for all puppies per focal time was 2.35 in the fourth week, 2.63 in the fifth week, 2.48 in the sixth week and 2.86 in the seventh and eighth weeks (Figure 5.1). The average number of behaviours shown per interaction went from 2.43 in the fourth week to 2.93 in the fifth, 3.36 in the sixth, 4.04 in the seventh and 4.31 in the eighth week (Figure 5.2). The average number of reactors to each focal puppy within a focal period was 2.08 in the fourth week, 2.34 in the fifth week, 2.26 in the sixth week, 2.63 in the seventh week and 2.57 in the eighth week (Figure 5.3).

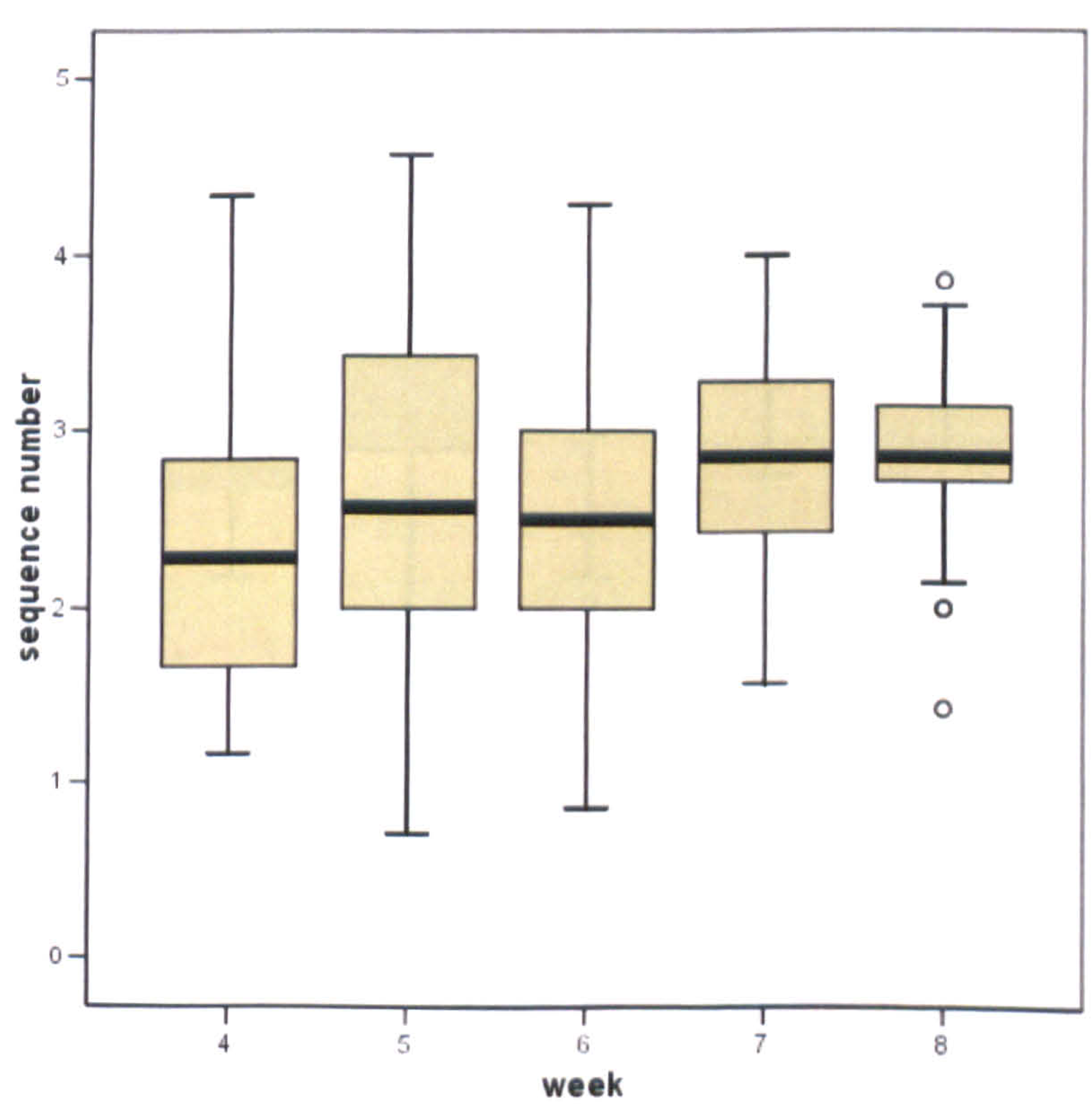



Figure 5.1: Box-plots of the number of dyadic interactions per focal time, for weeks 4 to 8. Heavy lines indicate medians, the box extends from the 25th to the 75th percentiles, and the horizontal lines indicate minimum and maximum values, except for values more than three interquartile ranges from the nearest quartile, which are shown as individual points.

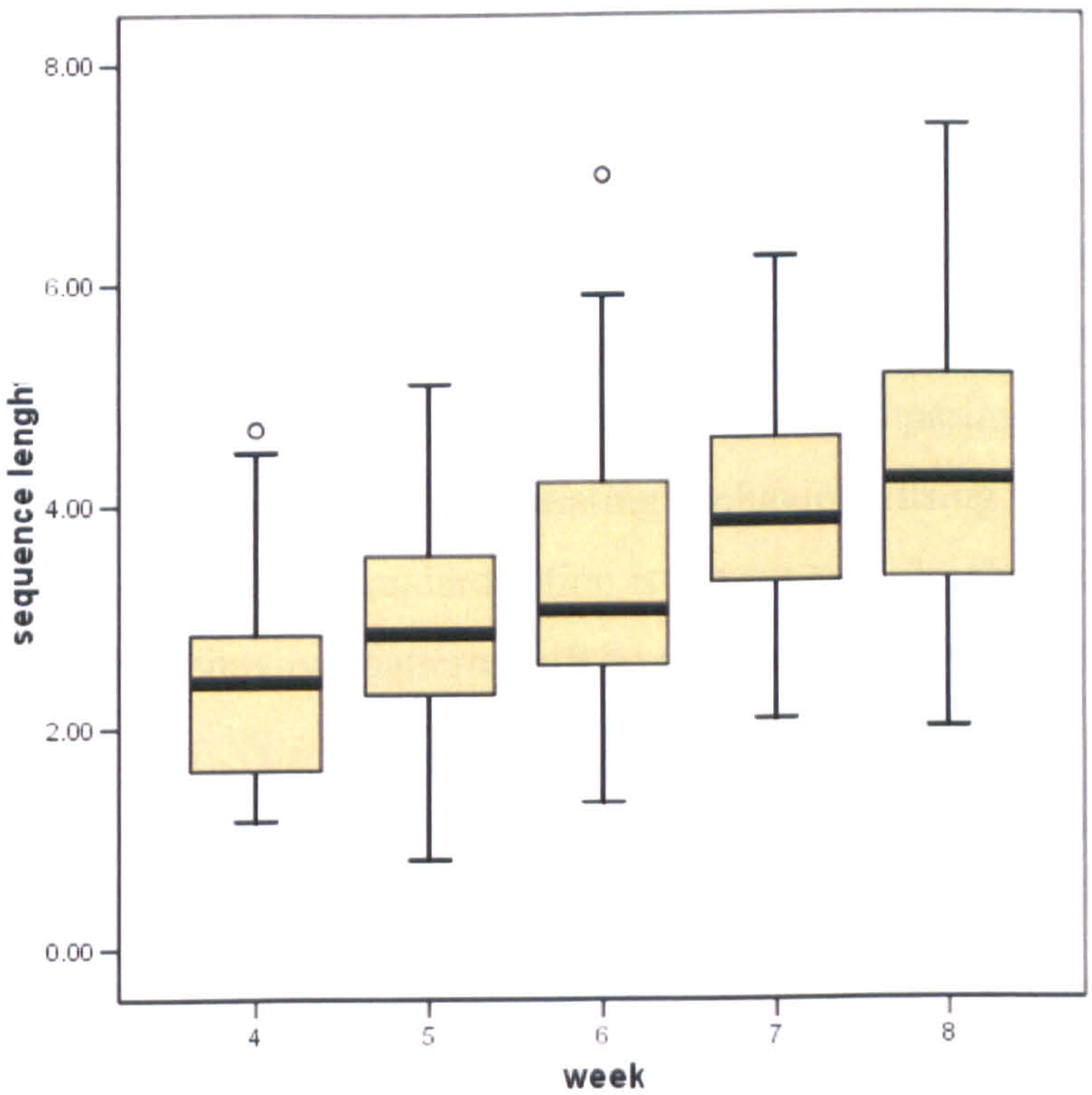



Figure 5.2: Box-plots of the number of behaviours per dyadic interaction, for weeks 4 to 8. See Figure 5.1 for definitions and symbols.

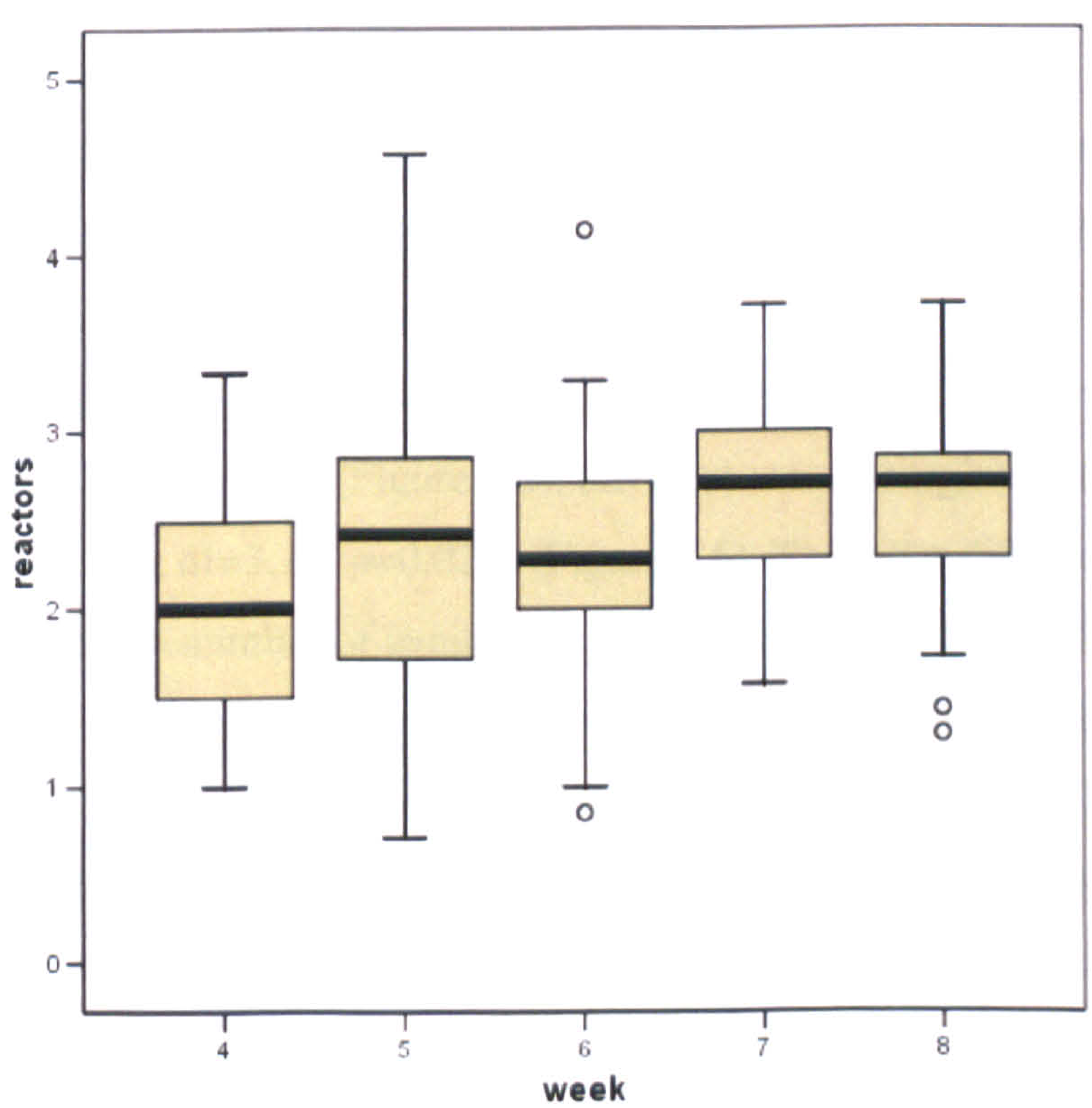



Figure 5.3: Box-plots of the number of reactors per sample time to each focal puppy, for weeks 4 to 8. See Figure 5.1 for definitions and svmbols.

In 56.6% of dyadic interactions observed (n=1872), the focal puppy was the initiator. Here the behaviour "pushing" was the one used most for starting (25.4%), followed by "biting" with 12.7 %, "muzzle nudging" (9.5%) and both "jumping at" and "rubbing against" (7.9%). Initial biting was rarely accompanied by any behavioural element coding for play-interaction; thus biting used here is always assigned to the ethogram-group D3 (uninhibited attacking behaviour, Chapter 3). It was very rare (< 0.2%) for play-biting (ethogram group F) to be an initiating behaviour, though play-biting could be seen later on in an interaction that had started with biting or another behaviour. In order to apply statistical tests to this data, for comparing between breeds, a standardised method for measuring the "initiating" behaviour, using a standardised ethogram would be essential. Since standardisation is not yet sufficiently good, no further analysis of initiating behaviour patterns will be attempted here.

The following factors were examined for effects on these three measures of development: the sex of the puppy, the litter, or the stage of development (week). Statistical analysis of these variables was done without log-transformation of the data, using two-way ANOVA with two-sided Dunnett test as the post hoc test. Sex made no difference to the number of dyadic interactions ($F=0.002$; $df=1,4$ $p=0.969$), the number of behaviours performed ($F=1.588$, $df=1,3$; $p=0.286$) or the number of reactors per focal sample ($F=0.013$; $df=1,4$; $p=0.916$). Sex was therefore omitted as a factor in subsequent ANOVAs, in which the independent variables were week (fixed factor), litter (random factor) and their interaction.

The number of reactors did not change significantly from week to week ($F=1.487$; $df=4,12$; $p=0.268$) (Figure 5.3), but there was a marginal difference between litters ($F=4.224$; $df=3,12$; $p=0.027$) (Figure 5.6). The latter difference does not appear to reflect the number of available partners, since litter D, consisting of seven puppies, had more reactors than litter C (ten puppies). The number of behaviours per interaction was slightly different between litters ($F=3.273$; $df=3,12$; $p=0.058$) (Figure 5.5) but increased significantly from week to week (Figure 5.2: $F=7.767$; $df=4,12$; $p=0.003$), presumably as the behavioural repertoire of the puppies became more sophisticated.

The opposite applied when looking at the number of dyadic interactions per focal time (Figure 5.1). The slight increase from week to week was non-significant ($F=1.113$; $df=4,12$; $p=0.396$) but there was a significant difference between litters ($F=5.007$; $df=3,12$; $p=0.015$) (Figure 5.4).

The socialisation period is thought to have reached a decisive and important phase between week seven and week eight, going from primary to secondary socialisation (for a review see Lindsay, 2000). Thus the fourth till seventh weeks were tested individually against week eight, to estimate the point at which social behaviour achieved a level characteristic of socialisation. The increase in the number of dyadic interactions was significant from week four ($p=0.001$) and week six ($p=0.018$) to week eight, and from week seven to week eight there was no difference in the number of dyadic interactions per focal puppy.
The number of behaviours per interaction showed an almost analogous trend. Week four till week six showed significantly fewer behaviours per interaction compared to week eight ($p<0.001$ in all cases) whereas the difference in development from week seven to week eight was not significant ($p=0.580$). The same picture can be seen with the number of reactors per dyad: week four and week six show a significant difference compared to week eight ($p<0.001$ and $p=0.047$ respectively) whereas the difference between week five ($p=0.184$) and week seven ($p=0.955$) to week eight were not significant.

The litter by week interaction was significant for all three measures, indicating that the litters developed at different rates (number of dyadic interactions: $F=5.217$; $df=12,132$; $p<0.001$; number of behaviours: $F=2.894$: $df=12,132$; $p=0.001$; number of reactors: $F=4.669$; $df=12;132$; $p<0.001$)

The number of reactors and the number of sequences observed were similar between litters at week eight, but more divergent in earlier weeks (Figures 5.4 and 5.6), possibly reflecting different rates of development between litters. The length of sequences in Litter A changed from being similar to Litter D in weeks four to six, to being similar to the longer average sequences of litters B and C in weeks seven and eight (Figure 5.5).

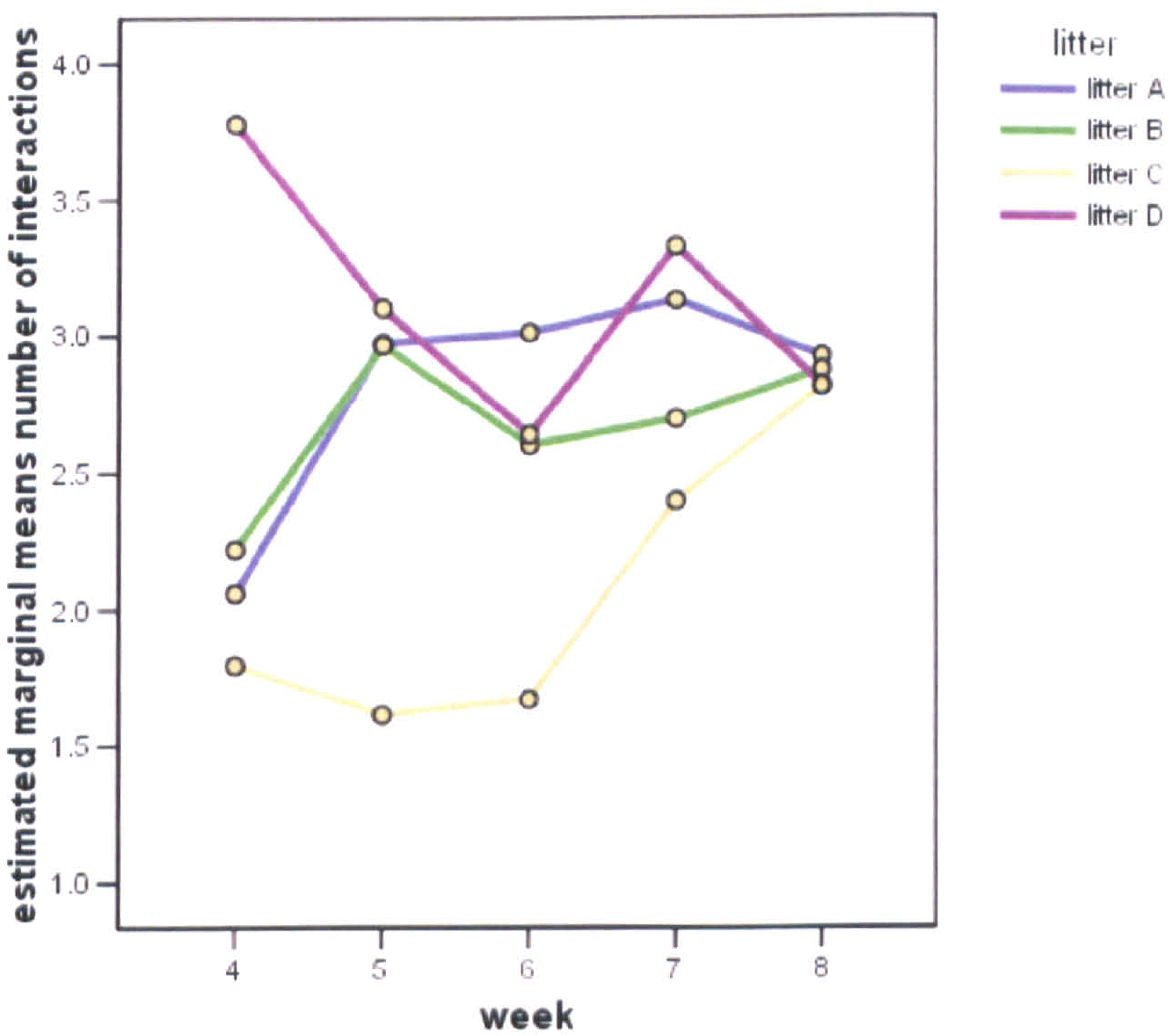



Figure 5.4: Estimated marginal means for the number of interactions per focal puppy per sample, shown for each litter per week

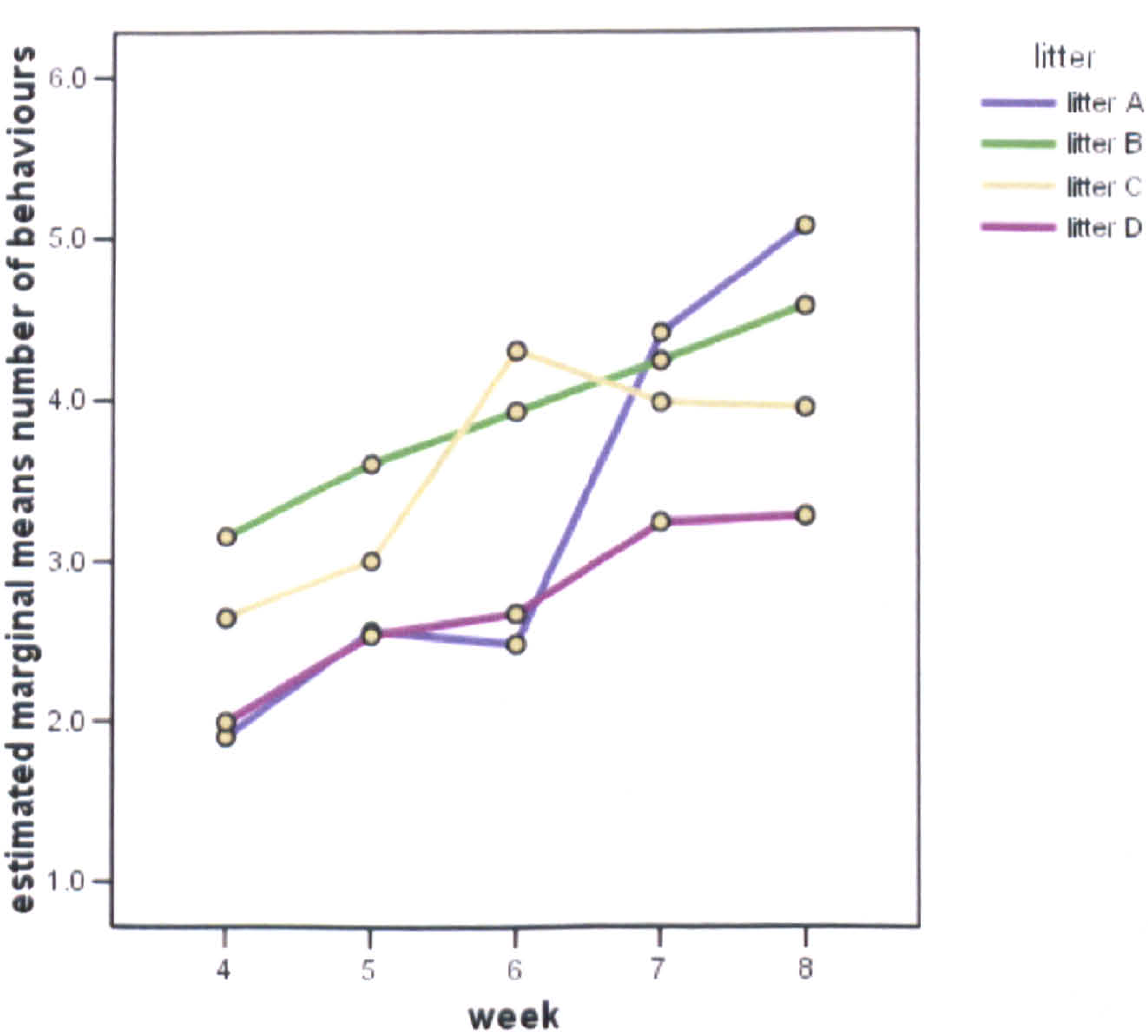



Figure 5.5: Estimated marginal means for the number of behaviours per dyadic interaction per sample, shown for each litter per week

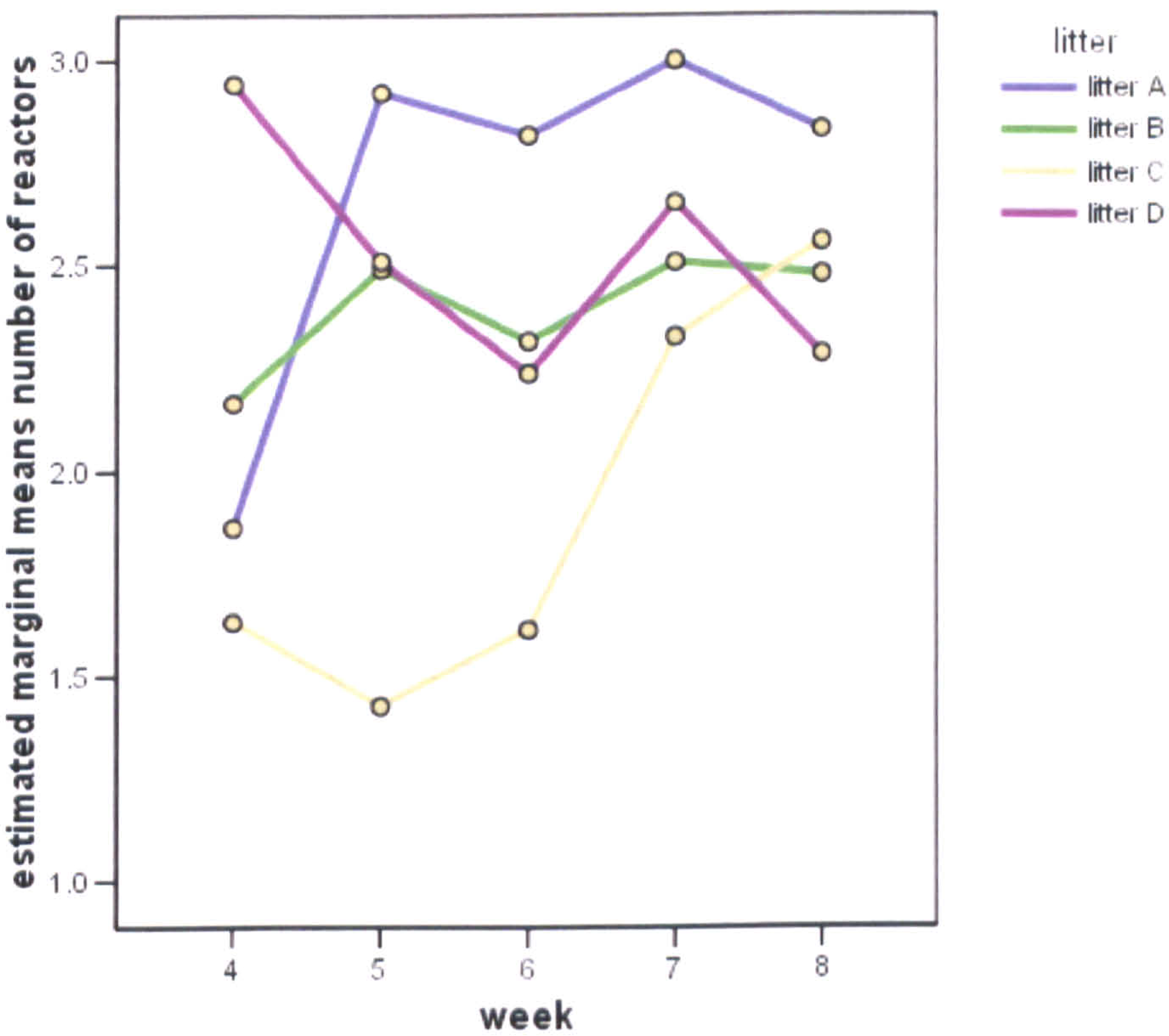



Figure 5.6: Estimated marginal means for the number of reactors per sample, shown for each litter per week

5.5.2 Qualitative development of behaviour: functional groups from the ethogram

5.5.2.1 Mean number of behaviours per focal time per week for all puppies

The mean numbers of behaviours shown per dyadic interaction per focal time were aggregated weekly for all 37 puppies. Data are shown non-transformed and it can be seen that, apart from social approach, the average puppy did not show many behaviours per focal time – even when the behaviours were grouped following the ethogram from section 3.4.3, as it is the case here (see Table 5.2)

Table 5.2: Mean frequencies of behaviours per focal time per week for all puppies

| Behaviour | Week | Mean number | Behaviour | Week | Mean number |
|---|---|---|---|---|---|
| Behaviour for social approach | 4: | 10.11 | Imposing behaviour | 4 | 0.47 |
| | 5 | 11.57 | | 5 | 0.46 |
| | 6 | 8.89 | | 6 | 0.29 |
| | 7 | 12.87 | | 7 | 0.39 |
| | 8 | 15.49 | | 8 | 0.39 |
| Behaviour for passive submission | 4 | 0.00 | Threat behaviour | 4 | 0.49 |
| | 5 | 0.00 | | 5 | 0.71 |
| | 6 | 0.01 | | 6 | 0.80 |
| | 7 | 0.03 | | 7 | 1.12 |
| | 8 | 0.10 | | 8 | 1.46 |
| Inhibited attack behaviour | 4 | 0.13 | Attack behaviour | 4 | 0.53 |
| | 5 | 0.20 | | 5 | 1.24 |
| | 6 | 0.29 | | 6 | 1.04 |
| | 7 | 0.51 | | 7 | 1.56 |
| | 8 | 0.47 | | 8 | 1.17 |
| Flight behaviour | 4 | 0.57 | Stress behaviour | 4 | 0.00 |
| | 5 | 1.00 | | 5 | 0.01 |
| | 6 | 0.94 | | 6 | 0.01 |
| | 7 | 0.96 | | 7 | 0.05 |
| | 8 | 1.10 | | 8 | 0.02 |
| Play behaviour | 4 | 0.06 | | | |
| | 5 | 0.16 | | | |
| | 6 | 0.35 | | | |
| | 7 | 0.44 | | | |
| | 8 | 0.77 | | | |

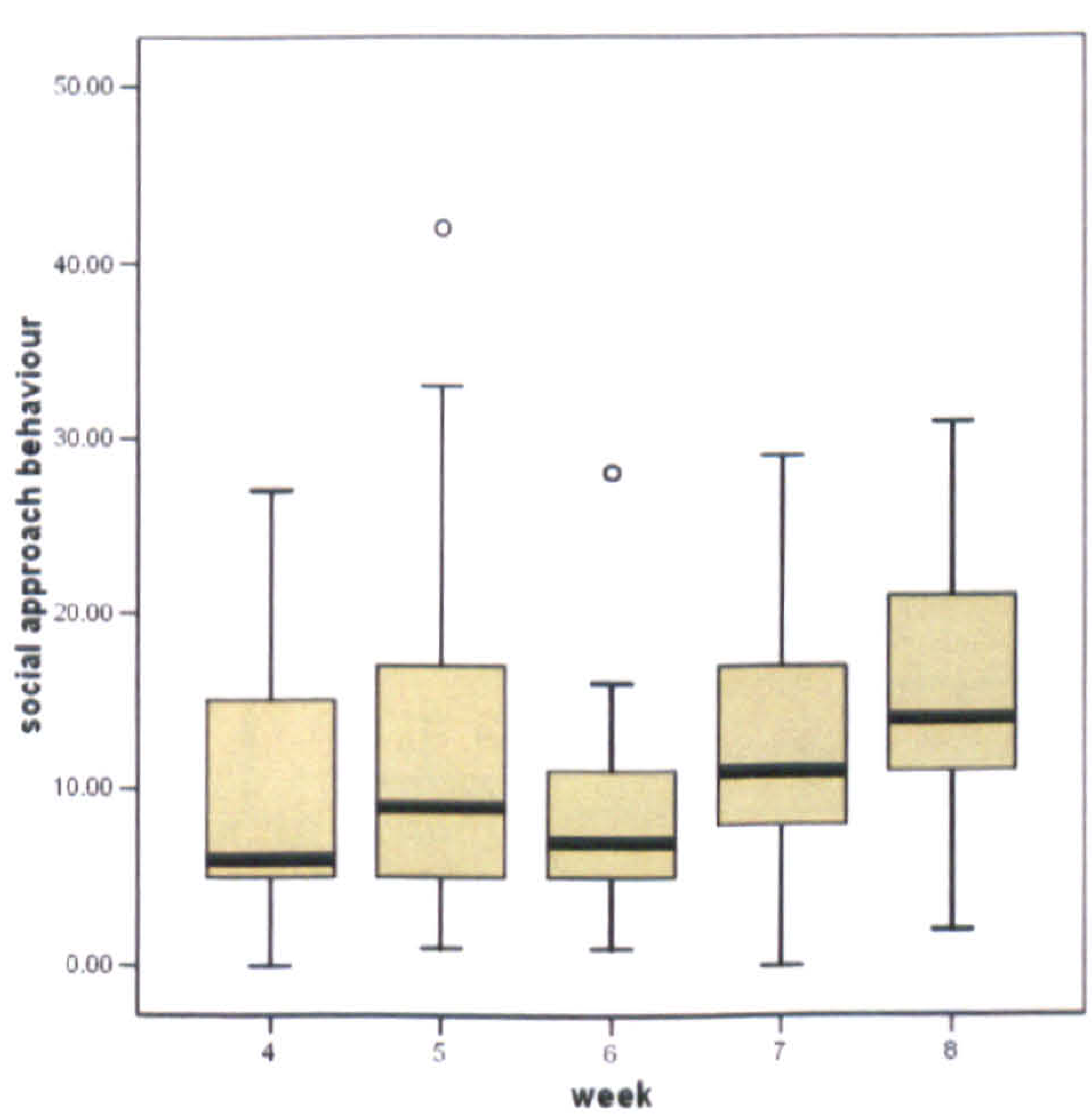



Figure 5.7: Box-plots of the number of social approach behaviours per sample time, aggregated per week, for weeks 4 to 8. Heavy lines indicate medians, the box extends from the 25th to the 75th percentiles, and the horizontal lines indicate minimum and maximum values, except for values more than three interquartile ranges from the nearest quartile, which are shown as individual points.

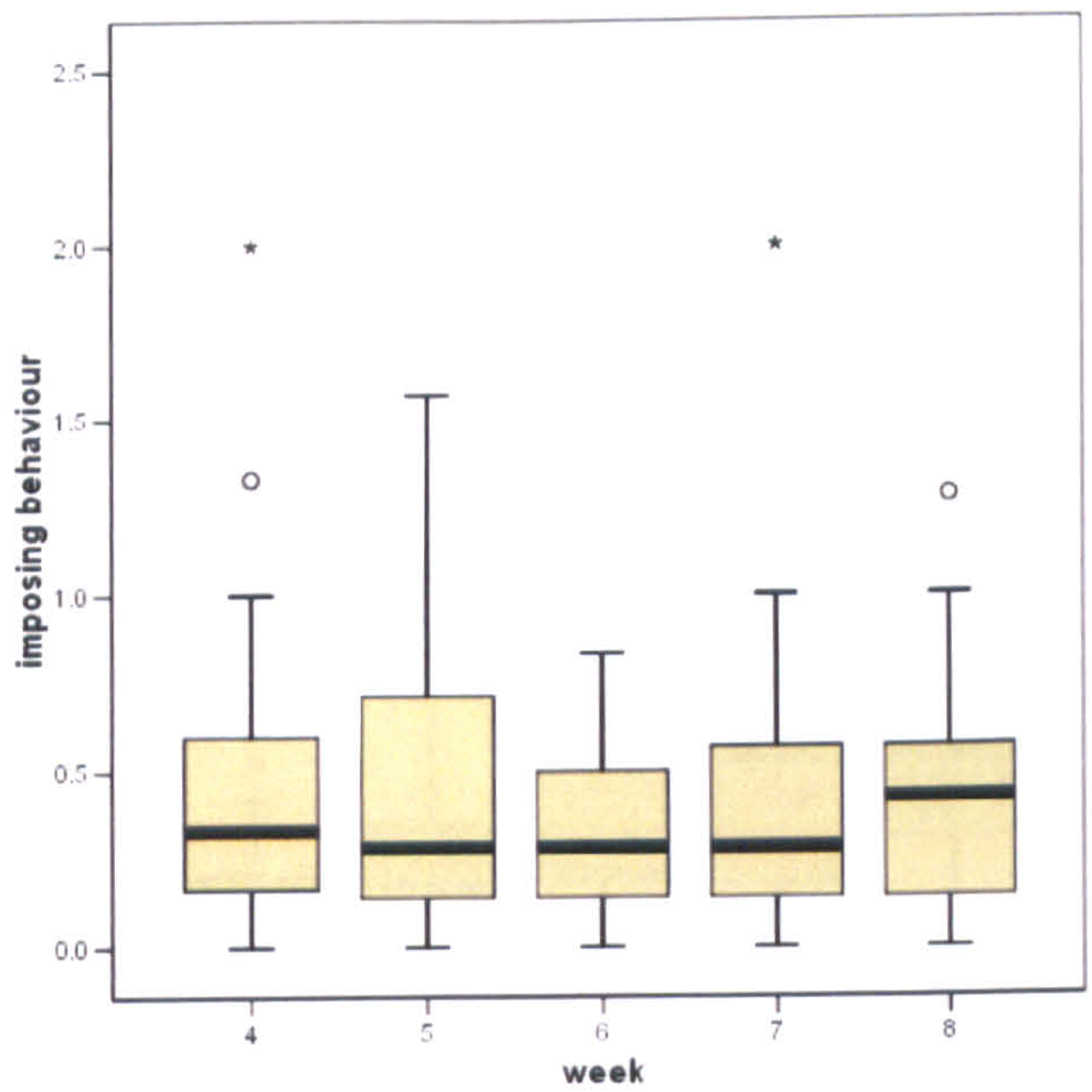



Figure 5.8: Box-plots of the number of imposing behaviours per sample time, aggregated per week, for weeks 4 to 8. See Figure 5.7 for definitions and symbols.

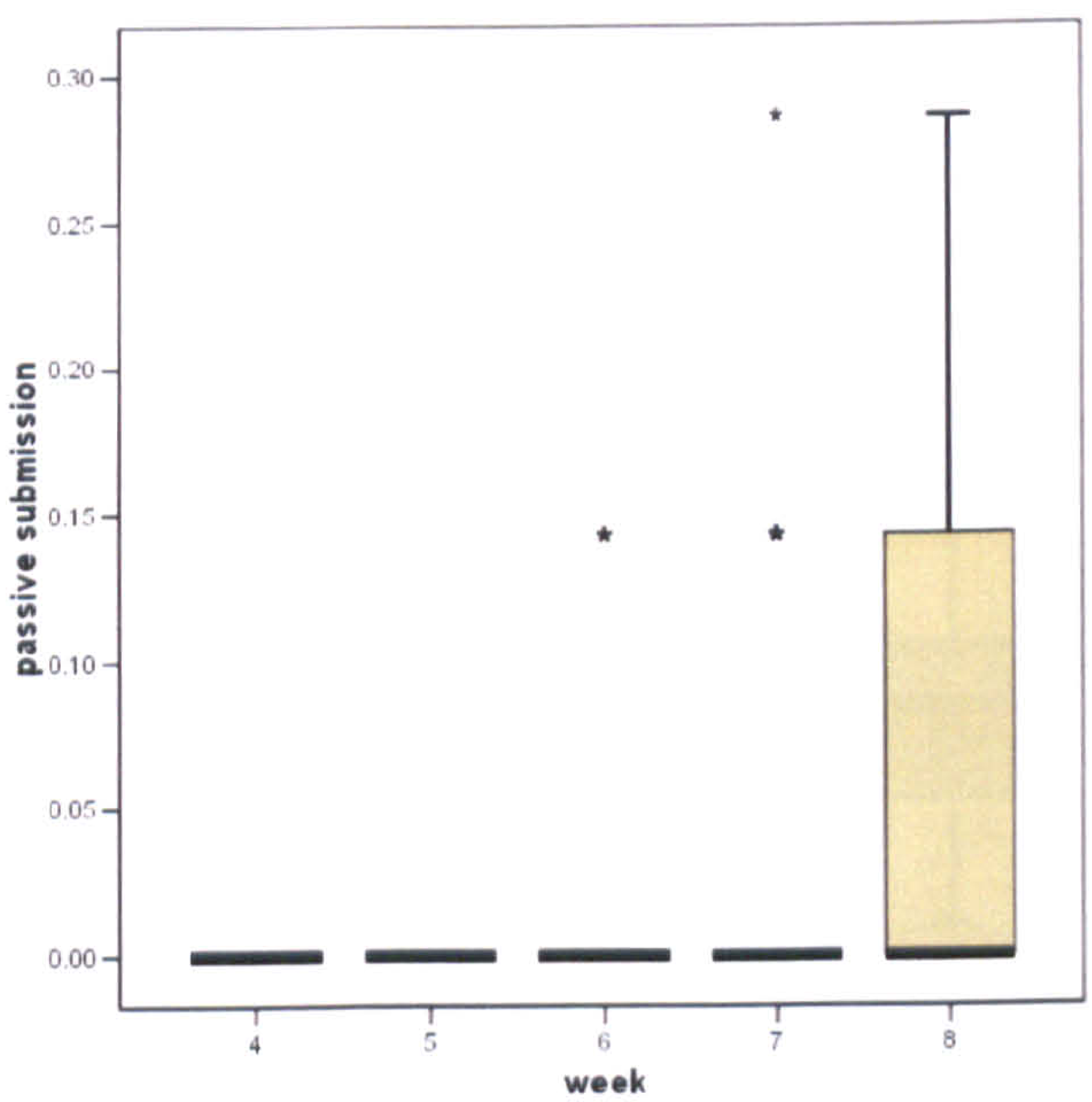



Figure 5.9: Box-plots of the number of passive submission behaviours per sample time, aggregated per week, for weeks 4 to 8. See Figure 5.7 for definitions and symbols.

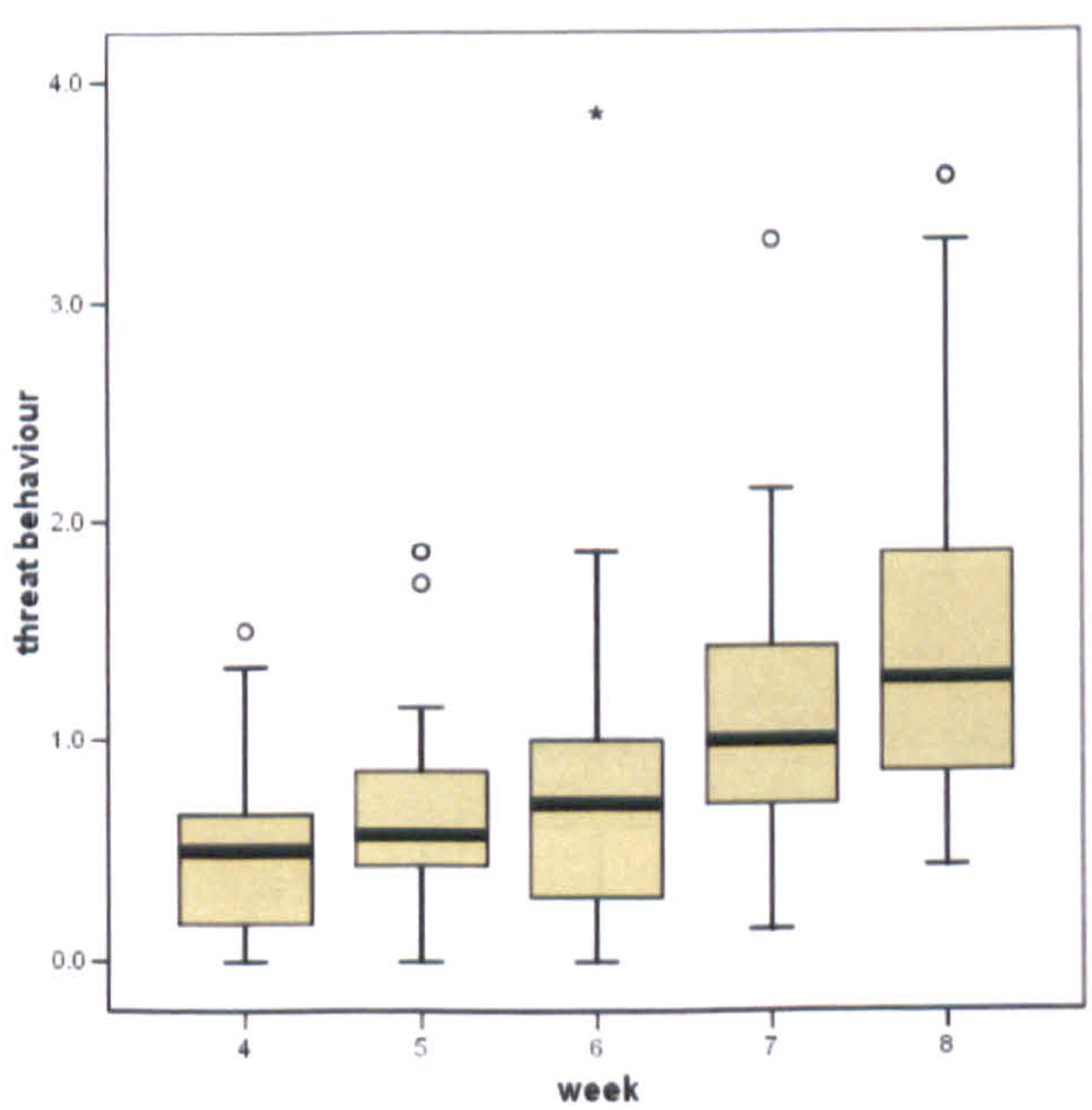



Figure 5.10: Box-plots of the number of threat behaviours per sample time, aggregated per week, for weeks 4 to 8. See Figure 5.7 for definitions and symbols.

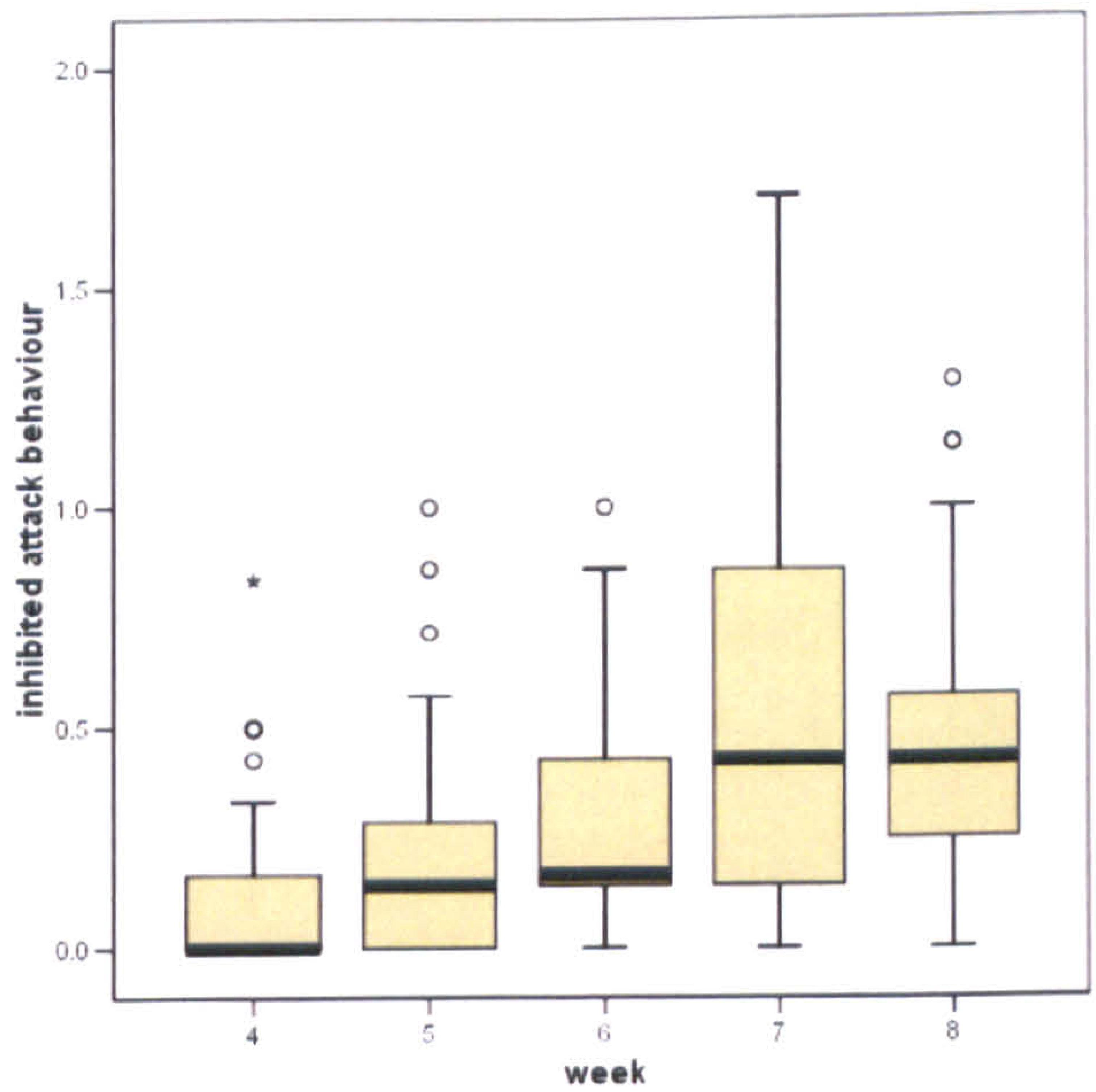



Figure 5.11: Box-plots of the number of inhibited attack behaviours per sample time, aggregated per week, for weeks 4 to 8. See Figure 5.7 for definitions and symbols.

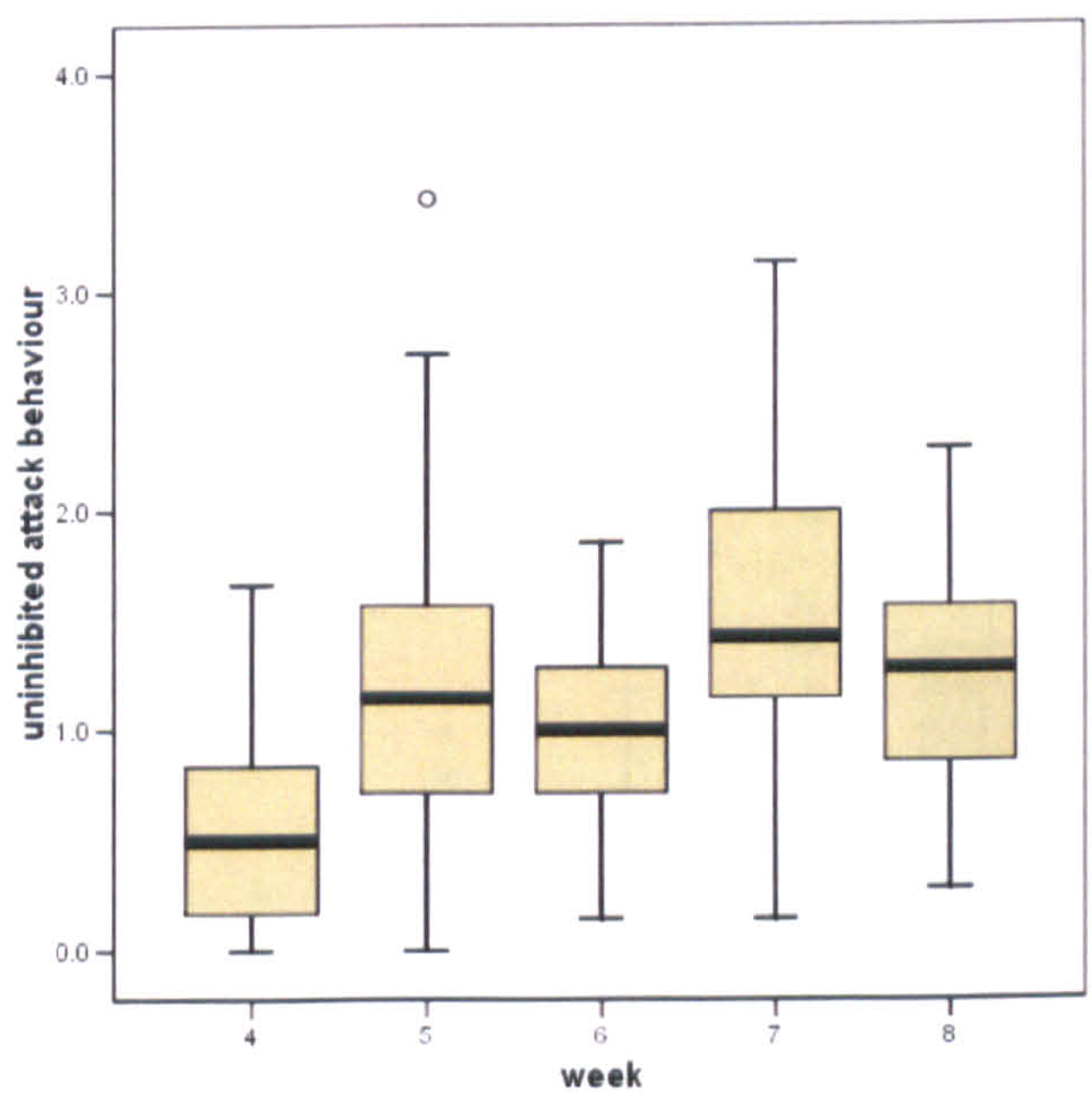



Figure 5.12: Box-plots of the number of attack behaviour per sample time, aggregated per week, for weeks 4 to 8. See Figure 5.7 for definitions and symbols.

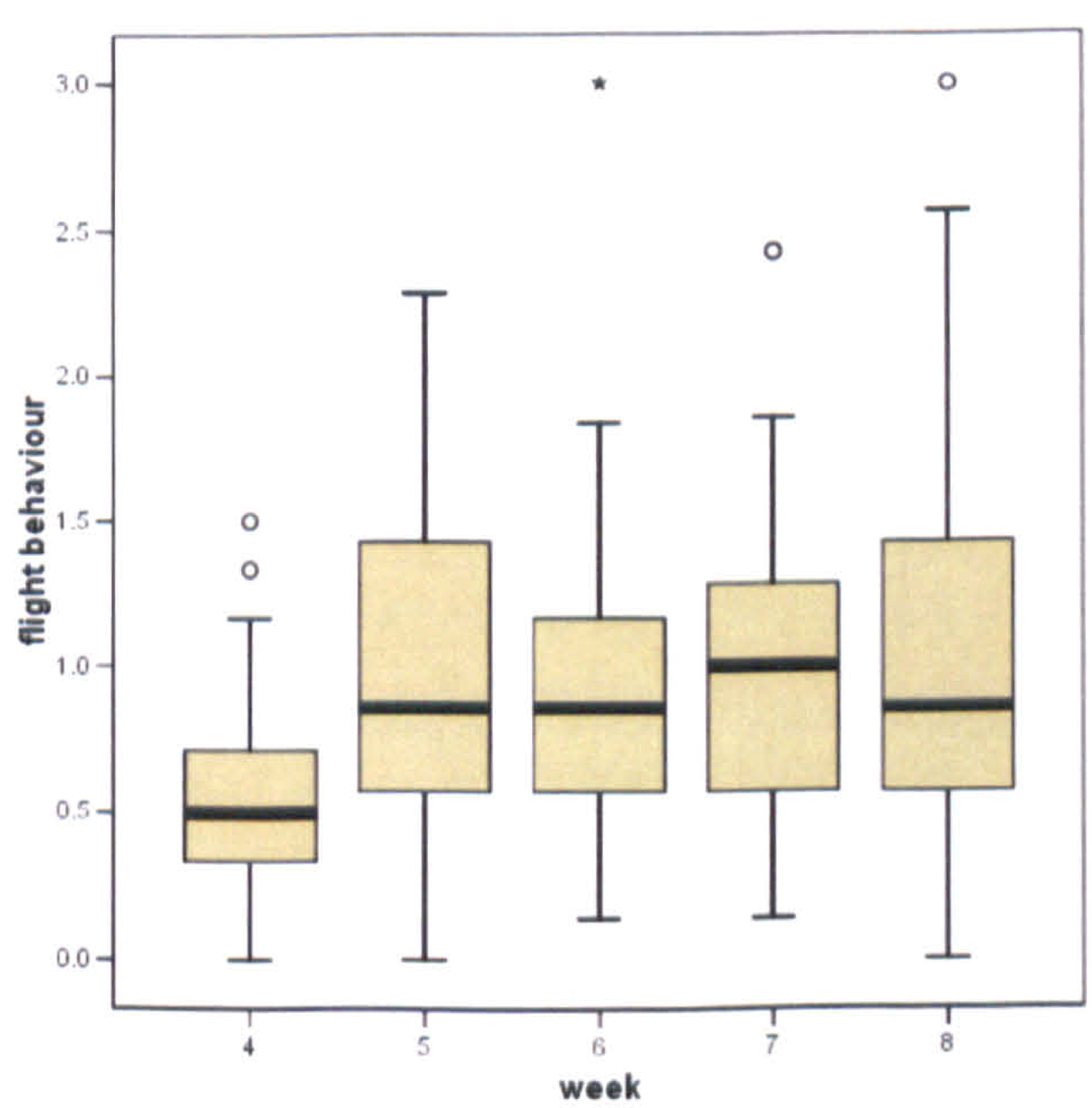



Figure 5.13: Box-plots of the number of flight behaviours per sample time, aggregated per week, for weeks 4 to 8. See Figure 5.7 for definitions and symbols.

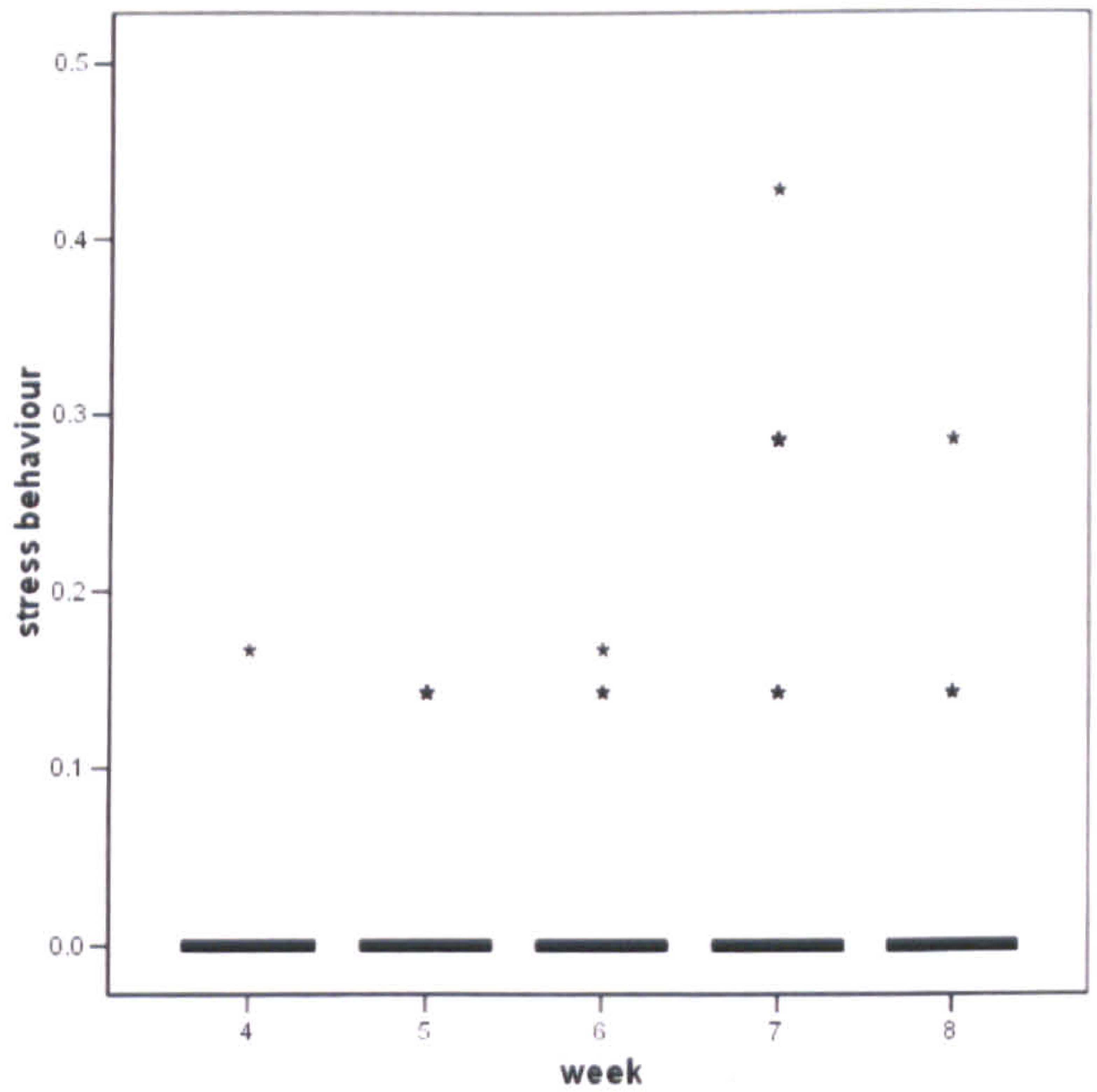



Figure 5.14: Box-plots of the number of stress behaviours per sample time, aggregated per week, for weeks 4 to 8. See Figure 5.7 for definitions and symbols.

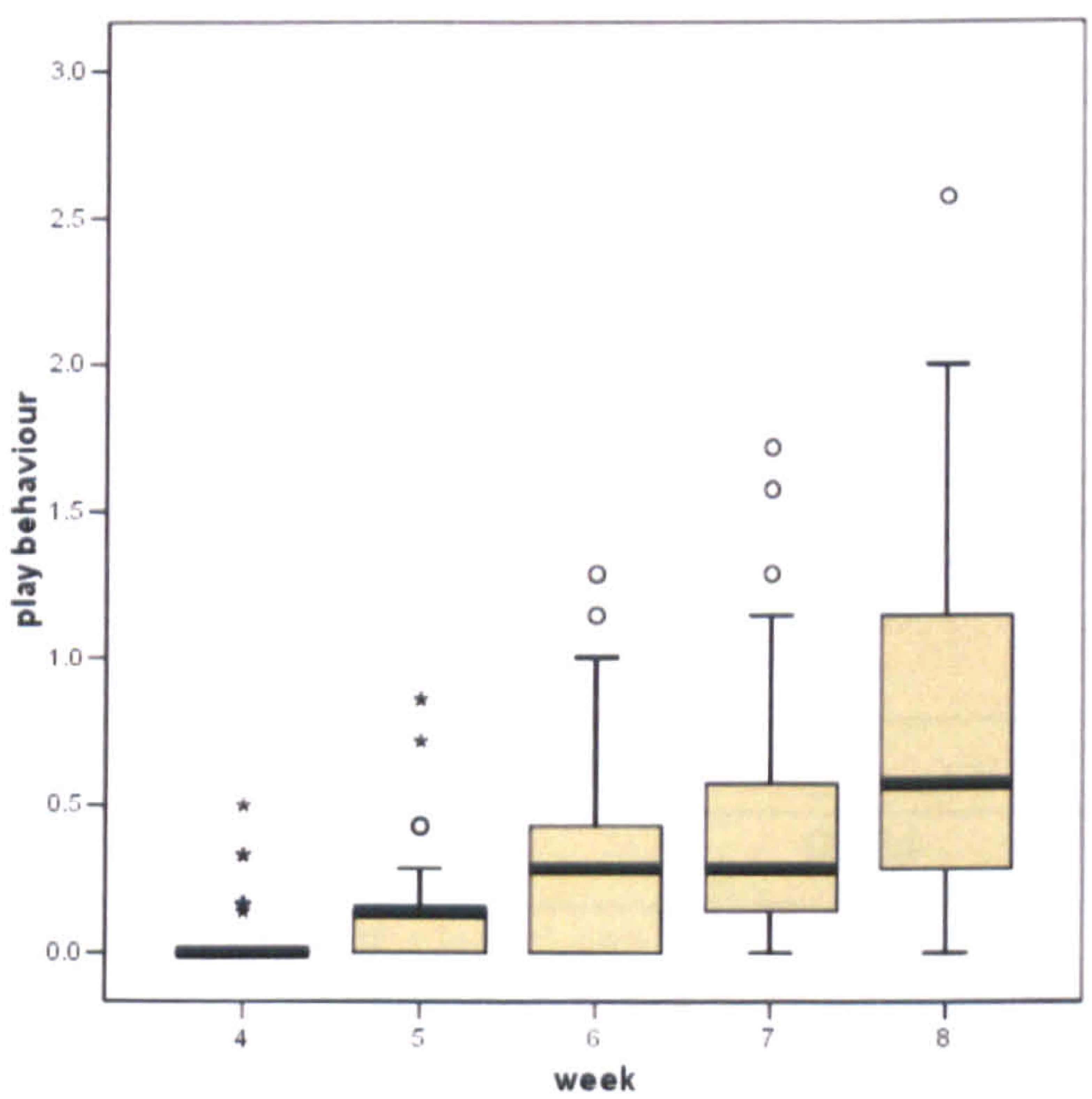



Figure 5.15: Box-plots of the number of play behaviour per sample time, aggregated per week, for weeks 4 to 8. See Figure 5.7 for definitions and symbols.

5.5.2.2 Factors influencing the behavioural development of the puppies

As in section 5.5.1 the following factors which could influence development in these different groups of behaviours were examined: the sex of the puppies, the litter or the stage of development (week). The data from the following behavioural groups were log-transformed and tested with two-way ANOVA with two-sided Dunnett test as post hoc test: flight-, uninhibited attack-, imposing-, social approach-, threat-, inhibited attack- and play behaviour; week four was omitted for play behaviour as it contained too many zeros. For the behavioural groups "passive submission-" and "stress behaviour" log-transformation did not normalise the data sufficiently to apply parametric tests, thus the Friedman-test and Mann-Whitney-U-test non-parametrical statistical methods were applied.

Sex had no effect on any of the behavioural groups tested with two-way ANOVA (Table 5.3)

Table 5.3: Results for the test of between-subjects effects for the different behavioural groups with "sex" being a fixed factor tested in each listed behavioural group with the respective behaviour as dependent variable.

| **Behaviour** | **F** | **df** | **P** |
|---|---|---|---|
| Social approach behaviour | 0.134 | 1,4 | 0.732 |
| Imposing behaviour | 0.166 | 1,3 | 0.712 |
| Threat behaviour | 0.108 | 1,4 | 0.763 |
| Inhibited attack behaviour | 0.211 | 1,3 | 0.679 |
| Attack behaviour | 0.050 | 1,4 | 0.834 |
| Flight behaviour | 0.429 | 1,4 | 0.549 |
| Play behaviour | 2.861 | 1,3 | 0.192 |

There was also no significant difference between the sexes for the behaviours "passive submission" (Mann-Whitney-U-test: $p=0.102$) and "stress" (Mann-Whitney-U-test: $p=0.599$).

Sex was therefore omitted as a factor in subsequent ANOVAs, in which the independent factors were week (fixed factor), litter (random factor) and their interaction (Table 5.3).

Table 5.4: Results for the test of between-subjects effects for the different behavioural groups, with week (fixed factor), litter (random factor) and their interaction, tested in each listed behavioural group with the respective behaviour as dependent variable.

| **Behaviour** | **Week** | | | **Litter** | | | **Litter*Week** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **F** | **df** | **p** | **F** | **df** | **p** | **F** | **df** | **p** |
| Social approach behaviour | 1.512 | 4,12 | 0.261 | 4.087 | 3,11 | 0.036 | 3.473 | 12,132 | 0.001 |
| Imposing behaviour | 0.810 | 4,12 | 0.543 | 1.399 | 3,10 | 0.297 | 1.976 | 12,132 | 0.031 |
| Threat behaviour | 21.581 | 4,11 | 0.001 | 8.037 | 3,8 | 0.010 | 0.803 | 12,132 | 0.647 |
| Inhibited attack behaviour | 6.896 | 4,12 | 0.004 | 1.930 | 3,7 | 0.231 | 1.498 | 12,132 | 0.133 |
| Attack behaviour | 7.717 | 4,12 | 0.003 | 3.336 | 3,8 | 0.075 | 2.585 | 12,132 | 0.004 |
| Flight behaviour | 2.052 | 4,12 | 0.152 | 3.472 | 3,17 | 0.040 | 3.835 | 12,132 | 0.001 |
| Play behaviour | 6.960 | 3,9 | 0.011 | 1.547 | 3,8 | 0.273 | 2.027 | 9,99 | 0.044 |

Three types of agonistic behaviour (threat, inhibited attack and attack) and play behaviour showed a significant increase in quantity per dyadic interaction from week to week. The litters showed different overall levels of social approach and flight behaviour and also in threat behaviour. The interaction terms indicate that the litters apparently developed at different rates for all types of behaviour, apart from threat behaviour and inhibited attack behaviour.

The following Figures (5.16 – 5.22) show the estimated marginal means per week and litter for the numbers of behaviours from the different behavioural groups per sample (behavioural groups per litter and week).

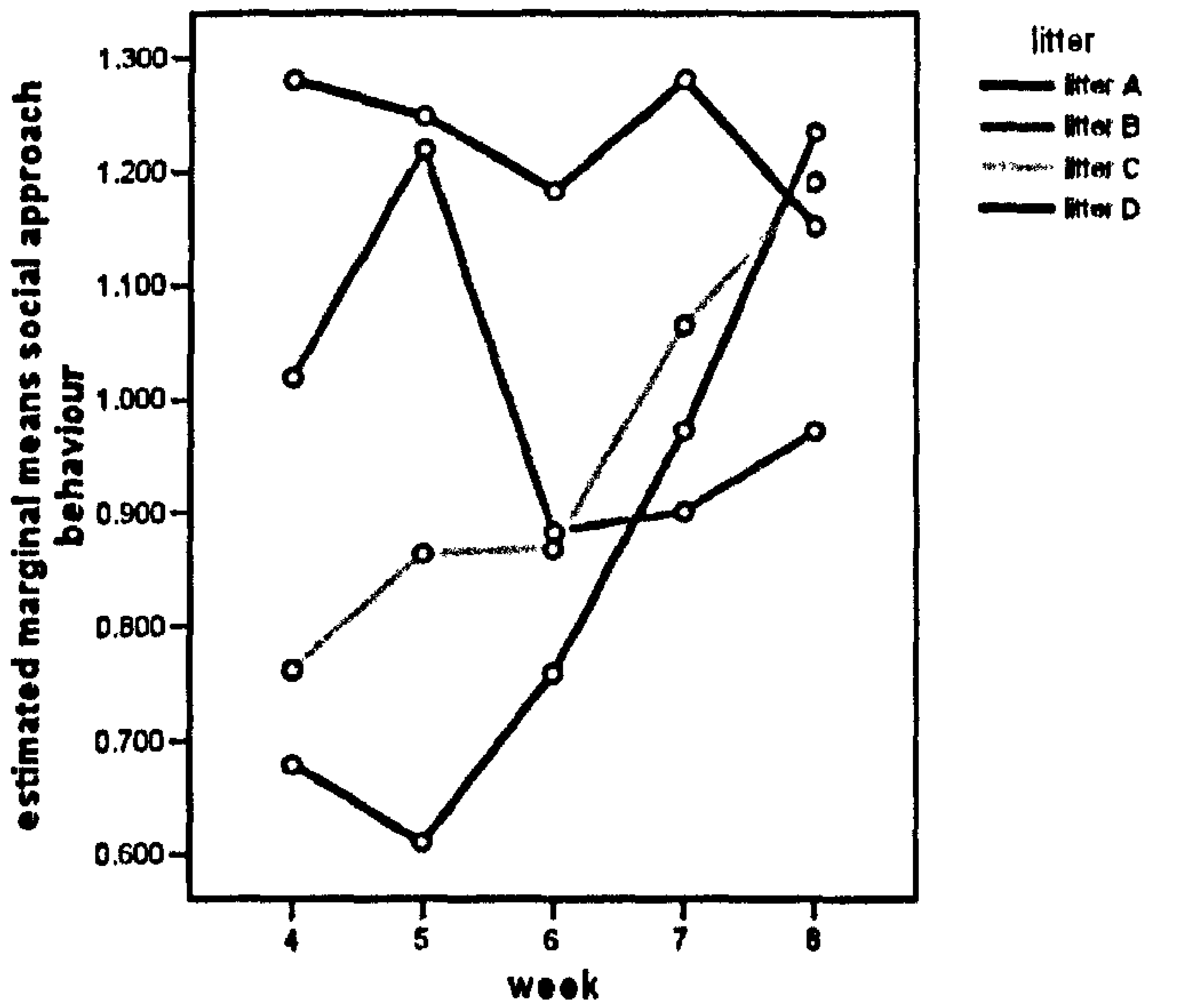



Figure 5.16: Estimated marginal means for the number of social approach behaviours per dyadic interaction per sample, shown for each litter per week. Data has been log-transformed (log10(x+0.5).

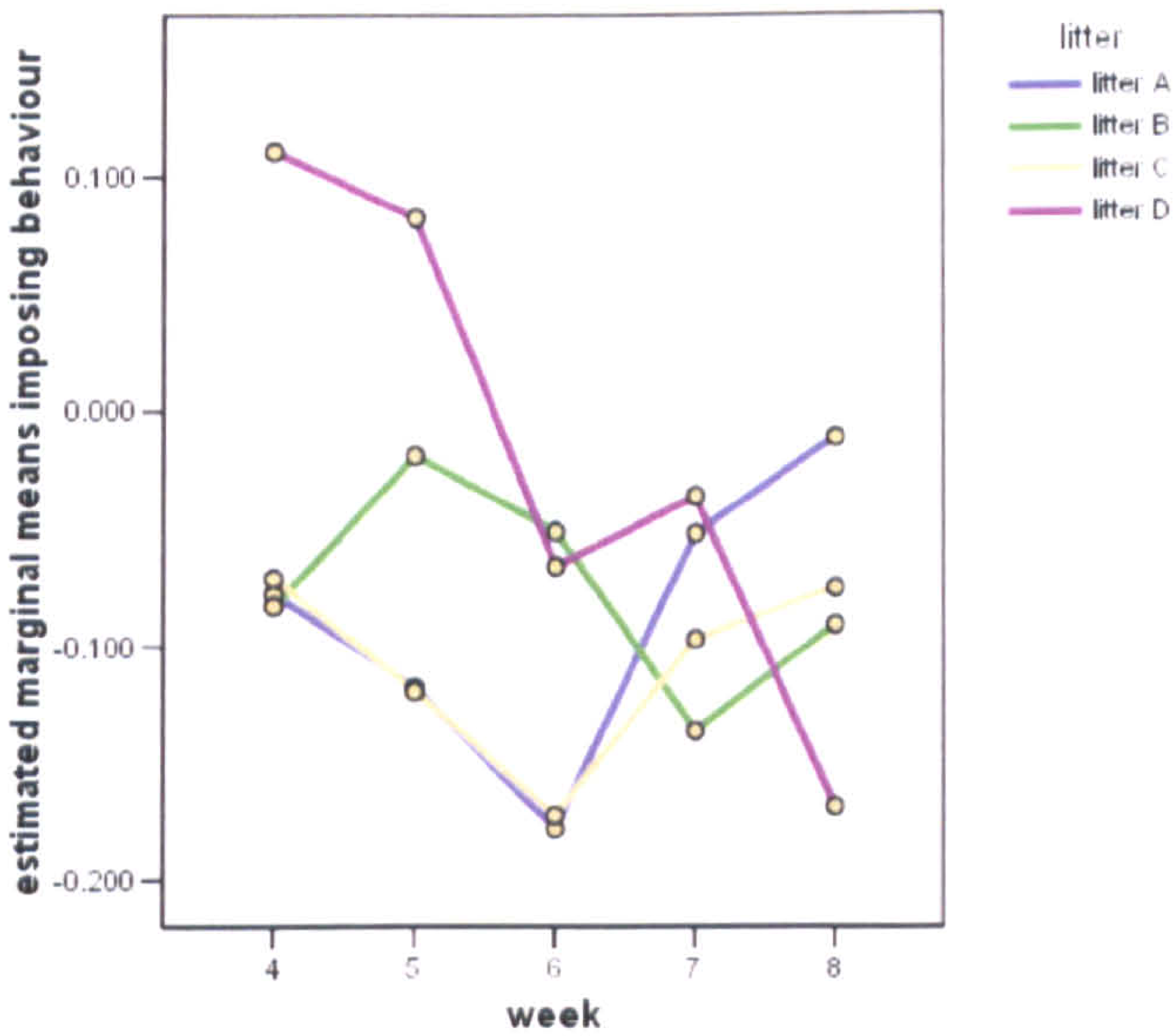



Figure 5.17: Estimated marginal means for the number of imposing behaviours per dyadic interaction per sample, shown for each litter per week. Data has been log-transformed (log10(x+0.5).

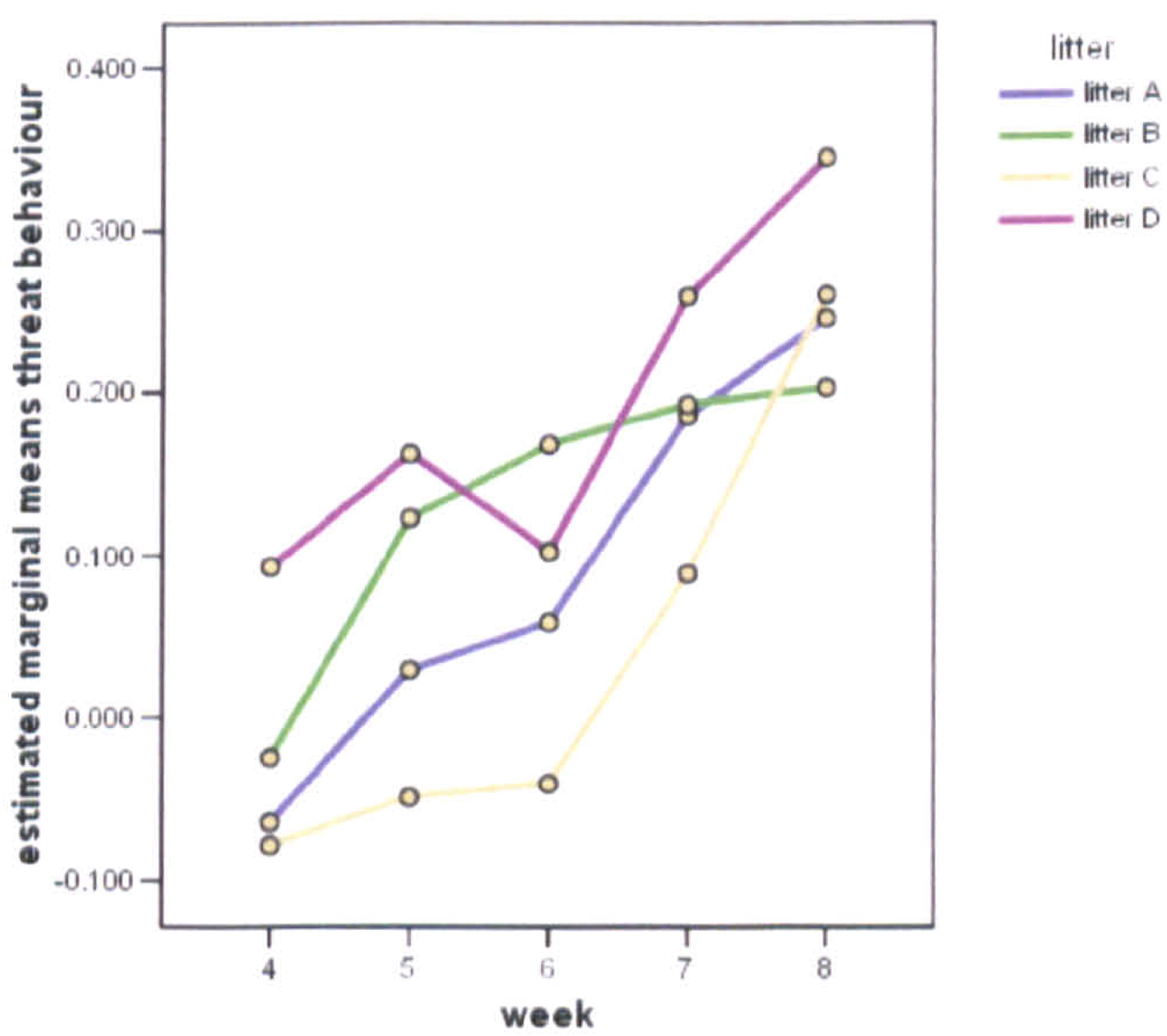



Figure 5.18: Estimated marginal means for the number of threat behaviours per dyadic interaction per sample, shown for each litter per week. Data has been log-transformed (log10(x+0.5).

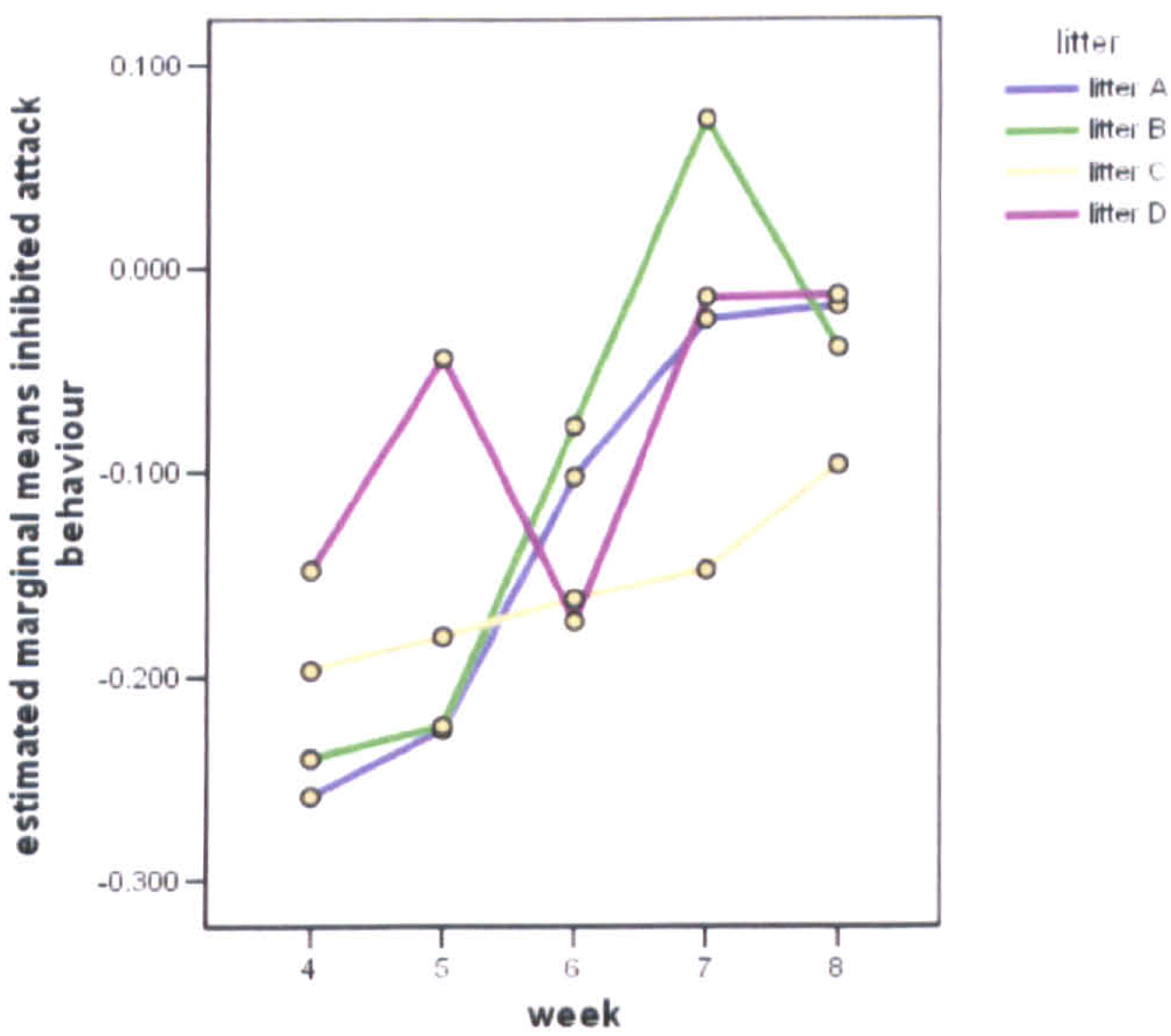



Figure 5.19: Estimated marginal means for the number of inhibited attack behaviours per dyadic interaction per sample, shown for each litter per week. Data has been log-transformed (log10(x+0.5).

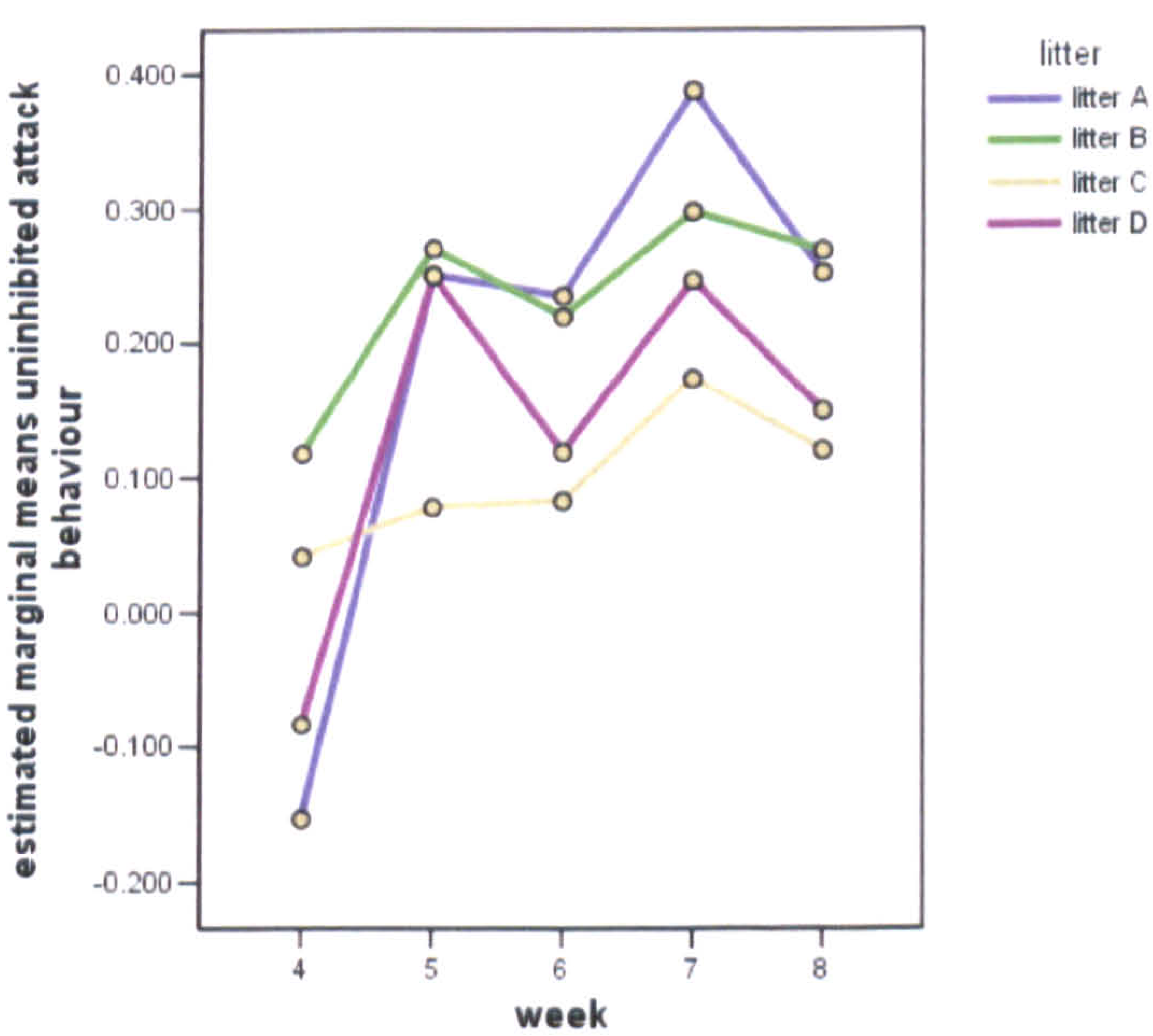



Figure 5.20: Estimated marginal means for the number of uninhibited attack behaviours per dyadic interaction per sample, shown for each litter per week. Data has been log-transformed (log10(x+0.5).

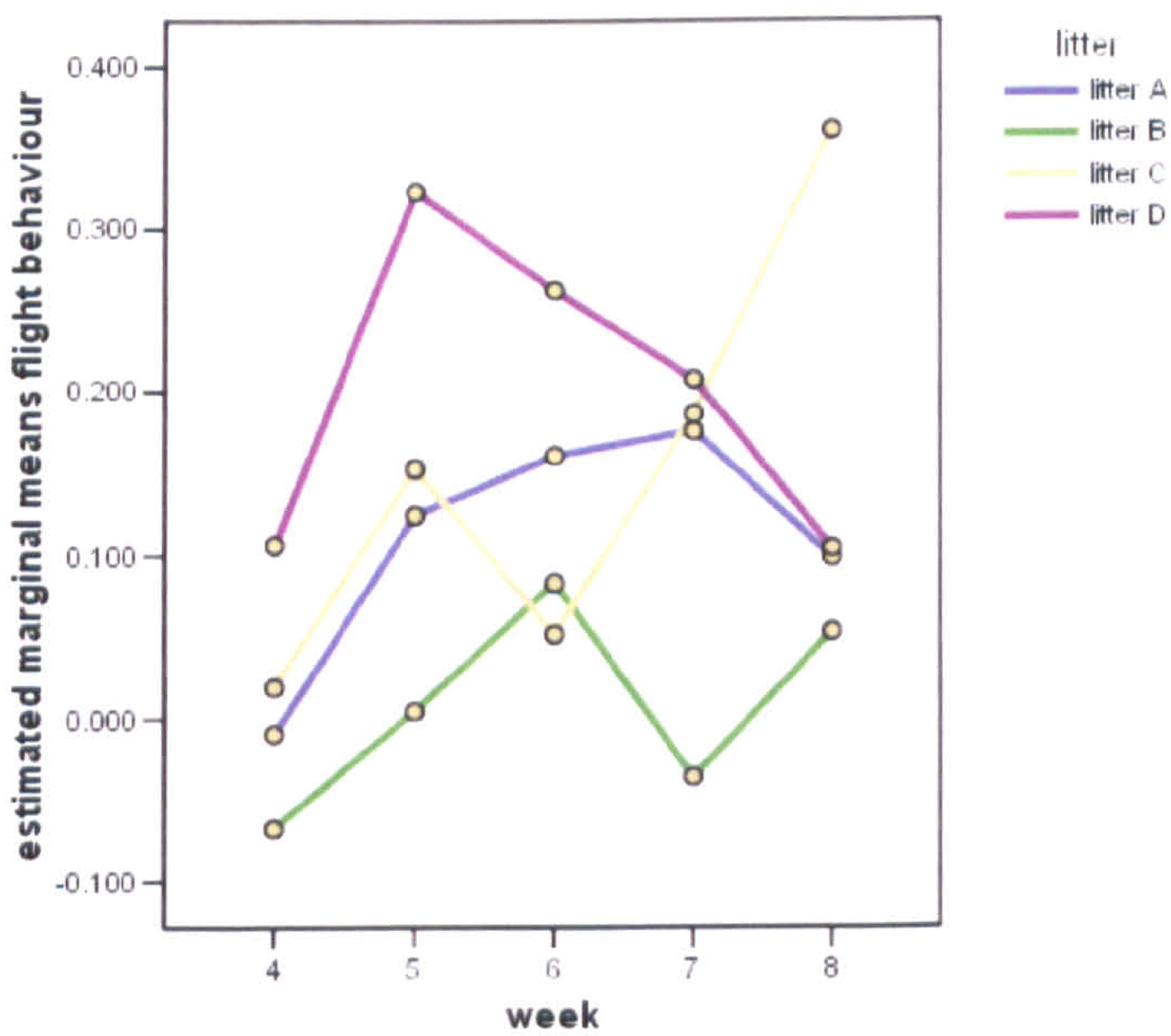



Figure 5.21: Estimated marginal means for the number of flight behaviours per dyadic interaction per sample, shown for each litter per week. Data has been log-transformed (log10(x+0.5).

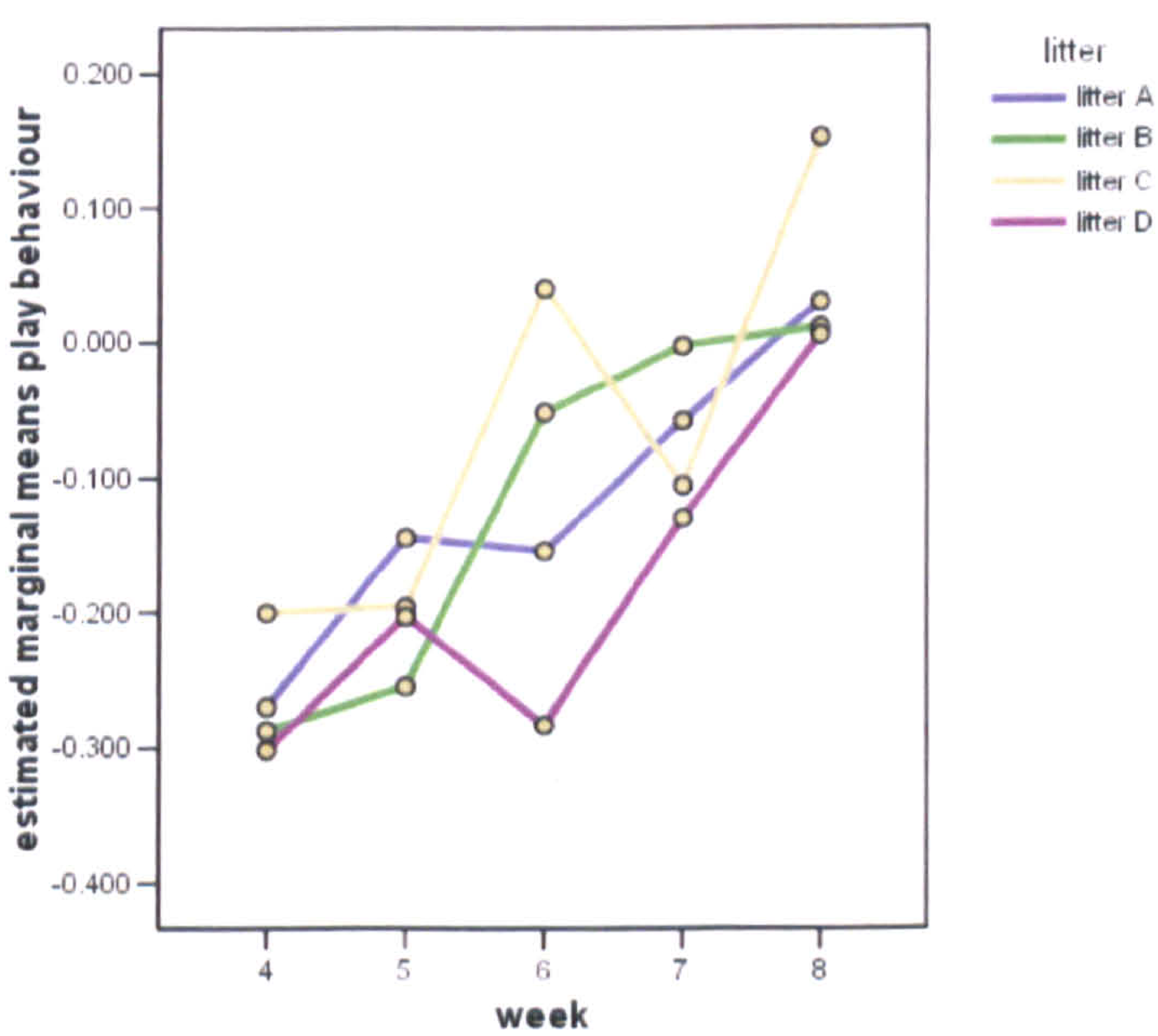



Figure 5.22: Estimated marginal means for the number of play behaviours per dyadic interaction per sample, shown for each litter per week. Data has been log-transformed (log10(x+0.5): i.e. zero is plotted as -0.301.

"Passive submission" was not observed until week 6, but then increased steadily, although even in week 8 it was performed by less than half of the pups (Friedman test comparing weeks 4-8, $Chi^2 = 43.4$, $p<0.001$). The only significant change week to week was the increase from week 7 to week 8 (Sign test, p=0.030). "Stress" was observed rarely (only 41% of pups in all five weeks combined), but increased from week 4 (observed in 1/37 pups) to weeks 5 and 6 (3 pups in each) to week 7 (8), declining in week 8 (4)(Friedman test comparing weeks 4-8, $Chi^2=10.4$, p=0.040).

Since these were both rare behaviours, differences between litters were initially examined for all weeks combined. Litter D performed the least passive submission, and litter A the most (K-W $Chi^2=12.2$, p=0.007) (Figure 5.23). Conversely, litter D performed the most stress behaviour overall (K-W $Chi^2=9.7$, p=0.020) and in week 7 (K-W $Chi^2=12.4$, p=0.006). However, over all the 37 pups the correlation between stress behaviour and passive submission, though negative, was weak (Spearman rho= -0.203) and non-significant (N=37, p=0.230), so it is unlikely that these two categories of behaviour represent alternative strategies.

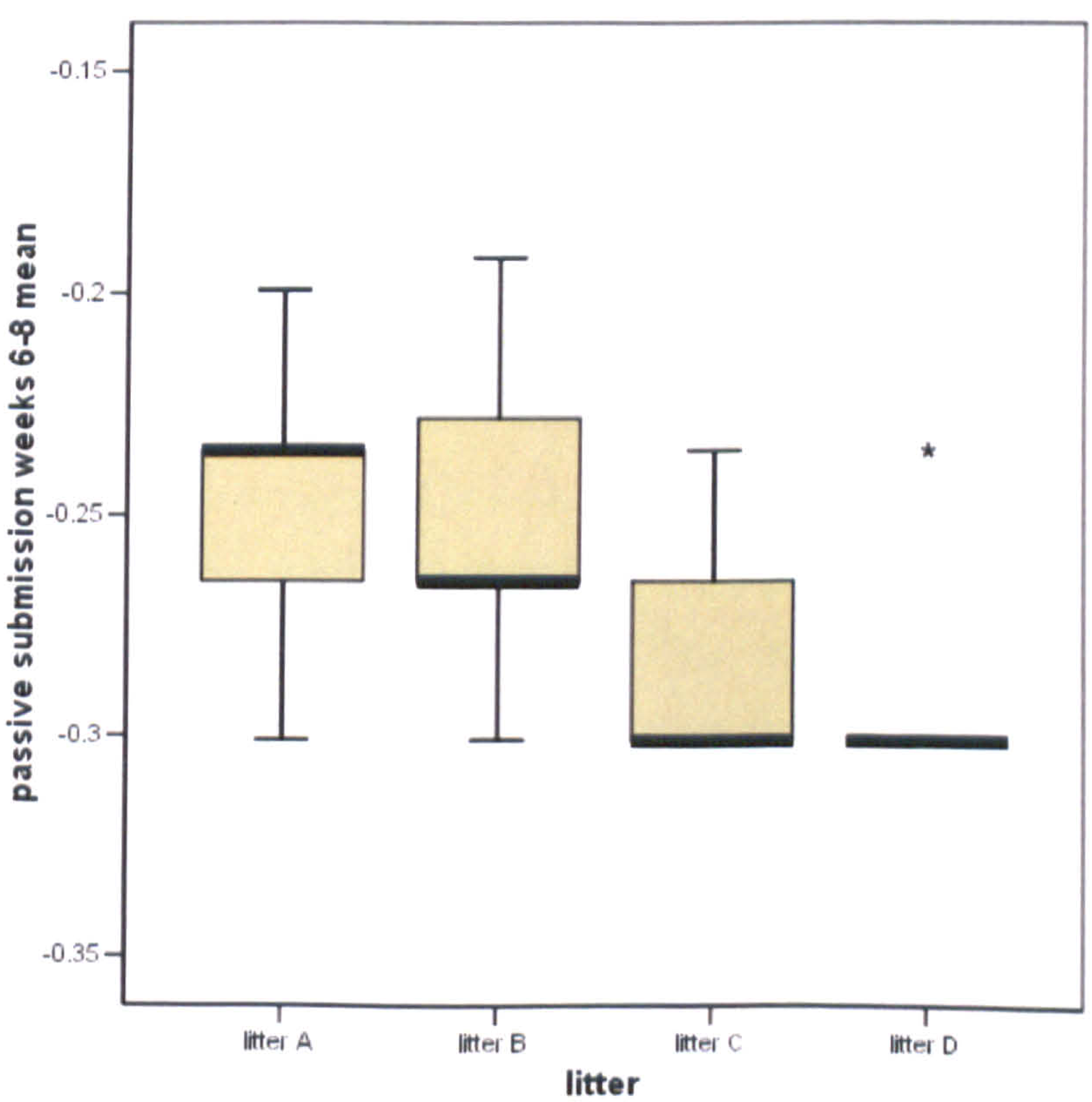



Figure 5.23: Box-plots of the number of passive submission behaviour, aggregated per litter, for weeks 6 to 8. Heavy lines indicate medians, the box extends from the 25th to the 75th percentiles, and the horizontal lines indicate minimum and maximum values, except for values more than three interquartile ranges from the nearest quartile, which are shown as individual points.
Data has been log-transformed (log10(x+0.5): i.e. zero is plotted as -0.301.

For all behavioural groups except passive submission and stress behaviour, the fourth to the seventh week were tested individually against week eight for the reasons already mentioned, using Dunnett's two-sided t-test. The complete results are given in table A5.1 to A5.7 in Appendix 6.

Play behaviour: the differences in development (increase in behaviours shown per week per dyad) were significant for all weeks. Week five => week eight p<0.001; week six => week eight p<0.001, week seven => week eight p=0.005.

Flight behaviour: only week four compared to week eight revealed a significant increase (p<0.001); the other three weeks (five, six, seven) revealed no significant change in number of behaviours per dyad.

Attack behaviour showed about the same distribution of significance as flight behaviour with only week four giving significant results (p=0.001).

Imposing behaviour: in none of the four tests was the increase significant.

Social approach- and threat behaviours again gave an almost analogous picture to play behaviour. The weekly increase in the amount of social approach behaviour per dyad (compared to week eight) was significant for week four (p=0.001), week five (p=0.010) and week six (p=0.001) but not significant for week seven (p=0.295).

Threat behaviour increased significantly between week four and eight (p<0.0001), five and eight (p<0.0001) and six and eight (p<0.0001).

Inhibited attack behaviour only showed a significant difference between week four and eight (p<0.0001) and week five and eight (p=0.001).

## 5.6 Discussion

### 5.6.1 Materials and methods

All data was collected by Altmann's focal animal sampling method (1974) as this is considered to be the most satisfactory approach to study groups of animals (Martin & Bateson, 1996). Some authors mention the disadvantage that, due to fixed observational periods, interesting and/or relevant events may be lost, as the observer has to shift focus at a fixed time, regardless of what may be available for observation (Redlich, 1998; Heine, 2000). Additional observation in the form of behaviour sampling (Martin & Bateson, 1996) would be necessary to produce a more detailed description of social behaviour and social relationships. The problem with the latter mentioned method is that it does not lend itself to statistical analysis, which is more straightforward with a uniform and standardised method like focal animal sampling (Gramm, 1999). A complete description would require 24-hour observation, but this is often not possible due to practical reasons (e.g. arrangements with the breeder etc.). One bias arising from restricted sampling periods, as used here, is that some breeds or litters may be more active than others, thus giving more information than others in a fixed period of observation. This had to be taken into account when it was decided to observe the Rhodesian Ridgeback puppies for two focal animal sequences of three minutes per day, thus following earlier investigations into the behavioural development of puppies from different breeds (for summary see Heine, 2000).
The main information extracted from all the comparable studies on puppy development was the first day of onset of each behaviour pattern from the ethogram (see Chapter 1). These data are quite easily tested statistically (see Schöning, 2000a; Heine, 2000), but are almost certainly biased because the sample size in each of the investigated breeds was small and the rearing conditions of puppies and litter composition were not standardised. Thus Heine (2000) correctly criticises any firm conclusions being drawn from such data, i.e. extrapolations leading to putting certain breeds on the breed-lists of a DDA. The same conclusion was noted by Schöning (2000a).

Another factor biasing comparisons between studies is the point that slightly different ethograms were used. The list of different behaviours (section 3.3) is useful to define the first day of onset for each behaviour. Rottenberg (2000) stated in this connection that the chance of interpretations of single behaviours being different between authors should be negligible, as the descriptions of both simple and complex behaviours from the different ethogram are quite precise. Differences between the ethograms, in the numbers of behaviour patterns, and different behaviours altogether, may cause difficulties, however.

In the current study the ethogram used had been validated by Rottenberg (2000), following Umlauf (1993), and consisted solely of behaviour patterns for social interaction, grouped together according to function. This ethogram, coupled with the sampling method used, does not produce a complete set of data for the first day of onset of any single behaviour, therefore this parameter was omitted from the present study. The grouping of behaviours helped here in comparing litters where individual puppies showed a different level of activity. But it can be stated that the number of litters investigated is critical to whether even these data give statistically significant information. And again, as mentioned for other studies beforehand (Schöning, 2000a), even the number of litters and puppies observed here was rather small for unambiguous conclusions.

### 5.6.2 Development of the social behaviour in Rhodesian Ridgeback puppies

This work concentrates on the development of social behaviours and social interaction between the puppies. The emphasis has been put on this special element in behavioural development, in order to compare trends in the puppies' social behaviour with their social behaviour as adult dogs in special test situations revealing social contact of different kinds with humans or other dogs (Chapter 6).
An earlier investigation into behavioural development of the Rhodesian Ridgeback had already shown that the Ridgeback puppies followed the developmental stages proposed by Scott & Fuller (1965). Social interaction began from the fourth week on (i.e. after day 21) (Schöning, 2000a). Thus the time span from birth till the end of week three was omitted from this investigation. In order to suit one of the breeders, the observation period for all litters started on day 23.

#### 5.6.2.1 Number and length of dyadic interactions among puppies and number of reactors

The sex of the puppies did not have a significant influence on any of these measures, although it cannot be completely ruled out that there might have been some interesting interactions with other factors. By removing it from the analysis such interactions could not be observed. It was nevertheless decided to do so due to the small sample size and the absence of any comparable literature mentioning such interacting factors.
Over the whole period, the litters differed in rates in the number of reactors, seemingly irrespective of the number of available partners within a litter, and in the number of dyadic interaction per focal time. The number of behaviours per interaction increased significantly the older the puppies became, irrespective of which litter a puppy belonged to. The litter by week interaction for all three measures was even more significant, indicating that the litters developed at different rates. There was a significant increase in number of dyadic interaction, number of behaviours per interaction and number of reactors when the earlier weeks of development (week four till six) were compared to week eight.

There are little data available on social interaction between dogs of that age for comparison. Redlich (1998) and Heine (2000) are the only authors among all those mentioned so far (see section 5.3), who looked explicitly at dyadic interactions; although their emphasis was on play and agonistic trends within play, they named nearly all interactions between puppies as "play" of some kind. Redlich counted 3815 dyadic interactions for her American Staffordshire Terriers (21 puppies, 3 litters) for week four to week eight; Heine counted 8400 dyadic interactions for her Border Collies (15 puppies, 3 litters). Only the data from Heine are comparable to the data from the Rhodesian Ridgebacks (3310 dyadic interactions, 37 puppies, 4 litters) presented here, as Redlich took different numbers of video sequences per litter in different weeks.
The comparison between Border Collies and Rhodesian Ridgebacks gives the impression of a vast difference in activity between those two breeds with the Ridgebacks being rather "lazy" compared to the Collies. Overall, the Border Collies showed an earlier onset in a total of 63% of all behaviours from the ethogram, and 66% of social patterns, when compared to the wolf.

For the Rhodesian Ridgeback, the same comparisons come to 30% and 25 % respectively. When looking at the median, quartile and extreme values for behaviours from the ethogram (first day of onset of any behaviour within the different dog breeds), the Ridgeback overall showed no significantly earlier or later onsets than the other dog breeds; but was slightly later than the average of the other dogs in the onset of about 75 % of social behaviours (Schöning, 2000a). The Border Collie was omitted in this last comparison due to those data being not available then, but the early onset of social interaction in that breed suggests that there may be real differences between breeds in the development of social behaviour. This needs to be tested as a hypothesis with a larger number of litters of individual breeds and a completely standardised methodology for data sampling and statistical analysis.
Unfortunately one other important factor for data comparison, the rearing conditions of the puppies, probably cannot be standardised completely between breeders. Cross-fostering experiments in standardised conditions could help to eliminate such biases.

For the Rhodesian Ridgeback puppies the overall trend was that the number of dyadic interactions per focal time increased from week four to week eight, though the differences from one week to the next were not significant. This increase can be interpreted as an increase in social activity overall. This agrees with data from other authors on the general activity of their puppies (Scott & Fuller, 1965; Feddersen-Petersen, 1994a; Althaus, 1982; Venzl, 1990). It can be assumed that the increase in the number of reactors is an automatic consequence of the increase in the number of dyadic interactions, rather than due to deliberate choices of interactors by the puppies themselves.

The puppies' sex had no influence of the development. This was observed also for the Border Collies (Heine, 2000), American Staffordshire Terriers (Redlich, 1998) whereas Dürre (1994) saw an influence of sex on the speed of behavioural development with Weimaraner puppies.

There were significant developmental differences between litters. Venzl (1990) observed developmental differences between her litters of Beagle puppies also, and attributed them, apart from different rearing and other environmental conditions, to different litter sizes. The fewer puppies there were in a litter, the smaller the number of dyadic interactions per focal time. This does not apply to the observations done here, since litter D, with the least number of puppies had, on average, a high number of dyadic interactions per focal time. The discrepancy could be due to the fact that Venzl's puppies came from six small litters instead of four large ones.

Unfortunately neither Redlich (1998) nor Heine (2000) gave numbers of dyadic interactions per focal time. Here many more litters within individual breeds will have to be investigated to establish whether the trend found by Venzl is reliable. With so few litters sampled it is difficult to search the rearing conditions, and any other environmental impacts on the puppies, for the significance of any factors influencing quality and quantity of development.

The number of behaviours per dyadic interaction also increased, in all litters, presumably reflecting greater complexity and reciprocation within each interaction. The difference from week seven to week eight revealed no significant changes in development for the number of dyadic interactions, the number of behaviours per sample or the number of reactors. These results fit in the overall picture of the periods of puppies' social development as first described by Scott & Fuller (1965) and then subsequently confirmed e.g. by Feddersen-Petersen, (1994a). The most dramatic changes in quality and quantity of behaviour can be found from week four to week six.

But here again the results need to be interpreted with caution due to low sample sizes, and the point that the puppies were not observed after week eight.

Other authors have not recorded social interactions in so much detail, making direct comparisons difficult. Venzl (1990) and Heine (2000) measured the absolute length of play phases and "recreational" phases for complete litters. Venzl stated that her Beagle puppies rarely had play phases longer than 30 minutes whereas Heine noticed activity phases for her Border Collies up to two hours in length. Again the question of definition is relevant, as Heine speaks of "play- and activity phases" whereas Venzl just talks about play phases.

Heine (2000) recorded an average bout for social or single object play by a puppy of twenty seconds. She attributed this to a limited time span for attention in puppies aged between four and eight weeks, but did not record how the interaction was terminated, which may often be through interference from another member of the litter. Durations of interactions in minutes may therefore not be particularly informative.

2.6.2.2 Qualitative development of behaviour: functional groups from the ethogram

Behaviours for social approach were the type shown most frequently by the Rhodesian Ridgeback puppies in dyadic interactions, looking either litter by litter or at development in time. The other behavioural groups, in decreasing frequency, were attack-, threat- and flight behaviour; here differences between individual weeks were apparent. In week four to seven, for example, the puppies scored higher on attack behaviour, whereas in week eight threat behaviour was commonest after behaviour for social approach. Flight behaviour was shown more intensively than threat behaviour in week four till six. The time-course of inhibited attack and play behaviour approximately followed those of flight and threat behaviour. Imposing behaviour was shown more intensively in week four and five and resembled here the quantity of flight-, threat- and attack behaviour of week four. Subsequently, imposing behaviour decreased and was overtaken by inhibited attack behaviour. Stress behaviour and behaviour for passive submission were uncommon throughout, with a slight increase in frequency towards week eight.

Altogether this development resembles the pattern already described by Scott & Fuller (1965), Zimen (1971) or Fox (1971,1972). Puppies start their individual ontogeny in social behaviour from performing certain behaviours quite "clumsily", neither controlled nor inhibited, but rather interacting on a yes-no-basis with a hundred percent of possible intensity (arising from immature muscles and nervous control of action).
The hypothesis Althaus (1982) proposed on the development of biting might well be relevant for other behaviours. Biting in dyadic interactions starts accidentally as puppies of that early age investigate their close environment with muzzle and teeth rather than sniffing, as they would do when older. Althaus (1982) assumed that social contacts carried out with the mouth developed from "yawning" behaviour, which itself develops from "suckling behaviour". He observed a quite stereotypic opening and short closing of the mouth around body parts of siblings in his Siberian husky puppies in the first two weeks of age. From the type of behaviour ("reflex-like, stereotypic") he assumed, based on the findings of Menzel & Menzel (1937) and Schmidt (1957), that yawning develops into a precursor behaviour of biting. By chance a puppy yawns near another puppy or object and starts making contact with full or partly open mouth, leading consequently to a more intentional and direct interaction with the open mouth against that object or sibling in further interactions.

Puppy behaviour becomes more differentiated and refined over time and practice until it approaches the complexity of an adult conspecific. Thus it was to be expected that puppies in the beginning of their social development would engage in short dyadic interactions with more or less intensive but unrestrained behaviour. Later in development these behaviours should become more refined and, in the case of aggressive behaviours against siblings and adults, restrained.
For example, the expression of unrestrained biting, apparently triggered by a conspecific approaching or passing by, becomes refined by the inclusion of, or replacement by, elements like inhibited attack, threats or submissive behaviour (Althaus, 1982; Feddersen-Petersen, 1994a), as the puppy learns about the respective information from these signals.

Zimen (1971) already describes clearly recognisable active submission for his wolf puppies in the fourth week and a progressive development in refinement and further variation for the following weeks. Redlich (1998) states that her American Staffordshire Terrier puppies showed a remarkably low tendency for submissive behaviour at all, even against adults, and sees this as a special trend inherent in the breed as such. Again the problem arises of comparing these data and drawing conclusions due to small sample sizes and disparate methods.
Redlich (1998) and Heine (2000) labelled an interaction as agonistic when any kind of agonistic behaviour occurred within it. Redlich stated that the agonistic interactions in her American Staffordshire Terriers escalated rather quickly, with biting, bite-shaking and not reacting to the other puppies' distress vocalisation; this was observed also by George (1995) for the Bullterrier puppies. Heine's Border Collies instead reacted quickly to the other's distress cries and abated their biting. This was observed also for the Siberian Huskies (Althaus, 1982), Weimaraner (Dürre, 1994) and wolves (Feddersen-Petersen, 1992). Comparison of these observations in different breeds is rather problematic, as statements about the course of agonistic interactions may spring from different observational methods. What is generally missing in these studies, is information on the overall development of social behaviour, not simply concentrating on agonistic or aggressive behaviour. The labelling of all interaction between puppies as "play", without looking explicitly at those behavioural elements that are considered as indicators for "play", is also problematic (Rottenberg, 2000).

Only 84 dyadic interactions (1%) among the Border Collies were agonistic (Heine, 2000). Redlich (1998) described higher numbers for three litters of American Staffordshire Terriers: 4.3 %, 15.3%, and 14.3% respectively. These numbers represent the average from all dyadic interactions counted for the respective breed or litter over the complete observational period. Thus they cannot give information on development across time and are in any case not closely comparable among breeds as they come from different methods of observation.

Redlich emphasised the behaviours used to initiate interactions. She said that the majority of all dyadic interactions (70%) were initiated by "play" behaviour. Behaviours like biting, jumping at, muzzle nudging, nose nudging, bite-shaking, mounting or putting one paw on the others back were grouped under "contact-play" and were stated to be typical behaviours for initiating an interaction. Among those contact-play behaviours biting was the one shown to start contact with another puppy effectively the most (35%), defined as when the partner reacts towards the acting puppy. Althaus (1982) and Heine (2000) also noted biting as the major behaviour to initiate play interaction among puppies whereas Beagles (Venzl, 1990) often jumped at the other puppy, and Bullterriers (George, 1995) raised a front paw towards the conspecific. Because of the different ethograms used, and differences in the terminology between the cited papers, "initiating behaviours" were not investigated further for the Rhodesian Ridgeback, apart from stating that the behaviour "pushing" is the one used in the majority for starting interactions, followed by "biting".

It is interesting that imposing behaviour (the term used here to describe signals that are conventionally regarded as indicating dominance) decreased significantly over time, while differences between litters were not significant. Conversely, inhibited attack behaviour increased in quantity over time. Again this development fits the observations by Scott & Fuller (1965), Fox (1971) and Zimen (1971), that behavioural ontogeny leads from the use of uninhibited invariant "all or nothing" behaviours in interactions, to a highly differentiated and in certain situations inhibited behaviour. This also fits Althaus' (1982) hypothesis that single behaviours develop from quite stereotypic and clumsy "yes-no" precursors into more differentiated and refined behaviours when older. In the beginning of dyadic interaction puppies might make contact with the whole body (putting the head on the back etc.), or even climb on top of or over a sibling, possibly accidentally.

So the question arises whether puppies at four or six weeks of age really do impose against each other, as adults would do. The hypothesis proposed here is that they do not impose in the true sense of the word. Imposing among adult dogs fulfils a certain aim: giving information on the proponent's own strength and goals in a certain situation, towards a conspecific which might have similar goals (i.e. an opponent). It is questionable whether conflicts, based upon threats necessary to avoid more risky interaction, actually occur among puppies. It seems more likely that threatening behaviour will develop earlier and in a more refined way than imposing, although they might both be aimed at the same goal. Imposing behaviour is used later on, in careful approaches towards both familiar and unfamiliar dogs, whereas threatening behaviour is shown in escalating conflicts (Feddersen-Petersen & Ohl, 1995). With the puppies the latter point may be more relevant, as conflicts may easily arise "on the spot" over certain resources e.g. a toy or food object, making an immediate solution (gain the toy vs. gain it not) necessary. Careful approaches using imposing behaviour might not be useful in this respect.

Passive submission behaviour and stress behaviour were displayed more rarely, with passive submission suddenly becoming common around week seven to eight. This would again fit the hypothesis that behaviour with more refined informational content tends to appear later on in the dog's life.
Passive submission among puppies is a communicative tool that may not be necessary until they are engaged in more "serious" kinds of conflicts. The low value for stress behaviours in any week would support the hypothesis that conflicts among puppies are of a different quality to those between adults. The hypothesis would be that passive submission behaviour is something puppies learn while using it, when leaving the juvenile stage and approaching puberty. Stress behaviour comprises of behaviours giving information on the state of arousal in several different situations. Here also puppies will have to learn and generalise the information content of these behaviours, which may require  a longer period than the first weeks of life.

Submissive behaviour, stress behaviours and some flight behaviours like displacement behaviours (when used for de-escalation in a conflict), are mostly shown in conflicts regarding status of some kind (Zimen, 1990). The concept of "status" among puppies is controversial. Scott & Fuller (1965) claimed to see a dominance hierarchy established among puppies for the first time towards the end of the juvenile period, when dogs approach puberty. Zimen (1971) stated that wolves do not build any status relationships before twelve months; the opposite was noted from Fox (1972). On the other hand Zimen observed a hierarchy among Poodle puppies at around week seven. Schleger (1983) saw the same for her Bullterriers around weeks five and six. Others looking at social relations among puppies could not observe any hierarchy (Althaus, 1982; Venzl, 1990; George, 1995; Dürre, 1994; Feddersen-Petersen, 1992; Redlich, 1998; Heine, 2000).

There are at least four criteria to estimate status-relations among individuals: who is the winner in agonistic dyadic interactions, who has priority access to limited resources, who shows evasive behaviour towards another individual and who has an inhibiting effect on the actions of another individual (Gattermann, 1993). Heine (2000) for example could observe none of these criteria for her Border Collies and stated that they did not engage in any "serious" interaction up to week eight. Again it is questionable, where "serious" conflicts (in Heine's opinion) really start and where play ends. Nightingale (1991) and Hoskins (1991), both cited in Bradshaw & Nott (1995), looked at Border Collie and French Bulldog puppies respectively and conducted pairwise competition tests for toys. Looking at the test results and at social play among the puppies in general, they found that individual puppies could move from top to bottom of the competitive "hierarchy" and back again, within a matter of days. No hierarchy was detected at all until the puppies were about six weeks old and even then borders between play and status related conflict were fluid.

The necessity for showing passive submission and for feeling "stressed" will arise when there is a still unresolved conflict regarding status and/or access to resources between individual members of a social group, and when these members live very close together, as puppies do. However, the absence of passive submission behaviour and stress behaviour points to the fact that conflict among young puppies might not be related to status. Conflict over resources (which occurs) is a momentary interaction, which may have no consequences for the future social organisation of the litter. For the Rhodesian Ridgeback puppies status-relationships were not explicitly looked at, but from the absence of stress behaviour and passive submission behaviour it can be concluded that conflicts over status and access to limited resources played a minor role. The sudden appearance of higher values for passive submission behaviours in all litters could be a hint, that around week eight the quality of conflicts changes and slowly develops to become more status-related.

Significant changes in development occurred for flight and attack behaviour only in comparisons between week four to week eight. Inhibited attack behaviour developed significantly from week four and five compared to week eight whereas the developmental changes for imposing behaviour were never significant. Play behaviour showed a significant change in quantity and overall comparisons with week eight, apart from the comparison between week seven and eight, and the same applied for social approach and threat behaviour. This again supports the hypothesis that behaviour undergoes development in information content and the function of the signal, and becomes altogether more refined in time.

As stated earlier already, Redlich (1998) and Heine (2000) classify almost any interaction among puppies as "play" apart from true fights. When Heine describes e.g. play-fighting, she lists single "agonistic" behaviours such as biting or snapping, but does not explicitly list single behaviours or complex behavioural states indicating play, e.g. mouse pounce or play-face. Her main factor for differentiation between play-fight and true agonistic interaction is the quality of snarling and growling, which is louder in agonistic interactions and can be mixed with barking sounds. According to Heine (2000) there will be no play-signals from the other partner in the dyadic interaction (without specifying these play-signals any further). Again it is questionable whether "agonistic" interactions displayed by puppies can really be called agonistic in the same sense as for adult dogs (see Chapter 1). On the other hand it is questionable in general whether interactions between puppies can be simply differentiated into play and agonistic interaction. This seems to resemble the broad public's view that puppies cannot do anything but be "cute" and play or be "wrong" and nasty, which might be used to justify harsh action by the owner.

Zimen (1988, 1990) called play a strategy to resolve social conflicts in wolves and dogs, a strategy which minimises the risk of a conflict becoming too serious with subsequent risk of injury. Bekoff & Byers (1982) state that play might sometimes be without an explicit goal but is never without a function. It is agreed by many authors, that the main function of play in early behavioural development is to train and refine the motor function of muscles and improve movement and action aimed at individual goals or targets, and to learn and refine skills in communication (summary see Lindsay, 2000), thereby increasing biological fitness.

To really look at the function of play and agonistic behaviour in puppies, a more detailed analysis of dyadic interaction is necessary, which has partly been started e.g. by

Redlich (1998) and Heine (2000). They looked at the course of dyadic interactions, noting which behavioural approach was answered by which behaviour, and whether the interaction was terminated afterwards or not. This approach was not taken here, as it was not in line with the main goal of this investigation, and so the data collected cannot be used to decide whether any interaction between puppies is always either play or agonistic interaction. Overall, the data suggests that between week four and week seven/eight there is an important step in development: the stereotypic yes-no exhibition of fight-flight behaviours abates, these patterns become more refined, and become more regulated by signalling. In parallel, the more sophisticated signals for daily regulation of social life start to appear in the behavioural repertoire.

In summary, further research in this field should concentrate on some relevant points. First a much larger number of puppies and litters for any breed, whether investigated so far or not, has to be looked at, under conditions that are as identical as possible. Second, the observational methods have to be identical, and the overall goals of such investigations, in so far as they influence what data are gained, when and how, should be similar. Third, cross-fostering experiments are needed to further pursue questions such as which factors have relevant impacts on puppy behaviour and the behaviour and character shown later on by the adult dog, and if indeed there are any breed specific differences in character (see Frank & Frank, 1981). Scott & Fuller (1965), for example, did some pilot studies on cross-fostering with Basenjis, and concluded that genetic contributions to breed differences overshadowed environmental contributions. But in later studies with hybrids they had to face the fact, that "cultural differences" between breeds were somewhat dependent on the environment.

# Chapter 6:

## Comparison of behaviours shown by Rhodesian Ridgeback puppies when eight weeks old, to aggression scores and behaviour shown in the aggression test when adult.

## 6.1 Aims

There are several reasons why it is of interest to be able to predict the character traits of an adult dog, and its preferred behavioural patterns in individual situations, from its behaviour when a puppy. Whether environmental factors or genetic factors have more impact on the development of a dog's overall character or temperament is of topical interest, as certain authorities in European countries place emphasis on genetic factors (e.g. breed) as if they determine whether or not dogs become dangerous to humans. So far, not much relevant literature exists in this field. As a further contribution to this debate, the behaviour of the Rhodesian Ridgeback puppies described in the previous chapter will be compared to the behaviour of the adult dogs already looked at in Chapters 2 and 3 of this thesis.

Hypotheses 1 and 2b shall be especially addressed here:

- Can it be deduced how an adult dog will behave later in life, especially when in a conflict situation, from its social and especially aggressive behaviour when a puppy?
- Does the owner, as potentially the most salient part of the dog's environment, play an important role in the development of the dog's social and aggressive behaviour, once it has left its siblings and mother?

## 6.2 Introduction

Not many long-term evaluations have been done on the development of behavioural elements and character traits in dogs. Those that have been done give contradictory results on test efficacy, as already stated in Chapter 1. For example, whereas Venzl (1990) could detect similar test responses between puppies tested with Campbell's test and again as adults for "contact behaviour" and "willingness for submission", Beaudet (1993) and Reid & Penny (2001) found only a weak association between puppy test results and results from the older dogs in general. Problems comparing these results spring from not using identical procedures when testing, not even where the age of the dogs is concerned. Whereas the puppy's age is mostly similar in the tests (around week six to week eight), the retests with the adult dogs are sometimes done after week 16, and sometimes when the dogs are nine or twelve months of age or even older. Different test procedures, including different scoring systems, further confound results. Campbell (1972,1974) looked for one temperament value per puppy, predominantly characterising its behaviour in social contexts. Reid & Penny (2001) added some environmental stimuli to Campbell's test, and later on asked the owners of the adult dogs about the dog's behaviour and reaction to different environmental stimuli, including social contact with known and unknown people.

Wilsson & Sundgren (1998) did not find puppy tests useful in predicting adult suitability for service dog work, as correspondence of puppy test results and adult performance was negligible. They found paternal effects playing a weaker role in the dog's behavioural development than maternal effects, though even the latter were more likely to be seen in juvenile than in adult behaviour. They also assumed a higher inter- than intra-litter variation in maturation.
Wilsson & Sundgren stress the point that puppy tests at the early age of six to eight weeks are not useful for determining the subsequent usage of a dog, because that age is a period where behaviour changes too rapidly to find significant correspondence with adult dog behaviour. The same point was stressed by Serpell & Hsu (2001).

Slabbert & Odendaal (1999), also looking at working suitability of dogs, tried to predict adult police dog efficiency. Their test was performed at different stages in development between the age of eight weeks up to nine months. Again predictive value was weak apart from the retrieval test at week eight and aggression test at nine months.

Serpell & Hsu (2001) compared the assessment of future guide dogs by their puppy walkers, with the assessment done by the guide dog training institution. They considered their questionnaire method more useful for the evaluation of prospective guide dogs (dogs were evaluated when 12 months of age) than testing the puppies. Comparing observation results from owners, given in a questionnaire, and independent testers, Stephen & Ledger (2003) suggested also that owner reports are more likely to provide a reliable external criteria for the validation of temperament tests than independent testers.

Rooney at al. (2003) looked at predictiveness of puppy tests in selecting dogs suited to become military search dogs. Puppies were first tested when eight weeks old. Tests comprised, among others, situations to test for fearfulness (novel experiences) and playfulness. Dogs were then "puppy-walked" in individual households and retested at eleven months of age. Only in one of the subtests was there a significant correlation between the responses at the two ages – and in the opposite direction to prediction. Rearing conditions proved to influence behavioural development significantly. The authors stated that puppy tests were unlikely to be useful predictors of adult behaviours.

This was also emphasised by Diederich & Giffroy (2003), who concluded that results from puppy tests are not encouraging. They criticised the poor implementation of the four quality requirements applied in behavioural testing (standardisation, reliability, sensitivity, validity). They pointed out a lack of uniformity in the general field of testing for character, temperament or later working abilities, in regard to the different authors' objectives, the characteristics of stimuli employed and the behavioural data, including its interpretation. They concluded that the literature on adult dog testing is more encouraging than that on puppy testing.

The study to be described here will follow a different approach to the cited studies. The puppies have not been tested once at a fixed age but been observed following a standardised protocol (see the previous Chapter) over consecutive days, and so should be less susceptible to the rapid variation in general activity observed in individual puppies. Emphasis was laid on the behaviour shown during social interaction with a sibling within a dyad. Results in Chapter 5 showed, that the puppies' development had come to a certain point of consolidation between week seven and eight. As no data was collected following this point it cannot be said whether this consolidation continued through the next months of life, but as this was the last week at the breeders' under fixed rearing conditions for each litter, the behaviour shown in week eight per puppy / per litter will be compared first between litters, and then with the behaviour of the same dogs as adults, undergoing a standardised temperament test.

## 6.3 Materials and methods

### 6.3.1 Dogs

The Rhodesian Ridgeback puppies have been described in detail in Chapter 5, and the adult Ridgebacks have already been mentioned in Chapter 2. Not all the puppies could be accessed when adult; the dogs listed in Table 6.1 were tested as adults. Adult dogs were tested at an average age of 35 months (ranging from 24 months to 48 months). This broad range was unavoidable since the puppies were sold all over Germany, and more time was needed to travel round for in-home visits and have the owners travel also. Arena tests were performed in the location already described in Chapter 2, apart from two dogs, that had to be tested in a remote part of a large public area in their own vicinity as the owners were unable to travel.

Table. 6.1) Rhodesian Ridgeback puppies tested as adults, showing the litter (letter code), sex, neuter status and age in months at testing.

| Dog number | Sex | Month tested |
|---|---|---|
| A2 | Female | 48 |
| A3 | Female | 40 |
| A5 | Female | 48 |
| A7 | Male | 40 |
| A10 | Male | 42 |
| B2 | Female | 42 |
| B7 | Male | 42 |
| B5 | Female | 32 |
| B8 | Male | 32 |

| Dog number | Sex | Month tested |
|---|---|---|
| C3 | Female | 24 |
| C4 | Female | 27 |
| C7 | Male | 24 |
| C8 | Male neutered | 28 |
| C10 | Male neutered | 27 |
| D1 | Female neutered | 30 |
| D2 | Female neutered | 32 |
| D3 | Female neutered | 30 |
| D4 | Female neutered | 32 |
| D7 | Male | 32 |

### 6.3.2 Testing procedures, scoring and ethogram measures

The procedures for testing and scoring adult dogs have been described in detail in Chapter 2. The ethogram and ways of measuring behaviour of puppies and adult dogs have been described in detail in Chapters 3 and 5.

### 6.3.3 Data collection, data samples and statistical analysis

Data collection, and statistical analysis of each separate dataset, have been described in detail in Chapters 2 to 4. The two datasets were compared using Spearman correlations, or Mann-Whitney U-tests where the adult tests had produced only two values for the aggression scoring: among the 19 adults, 15 had scores in subtest group D of 1 (no aggression) and the remainder had scores of 1.33 (mild aggression in one of the three test elements). Where relationships between one puppy variable and several adult variables were apparent, partial (Pearson) correlation tests were used to indicate which relationship was the more robust.

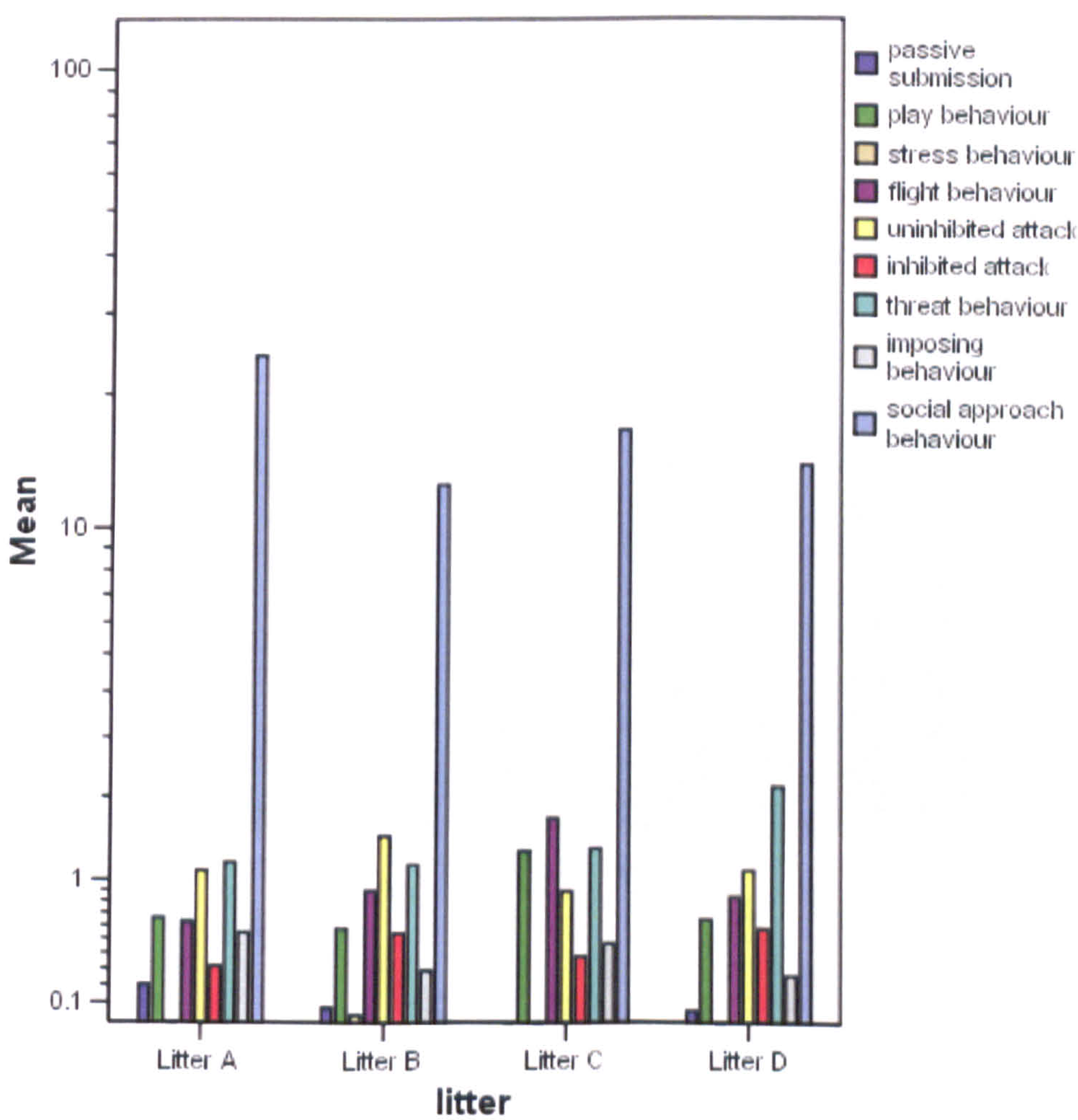
## 6.4 Results

### 6.4.1 Behaviour of the Rhodesian Ridgeback puppies in week eight

The comparison made was the behaviour of the puppies with the behaviour of the same dogs when adult, in certain (and partly stressful) situations of social contact with humans or other dogs. Behaviour in week eight was selected as this was the last week at the breeders' under fixed rearing conditions for each litter, and also there was only one significant change in behaviour from week seven, indicating a degree of consolidation in behavioural development in this period (see Chapter 5). Social approach was the most frequently performed class of behaviour overall in week eight, followed by uninhibited attack and threats (Figure 6.1).

Differences between the litters for rates of performance of each of the behavioural groups were tested with independent samples t-tests for equal variances. Significant differences between litters were scarce. Litter A and B did not differ significantly in any behavioural group. The same applied for litter B and D. Significant differences in display of behaviour could be found between litter A and C and as well between litter B and C, in two behavioural groups each: uninhibited attack behaviour (A/C $p=0.016$, B/C $p=0.025$), flight behaviour (A/C $p<0.001$), stress behaviour (B/C $p<0.001$). Litter A and D differed significantly in passive submission behaviours ($p = 0.044$) and imposing behaviour ($p=0.035$). C and D differed significantly in the display of flight behaviour ($p<0.001$).

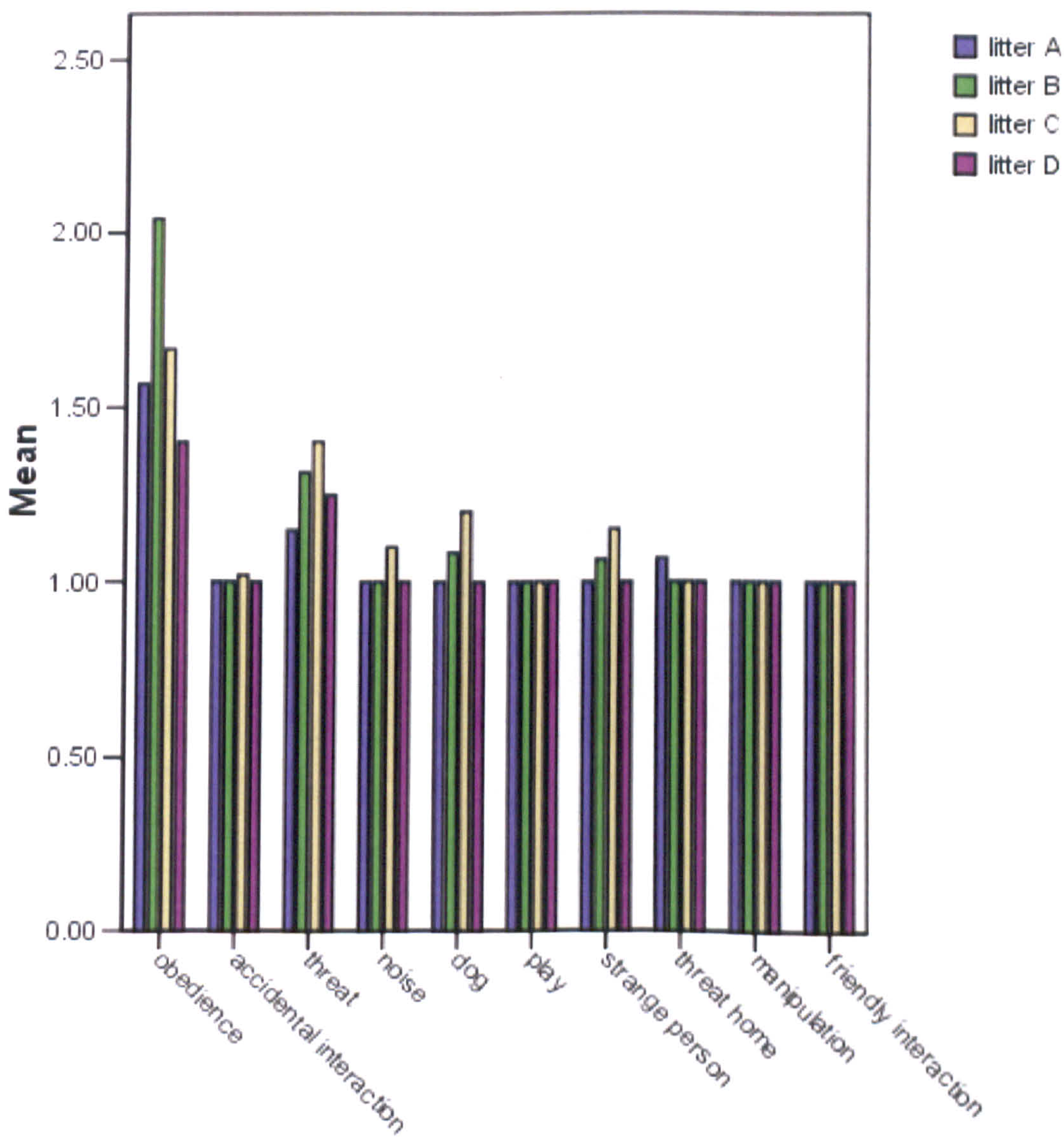
Figure 6.1) Average rate of performance per sample period, for all behaviour types for each litter at week eight. Y-axis has been converted into log-scale to facilitate examination of low-frequency behaviour groups



### 6.4.2 Aggression scores and ethogram measures of the adult Rhodesian Ridgebacks for the different subtest groups, divided by litter

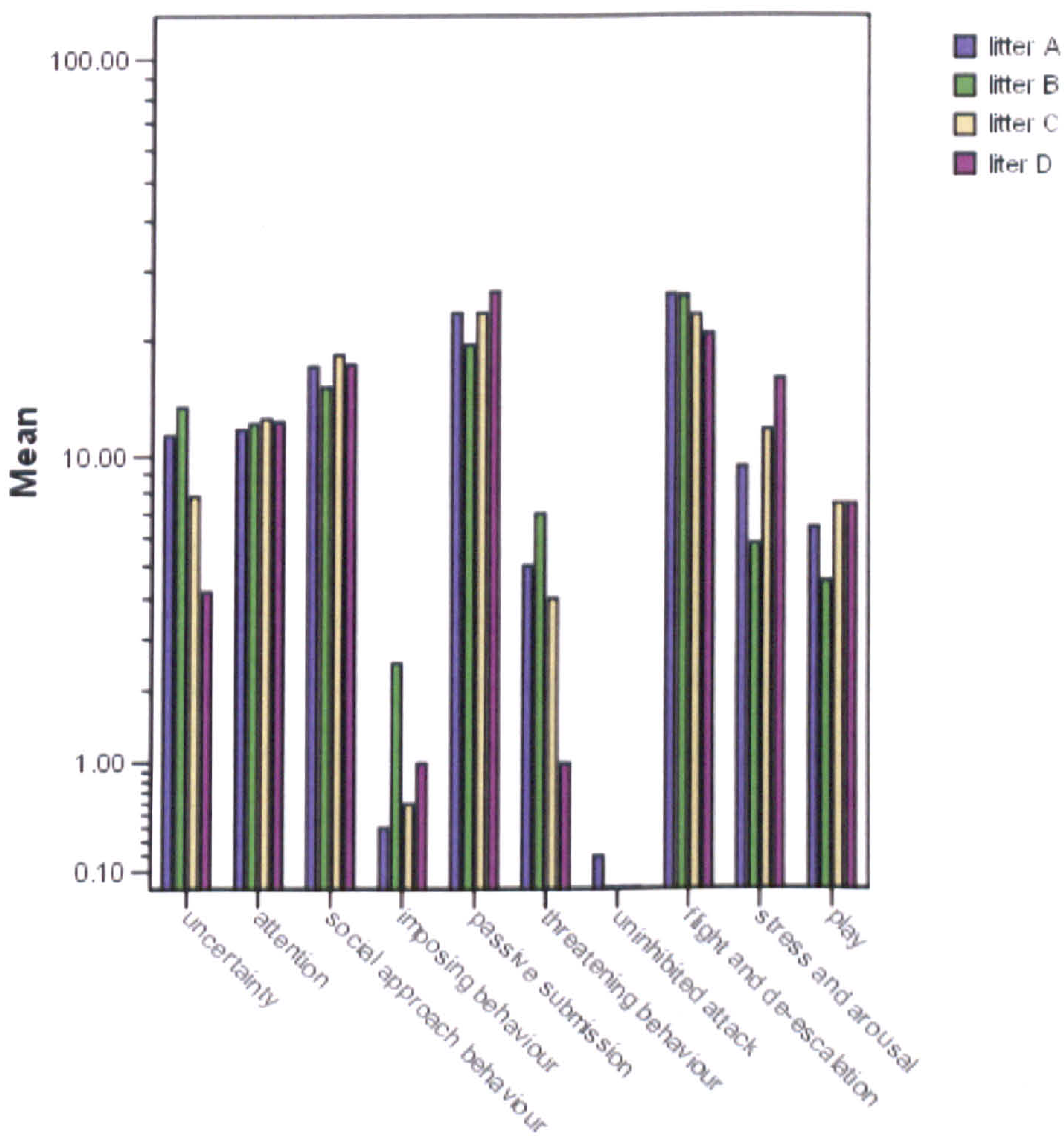
There were no significant differences between litters in the mean scores of the adult Rhodesian Ridgebacks in any of the individual subtest groups or the obedience scores (Figure 6.2) (for complete results of Kruskal Wallis tests see Table A5.1 in Appendix 5). Slight differences between litters, in mean scores above "1", can be seen in subtest groups B (threats), C (noise), D (dogs), F (strange person) and the obedience scores.

Figure 6.2) Mean aggression scores (Y-axis) of the Rhodesian Ridgebacks by litter in the individual subtest groups and for obedience (X-axis)



There were also few differences between litters in the display of components of the ethogram; Figure 6.3 shows the comparison between litters for mean counts in each of the individual behavioural groups from the ethogram, and the individual behaviours "attention" and "uncertainty". The only differences were for passive submission (K-W $Chi^2$=7.7 (showing a tendency); df=3; p=0.052) and stress behaviour (K-W $Chi^2$=12.3; df=3; p=0.007); in both cases dogs from litter D showed the highest values. Table A5.2 in Appendix 5 gives the full results of the Kruskal Wallis tests.

Figure 6.3) Mean counts for behaviours from the different behavioural groups and two single behaviours, by litter. Y-axis has been converted into log-scale to facilitate examination of low-frequency behaviour groups.



### 6.4.3 Comparing ethogram measures of the adult Rhodesian Ridgebacks to the behaviour displayed by the same dogs when eight weeks of age.

Given that there were few differences in the behaviour of littermates when they were tested as adults that could be ascribed to litter, correlations were examined at the level of the individual, between the behaviour shown by the 19 Rhodesian Ridgebacks when tested as adults and their behaviour as puppies in week eight. Behaviour groups excluded were "inhibited attack" (not shown by the adults) and "uninhibited attack" (just shown by two dogs). "Uncertainty" and "attention" were not considered separately for the puppies though the behaviour "uncertainty" was included in their group "behaviours for stress and arousal". Spearman rank correlation revealed no significant correlations between quantity of behaviours shown as puppies and as adults.

As there was some noticeable variation in the aggression scoring for subtest group B (threats) among the adult dogs, the behaviours shown as puppies were also compared to these results with Spearman rank correlation, but no significant correlations could be found.

Many test elements that the adult dogs were exposed to did not comprise dog-dog interaction, but all the behaviour of the puppies that had been recorded was interactions with other puppies. Therefore the adults' scoring in subtest group D (dogs) was compared to the behaviour shown as puppies. Among the 19 adults, 15 had scores in this subtest of 1 (no aggression) and the remainder had scores of 1.33 (mild aggression in one of the three test elements).

The puppies were therefore divided into these two groups, and their behaviour compared with Mann-Whitney-U Tests. The higher aggression scores in the adults was significantly linked to high counts for flight behaviour as puppies (MWU=8.500, p=0.031). There were also marginally significant links with high levels of play behaviour (MWU=10.500, p=0.050) and stress behaviour (MWU=22.500, p=0.053) in the puppies. Of these behavioural groups for the 19 adults, play behaviour was highly significantly correlated to flight behaviour (Spearman rho=0.615, p=0.005), possibly accounting for the apparent link between dog-dog aggression as adults and play as puppies. The correlation between flight behaviour and stress behaviour among the puppies was non-significant (Spearman rho=0.216, p=0.375), so the link with stress behaviour may be independent; a larger sample would be required to confirm this.

As the adult dogs performed almost no behaviour corresponding directly to the uninhibited attack and inhibited attack in the puppies, correlations between these behaviours and "uncertainty" and its counterpart "attention" in the adults (see Chapter 3) were examined. Also the obedience scores were examined as they had substantial variation in the adult Ridgebacks. For all behavioural groups no significant correlation between obedience of the adults and the puppy behaviour could be found, apart from uninhibited attack, where the correlation was positive (puppies with high counts for uninhibited attack behaviour showed high (i.e. "bad") obedience scores when adult; Spearman rho=0.577, p=0.010) (Figure 6.4). Uninhibited attack in the puppies was also significantly negatively correlated to attention behaviour in the adults (Spearman rho=-0.512, p=0.025) (Figure 6.5). Since attention and obedience were themselves correlated in the adults (Spearman rho), partial (Pearson) correlations were calculated between these variables and uninhibited attack in the puppies. The correlation between obedience and uninhibited attack seemed to be the relevant one, with attention just linked through its correlation with the obedience scores.

Figure 6.4) Scatter plot showing the relation of counts for uninhibited attack behaviour in the puppies (X-axis) and the mean obedience scores of the adult dogs (Y-axis).

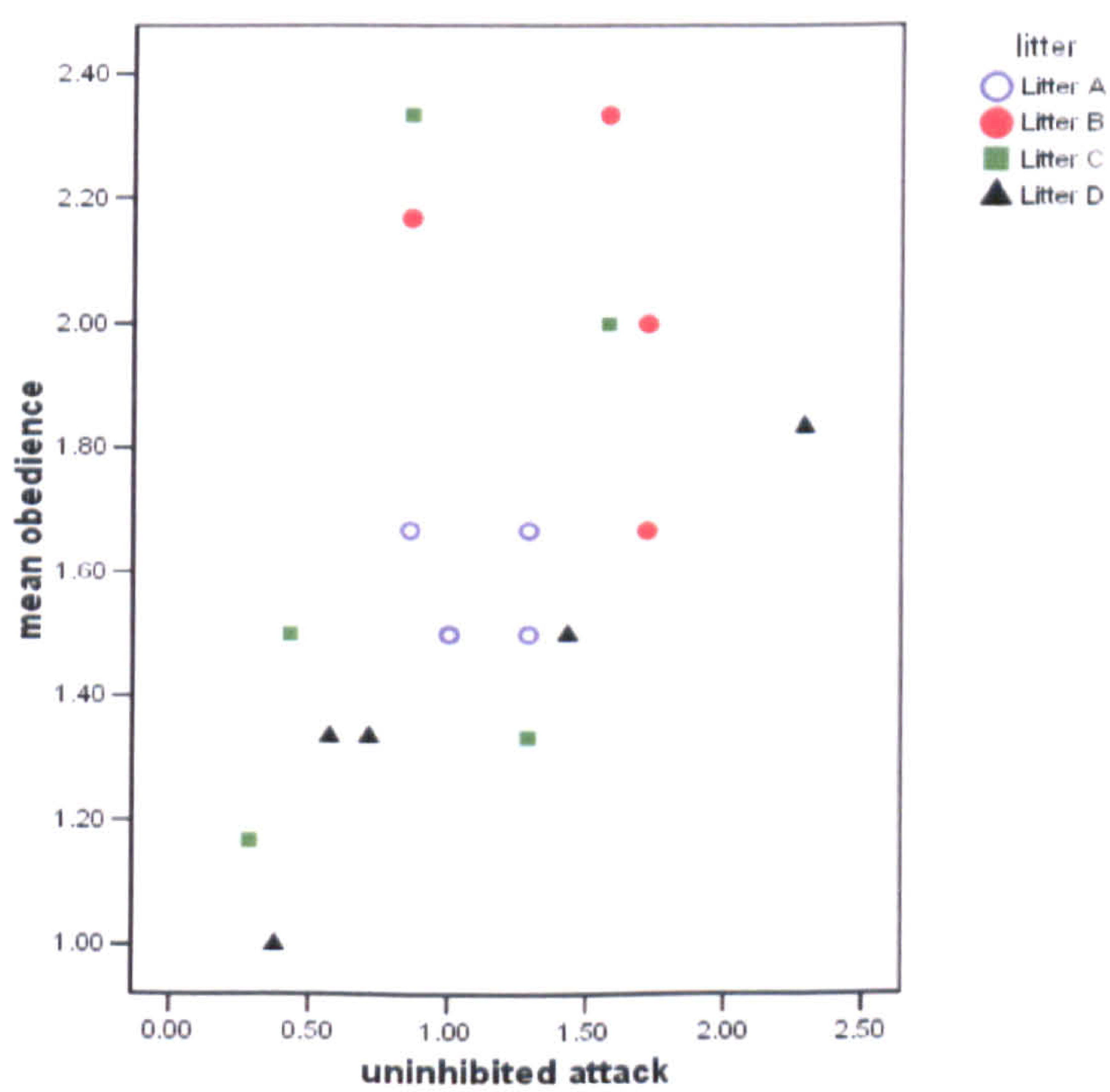
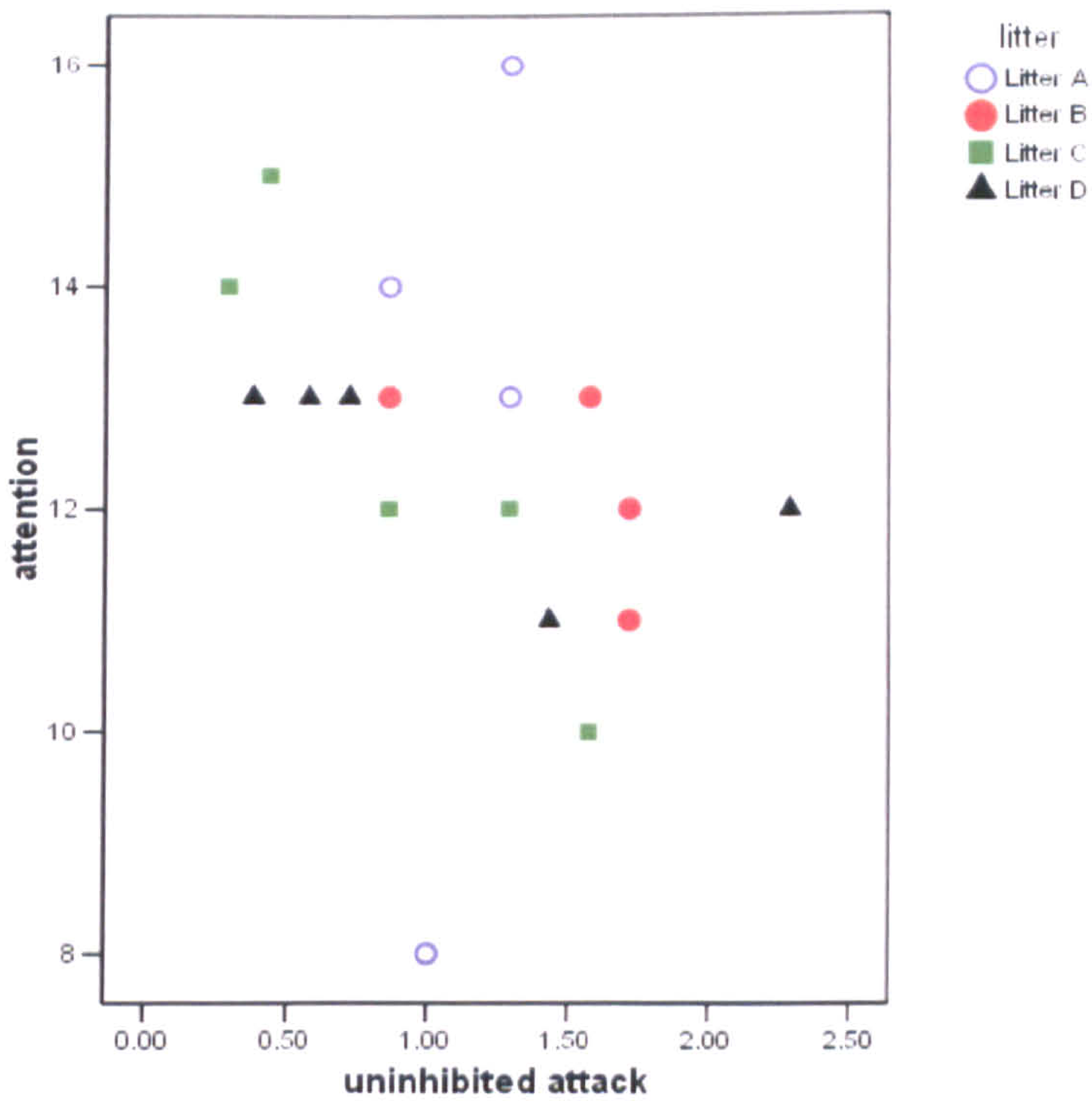


Figure 6.5) Scatter plot showing the relation of counts for uninhibited attack behaviour in the puppies (X-axis) and counts for attention behaviour of the adult dogs (Y-axis).




## 6.5 Discussion

### 6.5.1 Behavioural differences between litters in adult dogs

When the aggression scoring was examined, small differences between litters could be found but these were not significant. They will nevertheless still be discussed as "differences", assuming that they would have become significant if more litters had been sampled. Small differences occurred in subtest groups comprising threats, noise, other dogs and strange persons. Thus there was a tendency for non-significant litter differences to occur in some of the groups of stimuli with the highest aggression eliciting power, where breed differences also occurred (see Chapter 2) – indicating that something called "breed difference for aggressiveness" might still better be ascribed to "individual differences" until more data is available.
Looking at between-litter differences for the behavioural output, significant differences could only be found for stress behaviour and, in tendency, for passive submission. In

both cases dogs from litter D showed the highest frequencies; these dogs had been raised in almost identical conditions to litters A and B. Breed differences have also been found for both these behavioural groups (see Chapter 3).
These data seem to suggest that neither genetic nor factors in the environment experienced by the litter are predominant in leading to behavioural disparity between litters. But of course these results are inconclusive due to the rather small sample.

### 6.5.2 Behavioural differences between litters during week eight

In Chapter 5 it was shown, that for the Ridgeback puppies, expression of all groups of behaviour, apart from social approach behaviour, changed with time, but not significantly between litters. For social approach the four litters differed significantly in their development, most interestingly between litter A and B, even though these puppies were reared under conditions as nearly identical as possible in this field of research, and were kept together from day 31 (litter A) and day 27 (litter B) on respectively. In addition to their social approach behaviour, litter A and B differed remarkably in their development of imposing behaviour, although the development of imposing behaviour did not significantly differ when all litters were compared. These observations could suggest an underlying genetic difference (certain lines within breeds) but could also be explained by differences in maternal behaviour.

The litter was a factor leading to differences in development in the group of flight behaviour and threat behaviour also. Here the difference in development between litter A and B was not as significant as for social approach and imposing behaviour but can still be seen as more anecdotal evidence for genetically/maternally facilitated differences in behavioural development. Interestingly there was no significant difference between the litters with uninhibited and inhibited attack behaviour. Here apparently the development in time seems to be more relevant. As all puppies had additional contact with other adult dogs, and litter sizes were, when compared to other studies so far, rather large (see Feddersen-Petersen, 1994a; Schöning, 2000a), it will be interesting to compare many more litters with more variation in puppy numbers. A hypothesis could be that both uninhibited and inhibited attack behaviour will develop significantly differently between litters when there is a significant difference in puppy numbers, and also different amounts of contact with adult dogs apart from the mother.

When litter and time were looked at as a combined factor, they had a significant influence on behavioural output in all groups except for threat behaviour and inhibited attack behaviour, i.e. litters differed in their rates of development for different types of behaviour. This is especially interesting in case of threat behaviour as both time and the litter as individual factors had significant influences on behavioural development. The number of litters observed is too small to really draw conclusions from this. It could be speculated, that especially for threatening behaviour, playing a relevant role in well armed and highly social animals for preventing any actual damage in contests, genetically fixed abilities play as important a role as rearing conditions with their influence in time. Both could not only influence but supersede each other. The different rates of development between litters do not allow specific conclusions about genetic impact, as the litters (pups within litters) are subject to vast amount of environmental influences. A hint that there might indeed be genetically-influenced differences in development of social behaviours as a whole in the Rhodesian Ridgeback puppies can be derived from the fact that three of the four litters came from the same breeder (and two litters were kept together) under nearly identical rearing conditions.

Although the litters appeared to develop at different rates, by week eight, not much difference remained. Litters A and B did not show significant differences in the expression of behaviour in any of the groups at this age. As both litters were brought up under identical conditions, this would favour the opinion that it is not so much the genes but the impact of the environment on the genetic basis that decides on later behaviour and even temperament. Litter D came from the same breeder as litters A and B, so environmental influences on the puppies would have been similar, though not identical, when compared to these other litters.

Interestingly, there was no significant difference in display of behaviour between litter B and D, although litter A and D differed significantly in the display of passive submission and imposing behaviour. Litter C came from a different breeder than the rest and here differences in display of behaviour were significant for uninhibited attack behaviour (C/A, C/B), flight behaviour (C/A, C/D) and stress behaviour (C/B). These results could hint, that only slight differences in environment could result in behavioural differences in behaviours which become very refined in their informational content. Competence in the social signalling necessary for the rather sophisticated management of conflicts may be gained through intense learning under specific challenges from the social environment. This could apply to behaviours like threats, passive submission or imposing. Strong environmental differences apparently could lead to differences in behavioural display in other areas. Differences in behavioural display, when comparing litter C to the other litters, were mainly in the "fight-flight" area.

The point has to be stressed, that the rearing conditions for litter C were close to optimum, i.e. did facilitate overall correct socialisation; integration into the breeder's family, contact with many different environmental stimuli (humans, adult dogs, visual and acoustic elements, garden etc.). Poor socialisation does have a negative influence on the mental state of the puppies and later leads to dogs that are rather fearful and non-stress tolerant, many showing agonistic behaviour (flight, threat, attack) in conflicts of any kind (Vanderlip et al., 1985; Appleby et al. 2002). This trend for agonistic behaviour was seen by Riesenberg & Tittmann (2003) when testing puppies and adolescent dogs kept in a puppy-mill in a massively restricted environment, but could not have emerged from the generally well-socialised puppies tested here.

### 6.5.3 Comparing puppy behaviour to the behaviour of the adult dogs

When puppies and adults were compared, no significant correlation between those behaviours shown as pup and those shown as adult were found. Thus apparently differences between litters had become smaller as the dogs had grown up. Although in isolation no firm conclusions can be drawn from such a small sample, many other studies have come to the conclusion (see section 6.2) that puppy behaviour is not a relevant indicator for later behavioural patterns or character.

Since the dyadic interactions recorded among the puppies were most likely to be reflected in the dog-dog interactions in the test, these were examined in more detail. High aggression scores for the subtest-group comprising dog-dog test elements were significantly correlated to high counts for flight behaviour and behaviour for stress and arousal in the puppies. Dogs that were more easily stressed in interactions with siblings as puppies could be dogs that might be prone to become stressed more easily in dog-dog interaction later in life, and might react aggressively. But again there is no direct proof for any underlying genetic influence.

Uninhibited attack behaviour of siblings by the puppies could not be directly correlated to attack behaviour in the adults, because the latter was rare, but was compared to "attention" and "uncertainty" in the adults, since these had been linked to uninhibited attack behaviour in the whole sample of adults (Chapter Three). A high count for uninhibited attack behaviour in the puppies was correlated to poor obedience scores, but no such correlation was found for inhibited attacks. Since little information was gathered on the training provided by the new owners, this link is difficult to interpret, but may reflect some underlying association between lack of inhibition in attack and more general aspects of temperament.

### 6.5.4 Is it the genes or is it the environment?

Unfortunately so far no investigation has been carried out to look in this detail at the behavioural development from puppy to adult dog. Thus it is not possible to compare these data to any existing literature. The widely-held view among scientists, that puppy tests are not useful as predictors for adult dogs' behaviour and character (see section 6.2), is supported by this comparison between puppy and adult dog behaviour. Looking at puppy behaviour in such an intensive way as done here gave no clues, not even tendencies, as to what can be expected in the adult dog, bearing in mind that all these puppies lived in an environment, that can be regarded as "good" in respect to socialisation. A different picture can be seen with dogs living under conditions leading to social deprivation (Riesenberg & Tittmann, 2003; and see Chapter 1 also).

As an overall picture, the litters differed little in their behaviour in week eight. When the adult dogs were looked at in a standardised aggression test, differences between litters were not significant. The different behavioural reactions between the adults when they were confronted with another dog could be linked to how fearful (how likely to flee) they had been as puppies when reacting to littermates. This may support the conclusion of Goddard & Beilhartz (1984) that in puppies of eight weeks old, only fearful behaviour is predictive of adult behaviour, although they recorded puppy behaviour in a completely different way to this study.

Altogether it can be concluded that the question “nature or nurture” was not answered, but some new ideas of where and how to look for further answers have been found.

# Chapter 7:

# General discussion

## 7.1 Aims

This final chapter summarises the findings in the experimental Chapters 2 to 6 and compares the major findings to the existing literature. An evaluation is made of the extent to which the hypotheses set up in section 1.5 have been supported. Conclusions are also drawn from the results from the applied perspective of implications for breeding and keeping dogs, and preventing danger from dogs in the future. Finally, the limitations of the study and ideas for future work are discussed.

## 7.2 Hypothesis 1: It can be deduced from the behavioural patterns of a puppy in dyadic interactions how it will behave when adult, especially when reacting to threatening stimuli.

In Chapter 6 the social behaviour of Rhodesian Ridgeback puppies in their eighth week of life was compared in quantity and quality to the behaviour displayed by the same dogs as adults under standardised conditions. Similarities in behaviour between littermates, both as puppies and as adults, were examined. Also, links were sought between individual differences in the behaviour of puppies and their behaviour when adult, but none could be detected. The most likely explanation for this lack of correspondence is that the behaviour of eight-week-old puppies and adult dogs is qualitatively different, due to both maturation of behavioural systems, and individual learning.

Whereas the puppies in week eight predominantly showed behaviour from the group "social approach behaviour" in dyadic interactions, this was not the case with the adult dogs, though the individual test elements had presented opportunities for dyadic interactions. Furthermore, behaviours that serve in the de-escalation of a conflict or showing a stressful state were hardly ever shown by the puppies up to week eight, whereas these behaviours were often performed by the adult dogs. Between week seven and eight especially, the puppies' behaviour started to change in its informational content and the function of individual signals, and to become more refined, and these processes are known to continue through the remainder of the socialisation period and the juvenile period (Serpell & Jagoe, 1995; Bradshaw & Nott, 1995). The change between puppy and adult is also illustrated by the fact that the puppies showed uninhibited and inhibited attack behaviour quite regularly in dyads, though at a low level when compared to social approach, but did not attack at all in the aggression test, with one single exception, when adult. Even threatening behaviour, occurring in the puppies about second in frequency to social approach behaviour, was not shown often by the adults. Rather, they emphasised, especially when directly threatened, passive submissive behaviour, flight behaviour, behaviours for stress and arousal and, in some instances, play behaviour.

The "socially competent" adult dog can be regarded as a dog that is able to communicate in a refined way with its conspecifics and social partners from other species, keeping goals directed at raising its biological fitness in mind. These goals comprise gaining/holding access to resources of different kinds, including its own status against members of the social group, without running the risk of severe injury. These two elements of "social competence" do not apply to puppies as they, at least in week eight and earlier, do not seem to compete over resources and status as adults would do (Bradshaw and Nott 1995). Thus it is unsurprising that the display of social behaviour is different between puppies and adults.

Thus the hypothesis was not substantiated, but still cannot be rejected fully either, as the question still remains as to how to test puppies reliably about their future behavioural tendencies. The approach used here does not seem to be adequate, as is also the case with other "puppy tests" (Wilsson & Sundgren, 1998; Reid & Penny, 2001; Rooney et al., 2003), in spite of which these tests are widely used.

## 7.3 Hypothesis 2a: Dog breeds differ from one another in their aggressiveness due to their different genetic make up.

**Hypothesis 2b: The owner, as potentially the most salient part of the dog's environment, plays an important role in the development of the dog's social and aggressive behaviour, once it has left its siblings and mother.**

Hypotheses 2a and 2b will be dealt with together, as the results from Chapters 2 to 6 show that these points cannot be separated. Throughout Chapters 2 to 4 differences between breeds were sought in their display of aggression and biting history, and factors possibly influencing those. Concerning biting history, breed differences could only be seen for dogs that had bitten within the family. Here the group of DDA unlisted dogs, comprising a large number of different breeds, was over-represented. This finding resembled the observation of Horisberger (2002) but is to some extent biased through the sampling method, since some DDA unlisted dogs were tested specifically because they had been involved in biting incidents.

Since few dogs showed biting or any other offensive aggressive behaviour in the test elements, all scores of "2" (threats) and above were subsumed under the term "aggressive behaviour" and used to produce an average scoring per breed group. The terrier breeds (mainly Pitbull Terrier, and also Bullterrier, Bullterrier X and American Staffordshire Terrier) stood out, showing higher mean aggression. The terriers, especially the Pitbull Terrier, also stood out in the behaviour from the ethogram, specifically showing more threat behaviour and stress behaviour across the complete test, and imposing behaviour and uninhibited attack behaviour for the test elements performed in the dog's home. When the breeds were combined according to whether they were DDA listed or not, the listed dogs stood out for uninhibited attack behaviour and stress behaviour but also for play behaviour, which was used to some extent as means for de-escalation in a conflicting or stressful situation. Other authors (Mittmann, 2002; Böttjer, 2003; Bruns, 2003) did not find any general breed differences when looking at aggression scores, but found, irrespective of breed, factors influencing the occurrence of aggressive display; e.g. direct influence of the owner during the test through harsh leash correction.

This investigation showed that the obedience level of the dog was an important factor influencing aggression scores and also the display of other behaviour. Those breeds which had high mean aggression scores also stood out with "bad obedience". So the question is, how can a low obedience level facilitate aggression shown in the test?

The mere presence of the owners could influence the performance of behaviour passively; thus an obedient dog will not show any overt agonistic behaviour as long as the owner does not command it. It is also possible, since disobedient dogs showed a higher level of stress behaviour, that their aggressive behaviour had been elicited by stressful states (see section 1.3.1.5). Well trained dogs might gain a certain state of self-confidence, helping them to cope with the conflict-eliciting test elements without showing aggressive behaviour. A dog trained with positive methods might be strongly attached to its owner, gaining confidence in his/her presence in challenging situations.

Why the terrier breeds scored worse for obedience than others, can only be speculated from a caseload of 254 dogs. It is possible that the intervening factor is stress: "a stressful state hinders learning to a certain extent" (Liebermann, 2000) – assuming that owners inflicted stress during training or that terriers have a lower stress tolerance than other breeds. Another reason for bad obedience in terriers could lie more in the field of human sociology: Owners of certain breed types might not train their dogs, either because they do not want an obedient dog or because they think these special breeds cannot be trained. This leads to the question, why different people prefer to keep dogs from particular breeds - which cannot be answered from the data gathered for this thesis.

The qualitative and quantitative differences between breeds for certain behaviours from the ethogram shown here stresses the point that aggression is displayed as a result of many factors, which may be only slightly associated with the breed or certain genetic lines within a breed. Dependent on the actual situation, prior history and learning experiences, and individual tolerance levels for fear or stress and frustration, dogs might react with aggressive behaviour, whether that be threats or offensive biting. Tolerance levels themselves probably have some genetically-influenced features, but are also modified by learning.

The results from Chapters 2 to 4 so far do not support the hypothesis that aggressive traits are heritable in certain breeds, but rather emphasise hypothesis 2b, together with the findings in Chapters 5 and 6, that the owner plays an important role in the development of social and aggressive behaviour in dogs.

## 7.4 Hypothesis 3: The main emotional background for aggression is fear.

Overall, this hypothesis was supported by the results in Chapter 3. A high score for uncertainty correlated positively with high aggression scores in most of the test elements, apart from the dog-human "accidental interactions" and the dog-dog situations. The accidental interactions did not have high aggression-eliciting properties anyway, leading to the conclusion that they probably could not elicit relevant levels of fear or stress in most of the dogs. For the dog-dog situations it has already been proposed that they are the test elements most prone to be affected by learning during previous encounters, which can lead a dog not to show any fearful display while communicating with another dog. On the other hand, the fact that attention was always loaded opposite to uncertainty, and was always significantly correlated with low aggression levels in all subtest groups except "accidental interaction", supports the idea that fear is the main emotional background for aggression.

The results showed also, that fear need not inevitably lead to an aggressive output. Dogs can choose between different behavioural patterns to react adaptively in a fear-eliciting situation and the choice made is again subject to different inherited and acquired factors. "Adaptively" is defined from the dog's point of view, in the sense of being adequate to keep/increase its (perceived) fitness. The basic situations eliciting agonistic behaviour as summarised by Archer (1976) (see section 1.3.1.5) proved to be relevant to the dogs in this sample also. Though pain was never induced in the test elements, the test elements comprised shock, distance intrusion, novelty, unfamiliar situation or place, and frustration. None of these are mutually exclusive events; rather, they all overlap.

From the perspective of Spruijt et al. (2001), it seems appropriate to interpret the events eliciting agonistic behaviours in terms of the discrepancy between what is expected or frequently experienced by a dog and what is actual happening. "Fear", "uncertainty" or "uneasiness" are just names for complex emotional states created by these events, which might not be entirely appropriate to describe some of the events happening in a dog's life - and might exist only in the eyes of a human beholder; nevertheless some emotional states are probably elicited, and influence specific behavioural outputs.

## 7.5 Hypothesis 4: So-called temperament tests can discriminate between dogs that have bitten previously and therefore may predict aggression later in a dog's life

The test used here can elicit aggressive behaviour in dogs. Looking at the biting history of the 254 dogs, the test proved valid in detecting a certain proportion of the risk that any dog presents, and to qualify it in terms of which stimuli released the aggression. Results for aggression elicited were in concordance with the results of others using nearly analogous tests (Netto & Planta, 1997; Mittman, 2002; Böttjer, 2003; Bruns, 2003), though the test used in Lower Saxony (see Mittman, Böttjer, and Bruns) has never been validated. Results of testing validity were in concordance with Netto & Planta (1997) and Planta (2001) and it can be stated that, to a certain extent, the test used in this thesis is predictive of an individual dog's later behaviour, though not up to 100 percent. Interestingly, it appears that the dogs in this test did not actually have to bite; showing threatening behaviour was enough to be predictive, suggesting that many of the biting incidents had been escalated versions of the behaviour seen in the test. This was particularly clear for the dog-dog situations.

The in-home test done here was a new feature compared to published temperament tests (see Chapters 1 and 2) and, according to the clear differences revealed via statistical analysis, showed different results for nearly analogous test elements, depending upon whether they were done in the arena or in-home. This further emphasises giving the emotional background of dog behaviour thorough consideration, as in-home apparently different aspects were measured compared to the arena. Furthermore for aggression testing, social interaction between owner and dog should be looked at more closely. Finally, tests aimed at finding dogs within a population that might become dangerous later in life, should be designed in ways that take animal welfare as well as human safety into account.

The aim should not be to euthanise all dogs that fail a test, as they do so for different reasons, and there are a wide range of other possibilities to take safety precautions (i.e. temporary or permanent leash and/or muzzle; behavioural therapy or individual training; even keeping the dog at a shelter with other dogs).

It does not seem appropriate to just use a scoring system as described in Chapter 2, but rather to try to get as much information as possible on emotional states within the test that might trigger any behavioural output. The ethogram should provide the necessary information to differentiate which outcome is most suitable for each dog. The goal should be to filter those dogs from the population that show truly pathological aggressive behaviour (giving behavioural therapy a poor prognosis), thus presenting such a danger that society would be put at too high a risk.

The ethogram used here proved useful in detecting the emotional states of the dogs. For practical purposes, the complete 79 behaviours need not be used, but rather the different composite behavioural groups together with the two single behaviours "attention" and "uncertainty". This still makes a well trained tester obligatory. Further research is also needed in this field. The wolf ethogram is still the foundation for all ethograms used in research on dog behaviour. But dogs are not wolves. They have shown to be highly adaptable to and very flexible in contact with humans. They have not only lost many wolf-like features due to breeding, but have also developed behavioural elements not occurring in wolves (see section 1.2.2). This raises the question whether the functional groups in the wolf ethogram should be transferred to the dog. An ethogram is a set of descriptions used by an individual, and sometimes, as Chapter 1 and 3 have shown, only defined for an individual research objective (see e.g. Van den Berg et al., 2003). The point has to be stressed highly that in this field of research more emphasis should be placed on social behaviour between humans and dogs, and that some consensus should be found as to which ethogram and single behaviour patterns should be used.

## 7.6 Implications for breeding and keeping dogs, and preventing danger for the future

### 7.6.1 Implications for breeders and kennel clubs

The results presented here on behavioural development of puppies/dogs, and on how to measure temperament in the broadest sense, have some implications for breeders, although still more knowledge has to be gained in the field (see below). It does not seem appropriate any longer to just breed for phenotype and "beauty". Even breeding for special "working traits" (for hunting purposes etc.) has to be questioned when it is considered how dogs live within human society. Emphasising breeding for special working abilities should only happen in cases where the dogs are exclusively and only used for that purpose by experts in their field. This is seldom the case today and seems an unrealistic pipe-dream, especially when considering the cyclic popularity of certain breeds. So, some form of compromise has to be found for those breeds comprised under the term "working-dogs".

Breed standards should be adjusted to the contemporary scientific literature on dogs and should be stripped of any anthropocentric and anthropomorphic goals for behavioural patterns in certain breeds.

When deciding which dogs to breed with, the results of temperament tests should be considered. Already many breed clubs have their own tests that have to be passed for a dog to become a stud dog/bitch. Unfortunately most of these tests resemble working-dog tests without looking explicitly at tolerance levels for fear and stress and the respective behavioural patterns shown when in a fearful state, although in reality these are indirectly reflected in the results. From this thesis, it can be concluded that these traits should be addressed much more directly when selecting dogs for breeding (in combination with working abilities for the working-dog breeds).

It has to be kept in mind that a dog's temperament is not ultimately genetically fixed, as the results here have shown again. As long as we cannot divide clearly between what is a learned component of any dog's temperament and what is passed through the genes, all tests bear some element of uncertainty regarding future behaviour. Dogs can be trained to pass a temperament test like the one used here – but only to a certain extent, and a qualified tester should be able to improve the reliability of the results. Any training that was done would have to be superimposed on a certain degree of genetic influence.

Another important point is the fact that these tests tend to eliminate from breeding any dogs that were reared under conditions of deprivation, which are known to lead to low tolerance levels for fear (Riesenberg & Tittmann, 2003), thus "rewarding" those breeders that give their puppies a perfect start into life in human society, but also possibly eliminating certain potentially beneficial combinations of alleles from the rarer breeds because they happened to be carried by dogs raised under sub-optimal conditions.

### 7.6.2 Implications for owners

The results support the idea that the owner plays an important role for any dog in enabling it to become socially competent, to be able to communicate effectively and flexibly with other dogs and humans, and not be "dangerous" in human society. However, precisely how big the owner influence is, cannot be estimated from the data gained here, as the statistics used only reveal associations, and cannot distinguish cause from effect. It could be stated, that owners should be made responsible for their dog's development, and that the responsibility should also rest with the owner to acquire contemporary knowledge on dog behaviour, learning theory and training. Only then can the owner be guaranteed to continue the dog's socialisation successfully, once he has received the puppy from the breeder, and train it into something that might be called "everyday-suitability".

### 7.6.3 How useful is testing for temperament and how should it be done? Are there welfare implications to be considered?

The usefulness of such tests has already been discussed in sections 7.5 and 7.6.1. The question that could not be answered there was, how many test elements such tests should contain to give reliable answers. Apparently 16 elements has already given reliable results (Planta, 2001) but on the other hand it is not clear what role the order of test elements plays and what influence the length of the complete test has in eliciting a stressful state in the dog. From the evidence gathered here, it seems that the elements comprising subtest group A (everyday situations) could be omitted, as they were mostly presented consecutively, after the most stress eliciting elements had already happened, and did not elicit much aggressive behaviour. It is possible, however, that they might have been more informative if they had been presented at the beginning of the test when the dog was more naïve to the test situation.

The differences between the in-home and arena results have already been discussed. The in-home tests do not seem to be necessary to predict biting, but on the other hand they complete the picture of a dog's behavioural patterns in a stressful state, and shed light on its social competence. So whereas it might not in general be necessary to do in-home tests for all dogs that had bitten and were (at least temporarily) labelled as dangerous, it might become necessary in individual cases. The in-home test can further help in gaining knowledge on how dogs communicate and live with humans or whether there are genetic traits within families or breeds for certain behavioural patterns or tolerance levels, especially in the fields of social behaviour towards and communication with humans (questions raised by Hare & Tomasello, 2005).

For a better usage and understanding of such tests the concept formulated by Archer (1976) and Spruijt et al. (2001) should be kept in mind: i.e. the discrepancy between what is expected or frequently experienced by a dog and what is actual happening is what elicits agonistic behaviour. Thus everyday situations will often be able to elicit fear and subsequent aggression in dogs originating from deprived environments, but not in a population of generally well brought up dogs (see Appleby et al., 2002). This would in turn suggest, for the population of dogs dealt with here, that the majority had probably not been socially deprived as puppies, since otherwise more fear-based aggression would have been seen.

As an ultimate prerequisite for drawing any conclusions and making decisions about an individual dog following a test, the test has to follow a standardised protocol and has to be evaluated by trained persons. Preferably, the dog's evaluation should not only be done using the scoring system introduced in Chapter 2, but should also look at behavioural displays and, for example, try to quantify the displays of stress behaviour, active and passive submission, and flight behaviour, to gain an overview of the dog's individual problem-/conflict- solving strategies. Welfare considerations also indicate that testers should be able to evaluate the state of stress and fear within a dog during a test and adjust the protocol if necessary. Not only should pain never be inflicted in a test, but also the stress level should not exceed the point at which welfare might be compromised.

The borderline beyond which the dog is no longer able to adopt adequate coping strategies in individual test elements has to be carefully evaluated, and preferably not exceeded during a test. In parallel, the tester has to ensure that no learning of unwanted behavioural patterns is facilitated by the test. Dogs should not learn that threats or even attack might be an ultimate problem-solving strategy outside the test situation. Again this makes a well educated and practically experienced tester an essential requirement. The points concerning welfare implications and the learning of unwanted behaviour apply equally to the dogs used as test-dogs. Only a capable tester can ensure that no dog gets injured during a dog-dog encounter, which needs to go as far as bodily contact through the fence, at least in one test element. This test also shows that it is unnecessary to use an artificial hand or doll, that the dog can in general be tested without being muzzled, and that the test does not have to proceed so far that the dog definitely bites, since reliable predictions can be obtained at the "threatening level".

So far, aggression tests that shall decide on an individual dog's future are useful when they are put in the context of an existing agonistic incident. They are also useful as a prospective means of deciding which dog to breed from and which one not to breed from at all. But they are not adequate to be used as the only tool to decide which dog has to be muzzled permanently or has to be euthanised.

## 7.7 Limitations of this study

This study dealt with a non-random sample of 254 dogs. Although the sample size was comparable with other studies in the field of aggression tests, it still is a small sample considering all the drawbacks concerning valid and reliable results. In most of the cases only non-parametric statistical tests could be applied and in some aspects information had to be pooled that would have been of interest if looked individually (e.g. information on education etc.). The background of the dogs as puppies was not identical and where it approximately was (i.e. in the Ridgebacks) the sample size was again small.

Recruiting the dogs for this study was not done following a fixed protocol, rather they were an "opportunity sample", either as legal cases following an incident (not necessarily biting), as a legal requirement for the owner due to breed regulation, or as a member of the group that was monitored as puppies. The only exclusion criterion was the way the test could be done, i.e. whether the protocol from Chapter 2 could be followed or not. This resulted in a group that was neither homogenous nor randomised concerning breed, age, sex and living conditions. In particular, breed distribution and biting history were not comparable to what can be found in the general dog population in Germany; with the limitations already mentioned in Chapter 2 concerning the biting history.

Keeping these limitations in mind, it can be stated that the evaluations of this thesis advance the model of what is necessary to be done in the field of dog breeding, dog aggression, breed legislation and temperament testing and also what can be done practically, giving some promising results for the future and having implications on how the results from current aggression tests should be interpreted, especially in the course of DDA enforcement.

## 7.8 Perspectives for future work

The limitations already mentioned lead to what should be done in the near future to complete the picture addressed here. Evaluation of a much larger number of dogs, tested under a standardised protocol and using standardised terminology (see review by Jones & Gosling, 2005) will be necessary. Preferably the dogs should be grouped according to breed, history and actual living conditions (i.e. include shelter dogs also). Evaluation should be done with the least amount of anthropocentrism and anthropomorphism as possible (see review of literature and discussion in Chapter 2) and should concentrate on the issue of training also. For example, it seems necessary to gain more information whether, especially in the field of working dogs, dogs trained with some methods have more potential for dangerousness than others; mainly those with Schutzhund-training. This link has been stated by others (Netto & Planta, 1997) but could not be replicated in this thesis. In the long run it will be necessary that kennel clubs incorporate revised "temperament tests" in their breeding programmes, and that those results are analysed, not only differentiating between breeds but looking for family clusters also. The overall aim of breeding should be to produce socially competent dogs, that can fulfil certain working tasks where applicable and necessary, but that present no more danger to human society than normal, adequately controlled dog behaviour.

## 7.9 "Aggressive" conclusions

Dog aggression is a highly emotional issue, together with the breeding and keeping of dogs itself. It is hoped that this study has not only contributed to a more rational approach to these issues, but also has helped to incorporate more scientific aspects into the practicalities of breeding and keeping dogs. Specifically, this study suggests that it is difficult and to a certain degree rather questionable to deduce from a puppy's behaviour (e.g. aggressive behaviour) how an adult dog will behave later in life in specific situations, and whether it might become something called a "dangerous dog". The hypothesis that aggressive traits are heritable in certain breeds was not supported, but support was obtained for the idea that the owner plays an important role in enabling any dog to become socially competent, to be able to communicate effectively and flexibly with other dogs and humans, and not be "dangerous" in human society. Fear definitely seems to be one major emotional background for aggressive behaviour, but dogs do not necessarily always react aggressively out of fear. And last, temperament tests do have their justification, in that they can be predictive of an individual dog's later behaviour, but it should always be remembered that they will not 100 percent accurate.

Aggression in dogs should not be regarded as separate from its general biological concept, as described in Chapter 1. There is no maliciousness within aggressive dogs, and assumptions about intentions should still rather lead to Archer (1976), Dawkins (1976) or Maynard-Smith (1982) - aggressive behaviour being one means among others to heighten one's biological fitness. The results found here do fit in this picture, though they also point at some areas which need careful conceptualisation, for example where the "hierarchy" between human and dog is concerned. There is a lot more to be observed, learned, interpreted and understood with this, the most "domesticated" of all animals. And this may exactly be the reason, that research into this species is so complicated. Hare & Tomasello (2005) speak of dogs having evolved specialised skills for reading human social and communicative behaviour – and this will complicate any research in dog's social behaviour, as humans might see their own image in the mirror of their dog's behaviour.

# Appendix 1:

## Questionnaire for dog owners
## (English translation)

## QUESTIONNAIRE FOR DOG OWNERS

The answers will be treated in strict confidence

**Dog:**

Name:..................................... ..............Date of birth:............................

Breeder:............................................... Date when purchased:..............

Breed:...................................................................male female

Purchased from: Breeder Private Shelter

If Shelter: how long has the dog been there (........days, ........months):

Number of previous owners:

If breeder: where did the puppies live: House Kennel

Number of siblings: male: female:

**Owner:**

Name:.....................................................Telephone:..............................

Address:..........................................................................................

**Questions:**

1. How many people live together with the dog:

   Adults: male: female:

   Children: male female:

2. Living conditions: House Flat Size $m^2$:

   Garden: Y / N In town

   Suburb Countryside

3. Did living conditions change: Y / N . If Yes:

   Moving house Partner moving in Divorce Children

4. Information on any previous owners ......................................... ...........

   ..................................................................................................

5. Other animals in the house: Species:: Number:

   When purchased:..............................................................................

6. Health:

   Vaccination: 1 per year every second year none

   Neutered: Y / N Date:

   Severe Illnesses: Operations:

   Permanent medication:

   Pregnancy: Puppies:

7. Education / Training*:

Puppy-class age (from – to)

Dog-school: age (from – to)

Self-Education age (from – to) None

The dog was given away for training

At the moment I train the dog: less than 10 min/week 10-30 min/week

more than 30min/week 2-3 times per week every day

8. How well does the dog obey the following commands?

(please tick between 1 and 5: 1 = not / 3 = average / 5 = quickly and perfectly)

| | |
|---|---|
| SIT | 1----2----3----4----5 |
| DOWN | 1----2----3----4----5 |
| STAY | 1----2----3----4----5 |
| HERE | 1----2----3----4----5 |
| OFF / NO | 1----2----3----4----5 |

9. Has your dog received any special education?*

Gundog Schutzhund Search and rescue Agility

Guidedog Servicedog CGC-shot

CGC-no shot Dog-Dance

10. I trained my dog with the following:*

Verbal reinforcement Treat Play Stroking

Verbal correction Verbal punishment Physical punishment

Flat collar Choke collar Prong collar

Electronic collar Halti

11. The dog is trained by one person

The dog is trained by different members of the family/group

12. Is the dog especially attached to a particular person:

Yes - me Yes – someone else No

How strongly is the dog attached to you (please tick between 1 and 5: 1 = not attached / 3 = average / 5 = strongly): 1----2----3----4----5

* Tick as many as are applicable

13. Daily Routine:

a) Time(s) of feeding: Dog eats all food at once Y / N

b) Type of food:

c) Treats Y / N If Yes: when: why::

d) Number of walks/day: Times:

Duration: off leash on leash

e) Grooming: seldom 1 x / week 1 x / day

The dogs likes being groomed Y / N

If N: tolerates it /shows stress tries to leave growls

Bites brush bites owner

f) Dog sleeps in: Bed of owner dog's own bed owner's bedroom

other room/door open other room/door closed kennel

g) How often per week do you play with your dog:

h) Duration of one play-session: who starts play:

who finishes play:

i) Type of play*

Object thrown Dog retrieves Y / N

Dog carrying object is chased around Tug of war

Chasing without object

14. Does your dog beg for your attention (please tick one from 1 to 5:

1 = never / 3 = sometimes / 5 = always): 1----2----3----4----5

Is the dog reacted to when it begs : 1----2----3----4----5

How often per day do you stroke your dog altogether: less 10 min

10-30 min 30-60 min over 60 min

How often do you stroke your dog, when it has begged for it

(1 = never / 3 = 50 % / 5 = always): 1----2----3----4----5

15. How do you estimate the hierarchy between you and your dog (please tick one from 1 to 5: 1 = dog over human / 3 = dog and human on equal levels / 5 = human over dog): 1----2----3----4----5

If the dog lives with children, how is the hierarchy here: 1----2----3----4----5

How is the hierarchy between the dog and other adults living with it:

1----2----3----4----5

16. <u>If your dog lives with another dog, how is the hierarchy here</u>: (please tick one from 1 to 5: 1 = dog lowest in group / 3 = dog on equal level with others / 5 = dog top of group): 1----2----3----4----5

17. <u>If your dog meets other dogs on a regular basis, what is the usual hierarchy</u>: 1----2----3----4----5

18. <u>How does your dog react towards human strangers?</u> The following table lists different behaviours and displays, please tick all that are applicable:

| | In-home | Outside on leash | Outside off leash) |
|---|---|---|---|
| Looks at person | | | |
| Approaches person | | | |
| retreats | | | |
| Tail under belly | | | |
| Tail upright | | | |
| Tail relaxed | | | |
| Tail moving fast | | | |
| Tail moving slowly | | | |
| Ears up front | | | |
| Ears flat behind head | | | |
| Ears normal position | | | |
| Very fast approach | | | |
| Stays with person | | | |
| Sniffing and leaving | | | |
| Barks | | | |
| Growls | | | |
| Snaps | | | |
| Bites | | | |
| Jumps at person | | | |

Overall, how do you estimate your dog's behaviour towards strangers (please tick one box only): f riendly fearful aggressive neutral

19. When it is sitting in the car, how does your dog react towards strangers* :

no reaction watches growls barks jumps against window

20. How would you describe your dog's character in general *: fearful timid friendly curious brave calm active hectic playful aggressive

Has this character changed over time Y / N If Yes, why/what happened:

.....................................................................................................................

21. How does your dog react towards other adult dogs :

| | In-home | Outside on leash | Outside off leash |
|---|---|---|---|
| Friendly | | | |
| Fearful | | | |
| Aggressive | | | |
| Neutral | | | |

Does your dog react differently according to the other dog's behaviour Y / N

Does your dog react differently against puppies Y / N

When it is sitting in the car, how does your dog react towards other dogs outside*: no reaction watches barks growls jumps against window

22. Has your dog ever bitten an unfamiliar person?: Y / N

If yes, please describe the situation:

.....................................................................................................................

How often did your dog bite: Type of injury:

.....................................................................................................................

23. Has your dog ever bitten a a member of the family?: Y / N

If yes, please describe the situation:

.....................................................................................................................

How often did your dog bite: Type of injury:

.....................................................................................................................

24. Has your dog ever bitten another dog: Y / N

If yes, please describe the situation:

..........................................................................................................................................

How often did your dog bite: Type of injury:

..........................................................................................................................................

25. Has your dog ever been bitten by another dog: Y / N

If yes, please describe the situation:

..........................................................................................................................................

How often did your dog bite: Type of injury:

..........................................................................................................................................

26. How does your dog react in the following situations*:

a) at the vets: neutral friendly fearful

stays still when manipulated tries to flee growls bites

has the behaviour changed in time Y / N

if Yes: why?.........................................................................

b) Your doorbell rings: dog runs to the door Barks growls

wags tail How would you describe this behaviour (please tick only once): friendly fearful aggressive neutral excited

c) You want to take the food bowl from your dog: dog growls Dog snaps dog bites dog waits, till it gets bowl back dog leaves dog jumps to reach bowl

d) You want to take a toy object from your dog: dog growls Dog snaps dog bites Dog runs off with toy dog waits, till it gets toy back dog leaves without toy dog jumps at you to reach toy

e) Your dog begs for attention and you ignore it: dog leaves after 5 seconds dog leaves after 30 seconds dog tries for up to 3 minutes.

dog barks dog growls dog jumps at you Begging intensifies with time dog starts playing in front of you dog goes to another person (if available) dog shows behaviour(s) that it has previously been told off for

f) How does your dog (off leash) react towards the following:

| | Jogger | Cyclist | Coloured people | Rabbit | Horse |
|---|---|---|---|---|---|
| Neutral | | | | | |
| Approaches | | | | | |
| Hunting | | | | | |
| Barking | | | | | |
| Growling | | | | | |
| Snapping | | | | | |
| Biting | | | | | |
| Hides behind owner | | | | | |
| Flees | | | | | |

g) Your dog meets a child under the age of 5: neutral approaches avoids contact friendly aggressive

h) Your dog meets a child between 5 and 15 years of age: neutral approaches avoids contact friendly aggressive

27. How does your dog react towards strangers when meeting them in the dark:

friendly fearful aggressive neutral excited
guarding barks growls snaps bites

28. Dog runs off from you – does it respond to your come-back command*: Y / N

If Yes:: command given once command given twice
Given three times or more command given in usual voice
Command given louder than usual command given as threat

29. How does your dog react against gunfire / very loud noises*: not

Looks in direction looks at owner leaves
Runs in direction of noise trembles hides
flees barks screams hides behind owner

30. When you need to remove your dog from the sofa, does it*:

follow command to jump off | is effectively dragged off

resist being dragged off

growls | snaps | bites | cannot be dragged off

31. You walk in an unfamiliar area with your dog*: dog is neutral

dog keeps itself closer to you than usual | dog sticks at your side

dog shows stress | dog is fearful | dog panics

dog will not follow you

32. Thank you for answering these questions. If you think there is anything else important we should know, please write it down here:

# Appendix 2:

## Supplementary Table supporting Chapter 2

Table A2.1) Example of the complete calculations of Cronbach alphas for group B (test elements T 12,16,20,29). As the statistics have been done with German software, the decimals are given with ",".

| | | Mean | Std Dev | Cases |
|---|---|---|---|---|
| 1. | ST16 | 1,4370 | ,6488 | 254,0 |
| 2. | ST20 | 1,7441 | ,9666 | 254,0 |
| 3. | ST12 | 1,3976 | ,5992 | 254,0 |
| 4. | ST29 | 1,4961 | ,7099 | 254,0 |

Correlation Matrix

| | ST16 | ST20 | ST12 | ST29 |
|---|---|---|---|---|
| ST16 | 1,0000 | | | |
| ST20 | ,5950 | 1,0000 | | |
| ST12 | ,3951 | ,4221 | 1,0000 | |
| ST29 | ,3771 | ,5256 | ,3707 | 1,0000 |

N of Cases = 254,0

| Statistics for | Mean | Variance | Std Dev | N of Variables |
|---|---|---|---|---|
| Scale | 6,0748 | 5,1446 | 2,2682 | 4 |

Item-total Statistics

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Squared Multiple Correlation | Alpha if Item Deleted |
|---|---|---|---|---|---|
| ST16 | 4,6378 | 3,3228 | ,5922 | ,3814 | ,6887 |
| ST20 | 4,3307 | 2,2538 | ,6741 | ,4750 | ,6455 |
| ST12 | 4,6772 | 3,6740 | ,4839 | ,2355 | ,7410 |
| ST29 | 4,5787 | 3,2566 | ,5402 | ,3056 | ,7104 |

Analysis of Variance

| Source of Variation | Sum of Sq. | DF | Mean Square | Chi-square | Prob. |
|---|---|---|---|---|---|
| Between People | 325,3947 | 253 | 1,2861 | | |
| Within People | 254,2500 | 762 | ,3337 | | |
| Between Measures | 18,4518 | 3 | 6,1506 | 55,3009 | ,0000 |
| Residual | 235,7982 | 759 | ,3107 | | |
| Total | 579,6447 | 1015 | ,5711 | | |
| Grand Mean | 1,5187 | | | | |

Coefficient of Concordance W = ,0318

Reliability Coefficients 4 items

Alpha = ,7584 Standardized item alpha = ,7642

# Appendix 3:

## Supplementary Tables and Figures supporting Chapter 3

Figure A3.1) Histogram showing the distribution of social approach behaviour using total scores over all tests. The X-axis gives the number of dogs showing the behaviour at a certain frequency (Y-axis).

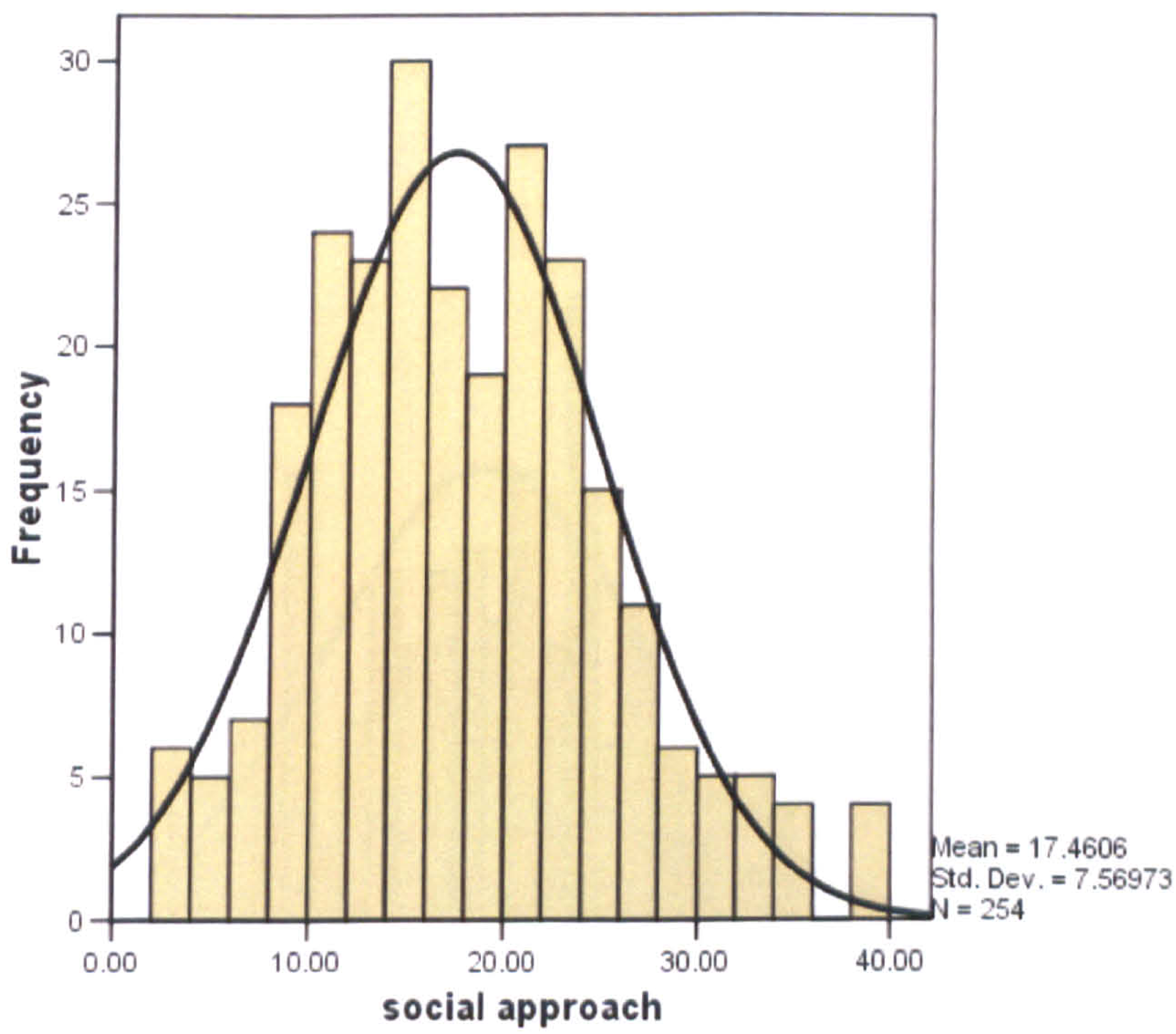



Figure A3.2) Histogram showing the distribution of imposing behaviour using total scores over all tests. The X-axis gives the number of dogs showing the behaviour at a certain frequency (Y-axis).)

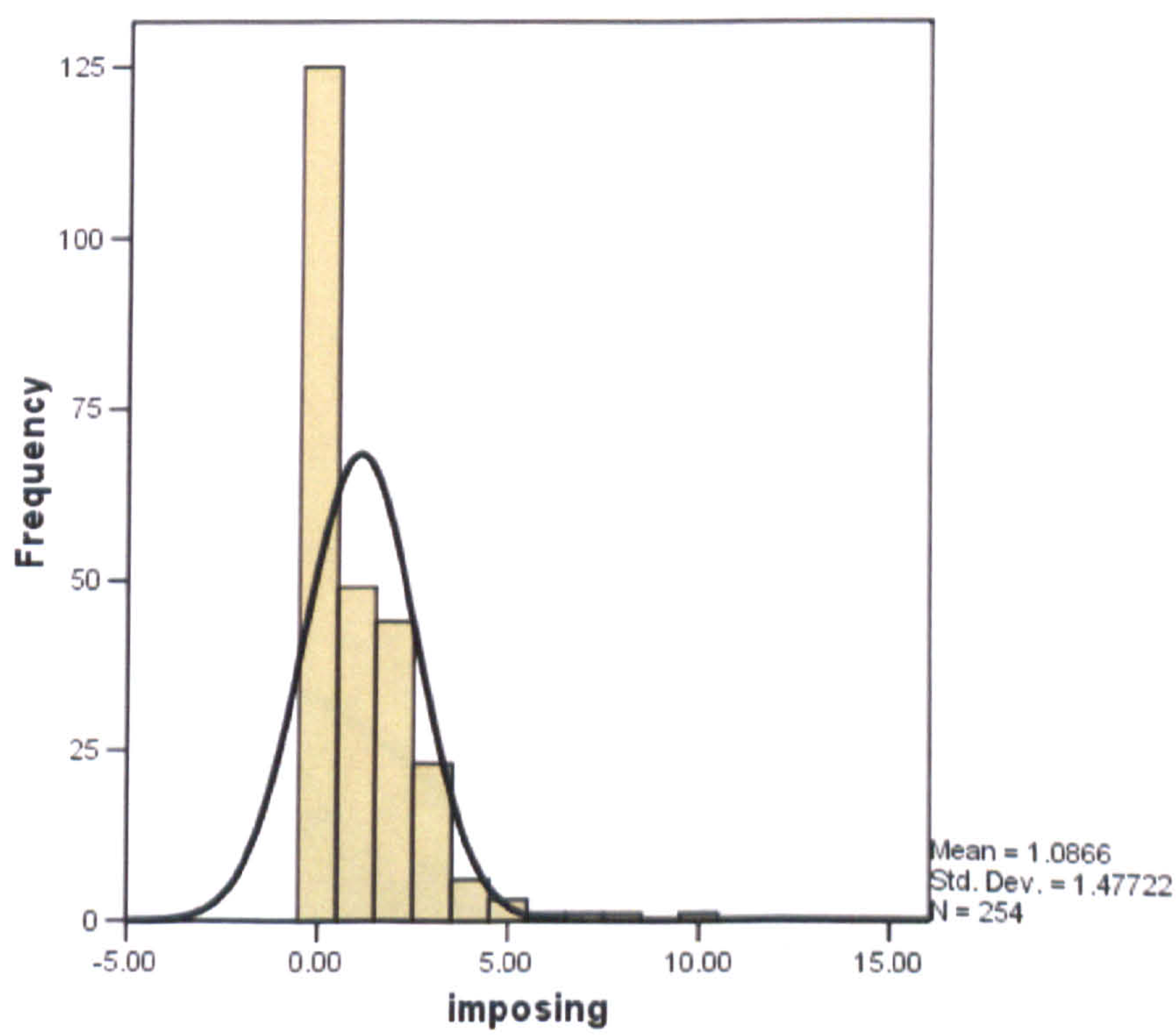


Figure A3.3) Histogram showing the distribution of passive submission behaviour using total scores over all tests. The X-axis gives the number of dogs showing the behaviour at a certain frequency (Y-axis).

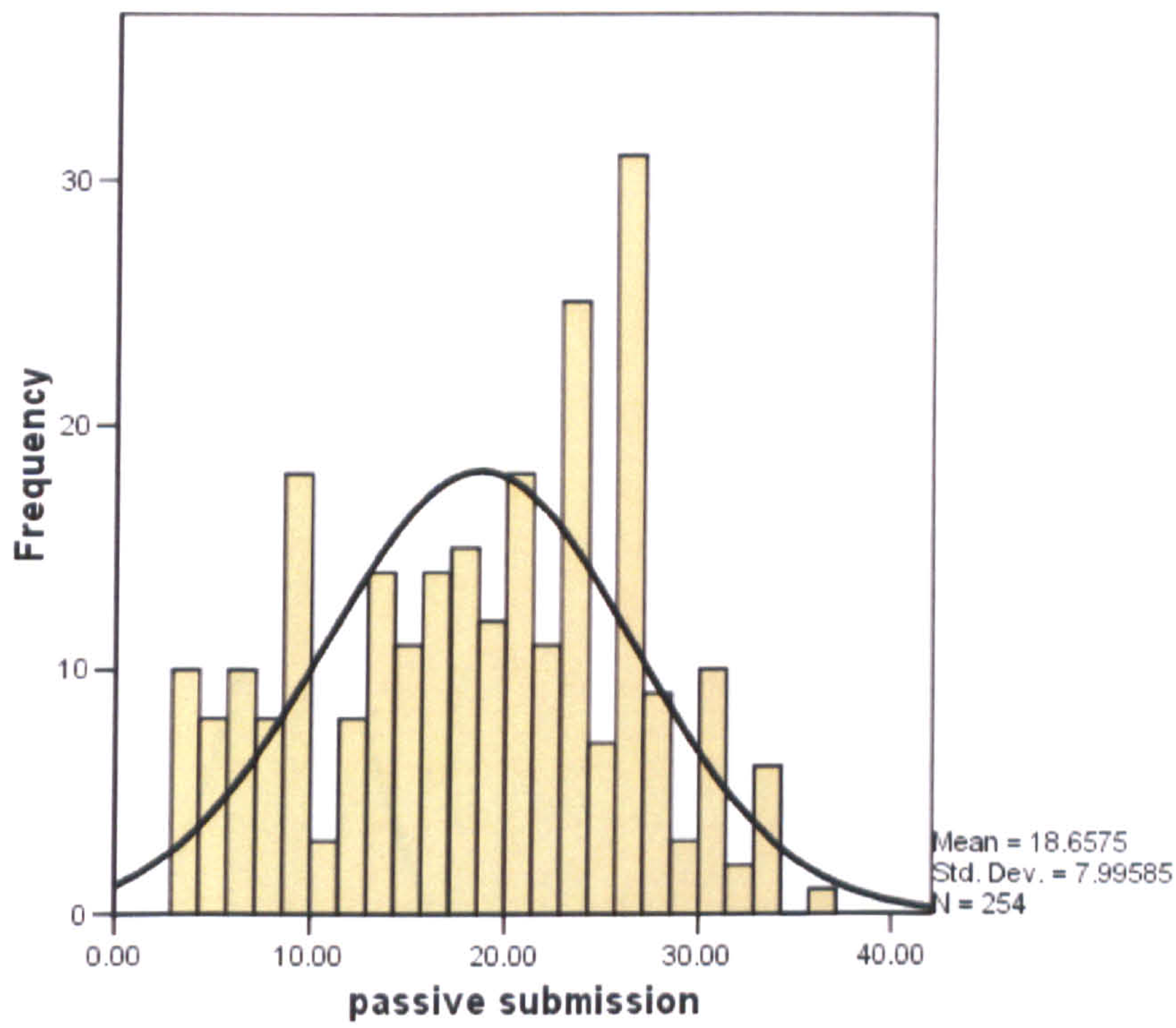



Figure A3.4) Histogram showing the distribution of threatening behaviour using total scores over all tests. The X-axis gives the number of dogs showing the behaviour at a certain frequency (Y-axis).

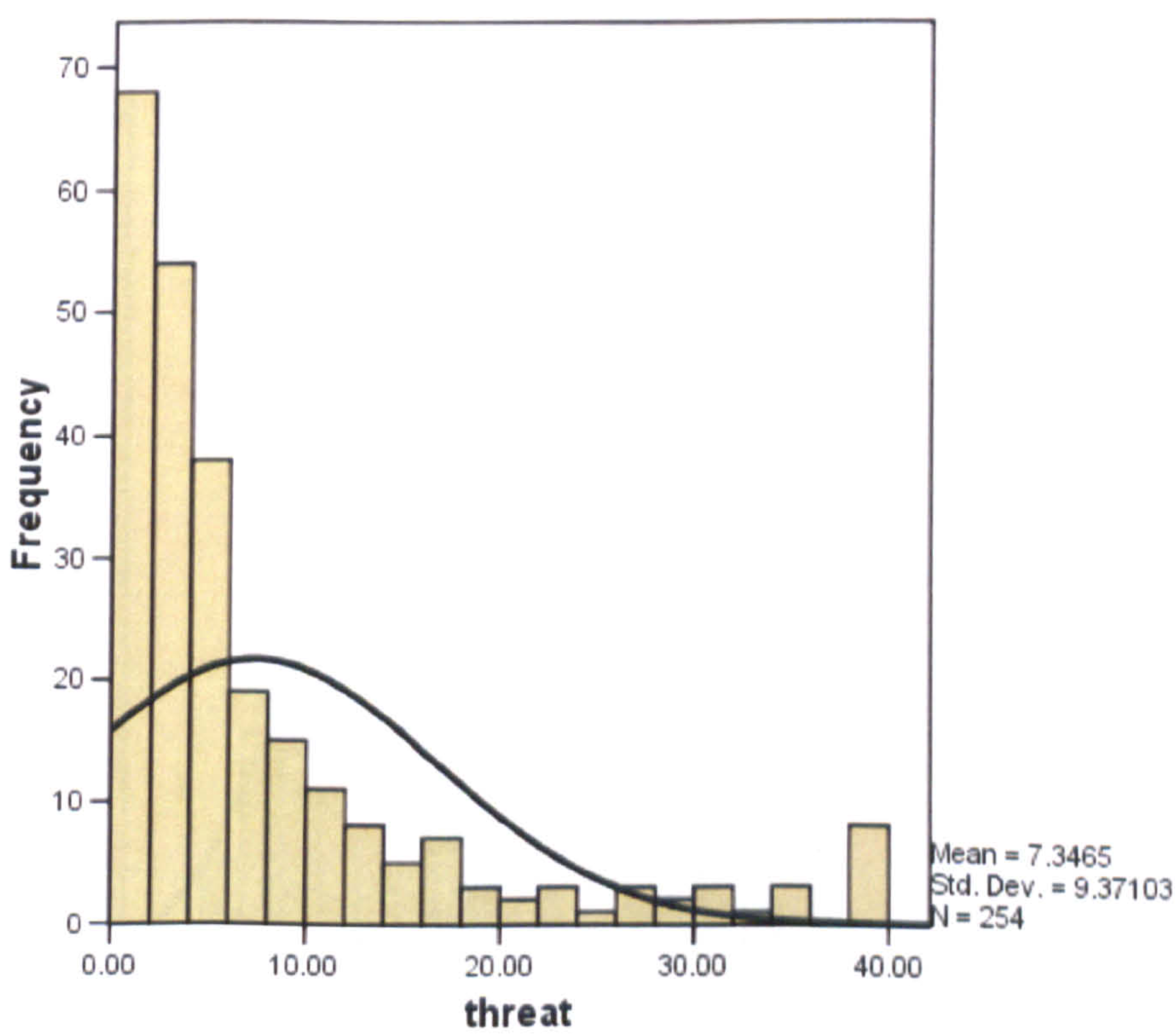


Figure A3.5) Histogram showing the distribution of uninhibited attack behaviour using total scores over all tests. The X-axis gives the number of dogs showing the behaviour at a certain frequency (Y-axis).

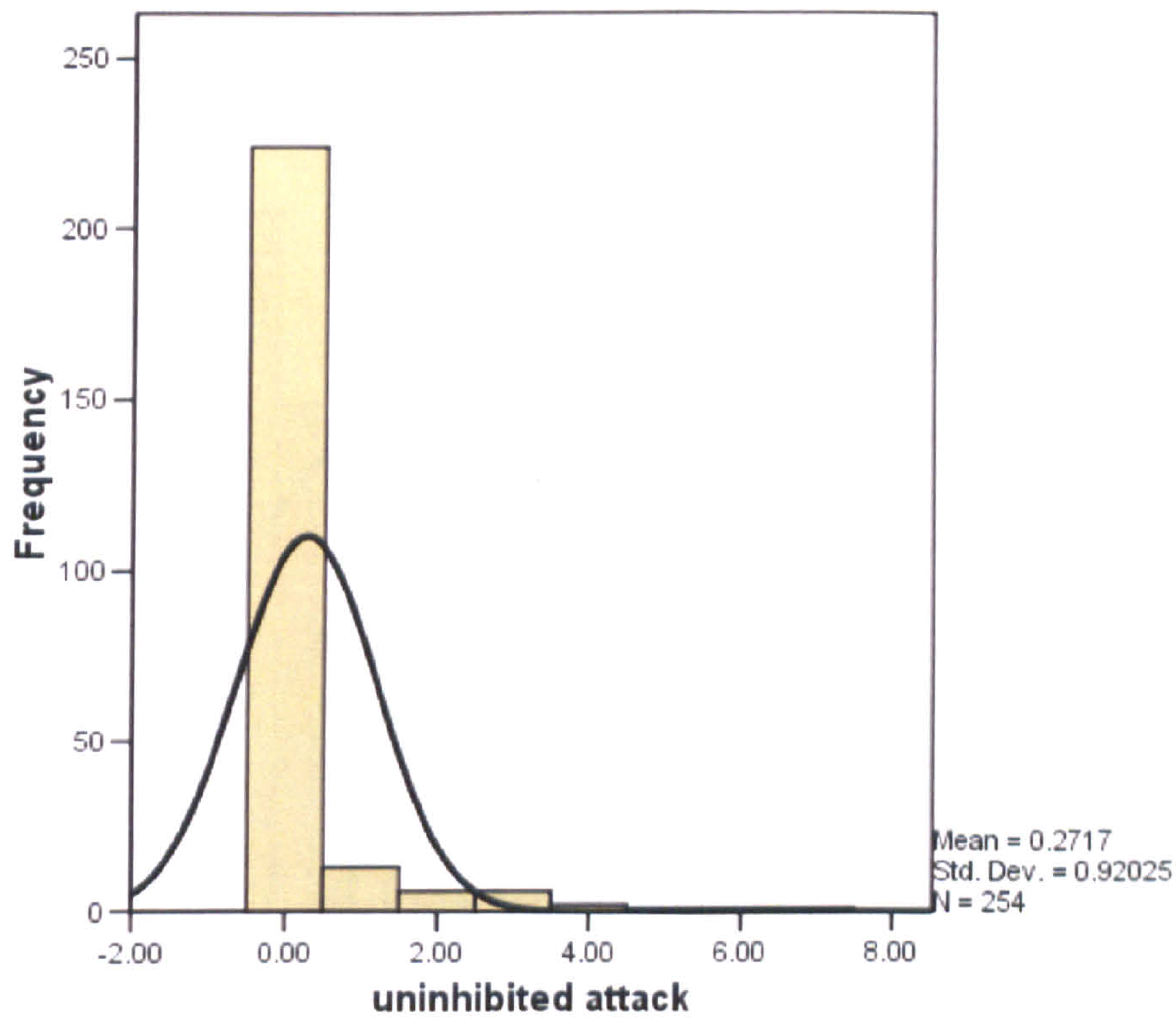



Figure A3.6) Histogram showing the distribution of flight behaviour using total scores over all tests. The X-axis gives the number of dogs showing the behaviour at a certain frequency (Y-axis).

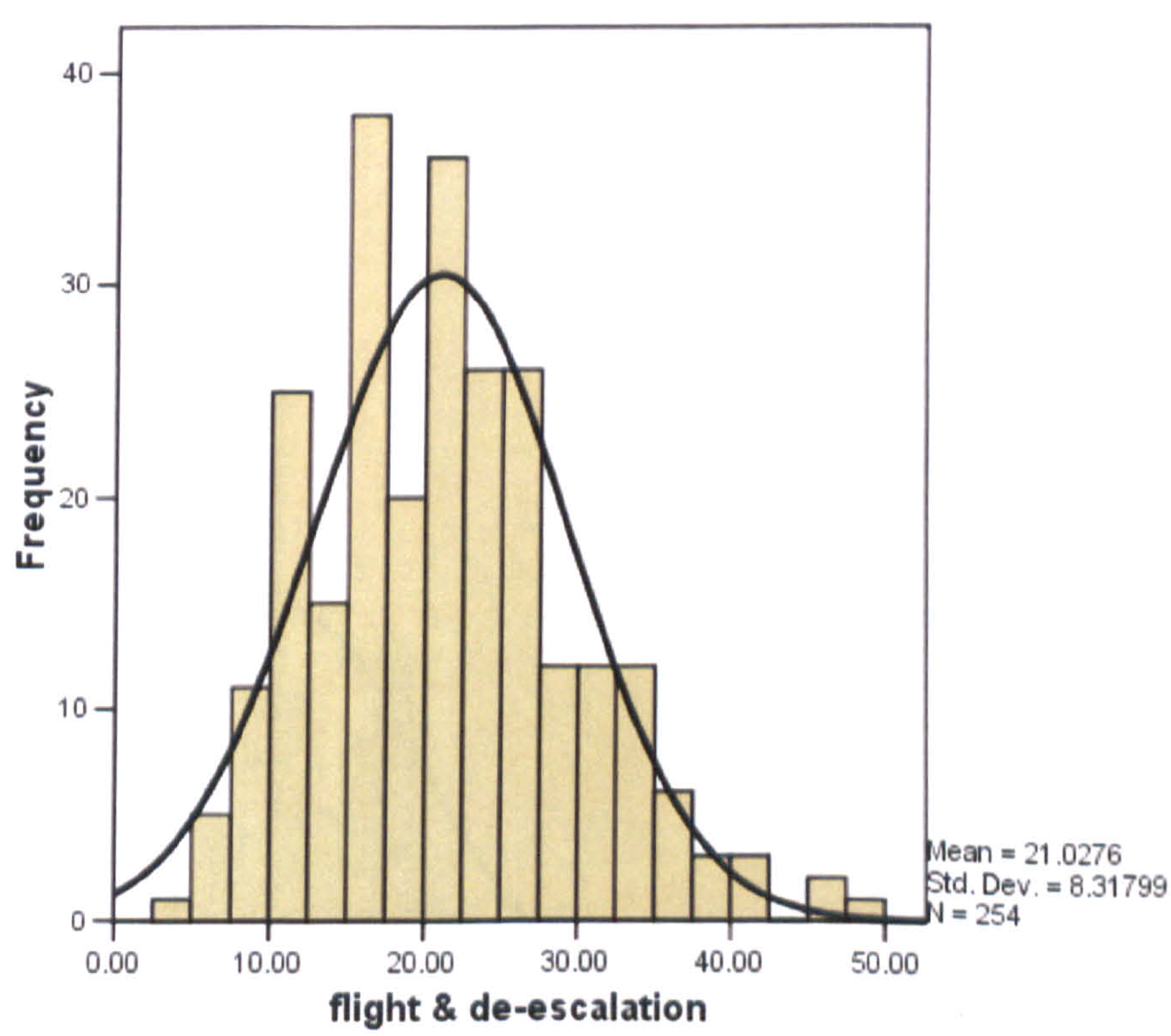


Figure A3.7) Histogram showing the distribution of stress behaviour using total scores over all tests. The X-axis gives the number of dogs showing the behaviour at a certain frequency (Y-axis).

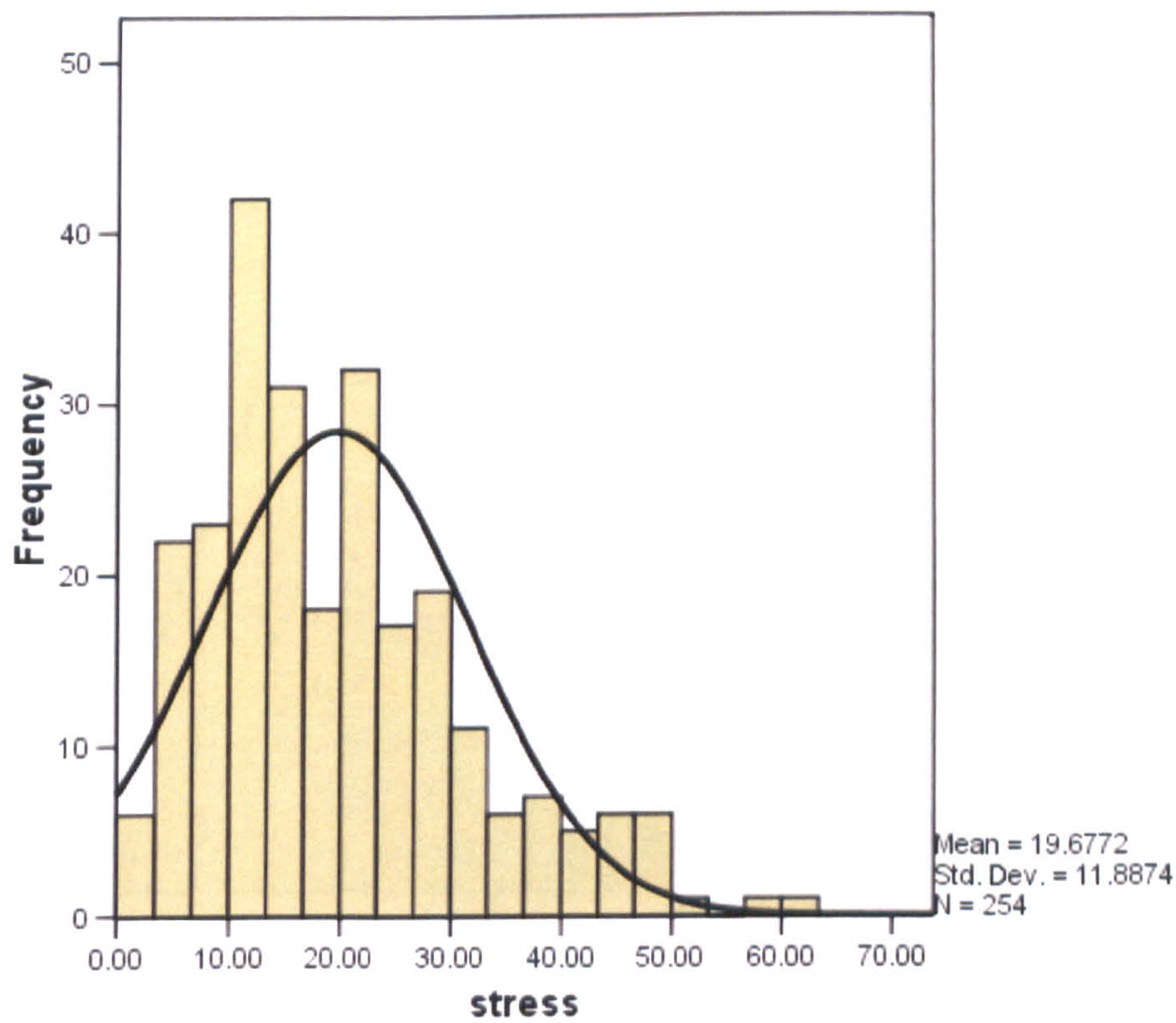



Figure A3.8) Histogram showing the distribution of play behaviour using total scores over all tests. The X-axis gives the number of dogs showing the behaviour at a certain frequency (Y-axis).

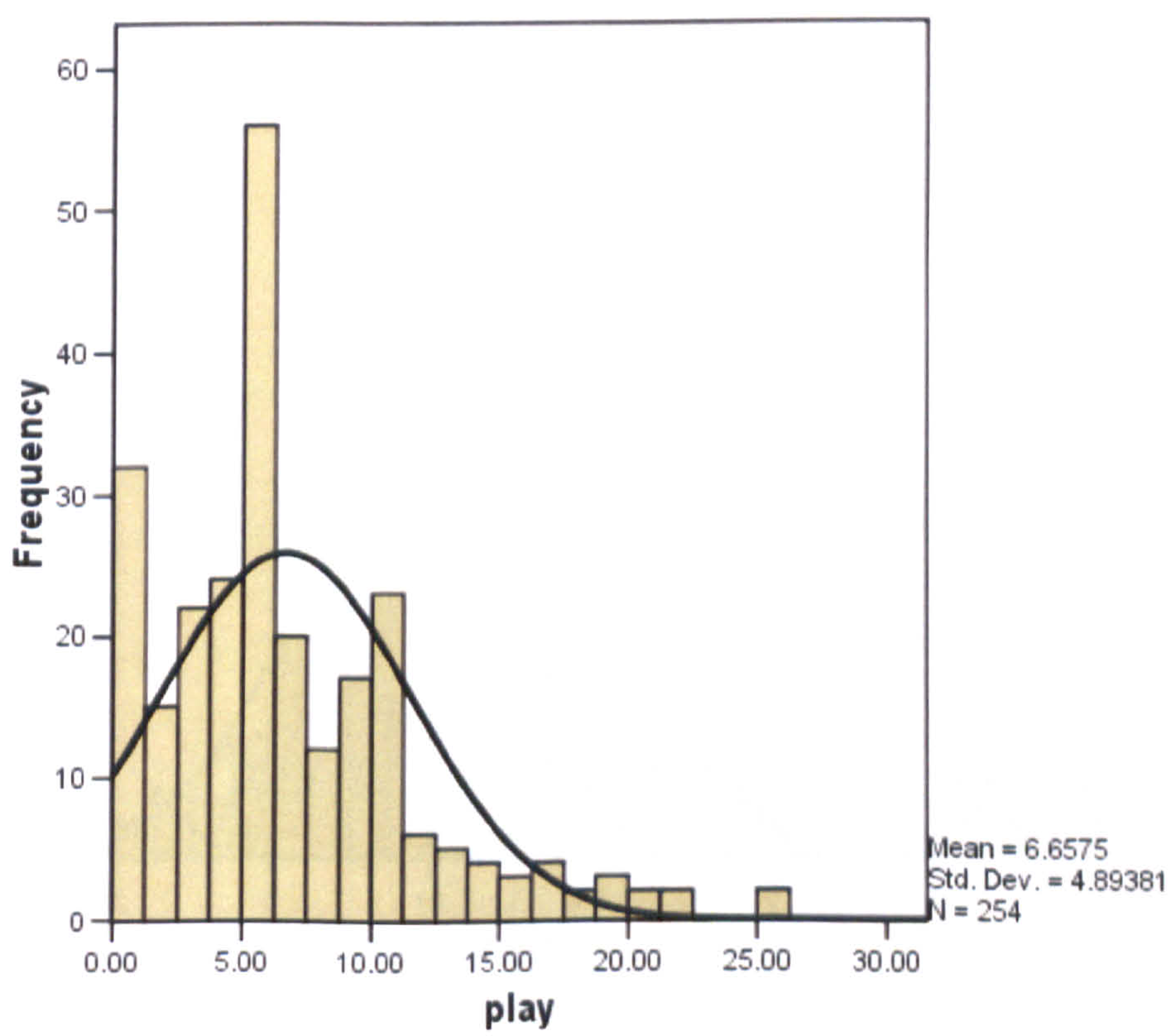


Figure A3.9) Histogram showing the distribution of "uncertainty" using total scores over all tests. The X-axis gives the number of dogs showing the behaviour at a certain frequency (Y-axis).

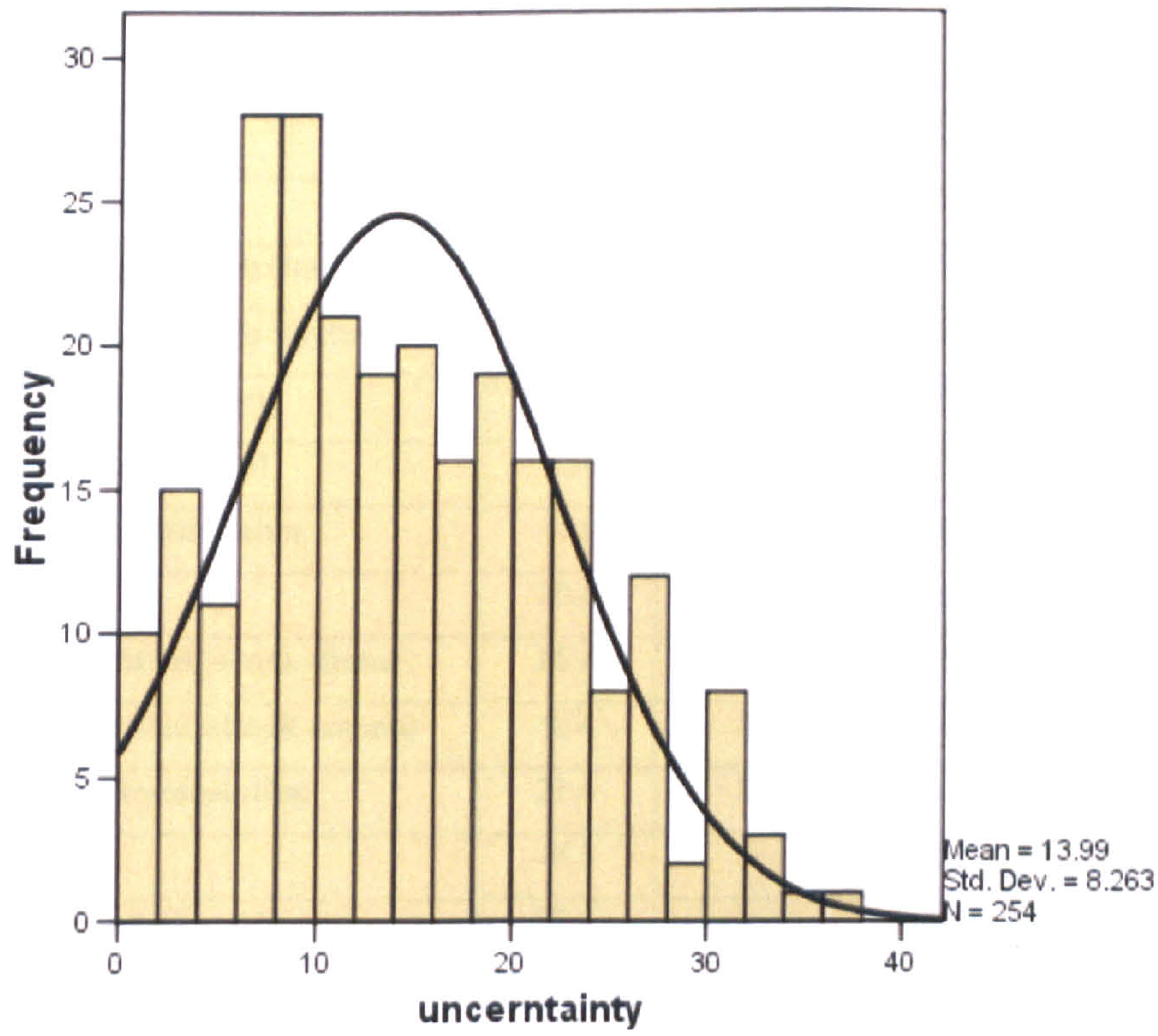



Figure A3.10) Histogram showing the distribution of "attention" using total scores over all tests. The X-axis gives the number of dogs showing the behaviour at a certain frequency (Y-axis).

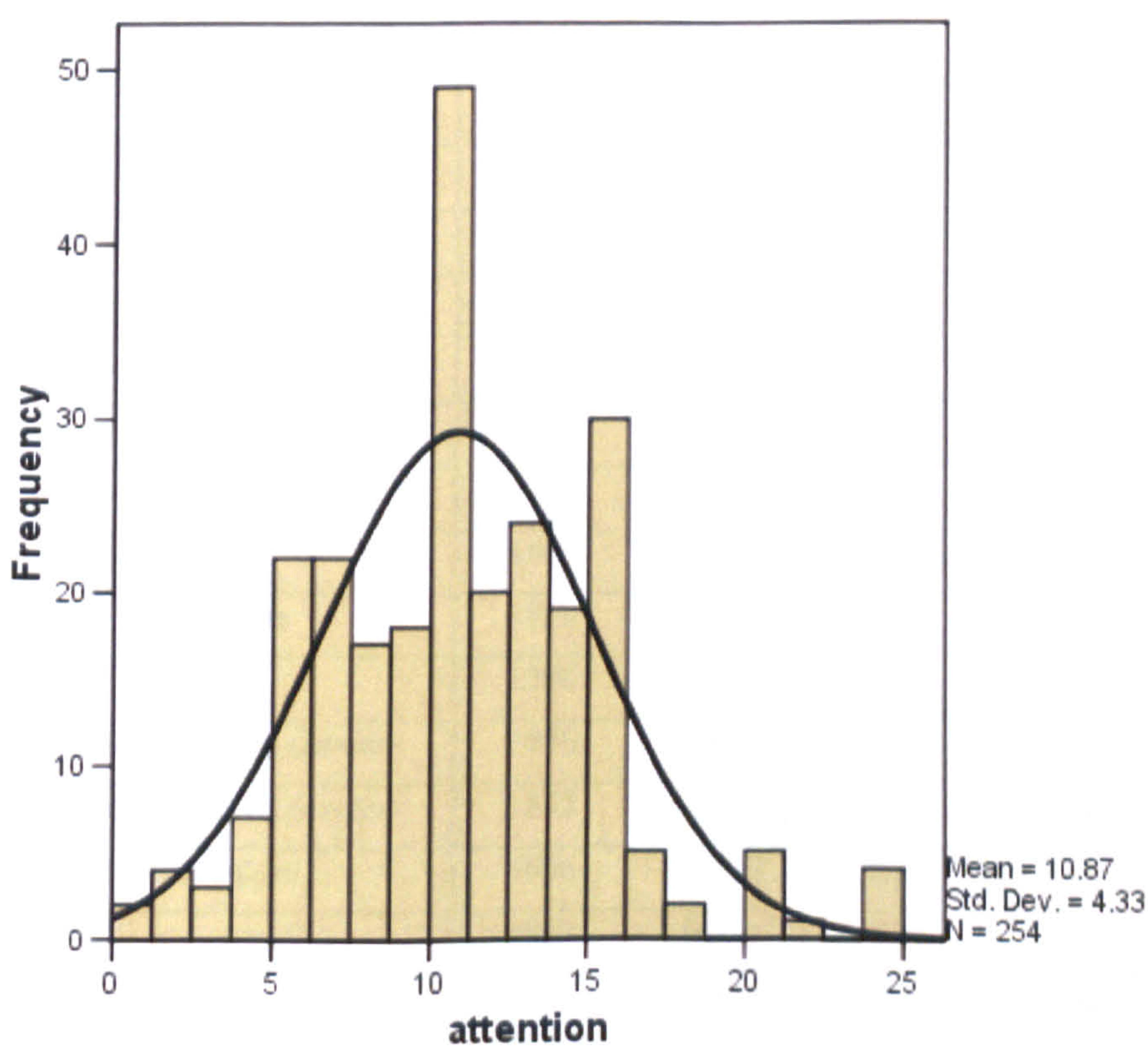


Table A3.1) Associations between the number of behaviours shown singly or in their respective groups, and breed groups and sex / neuter status of the dogs.

| Behaviour/ Group | K-W Chi-2 | df | Sign. p= | K-W Chi-2 | df | Sign. p= |
|---|---|---|---|---|---|---|
| | breed | | | Sex-groups | | |
| **uncertainty** | 16 | 8 | **.042** | .558 | 3 | .906 |
| **attention** | 5.8 | 8 | .668 | .731 | 3 | .866 |
| **Social approach (home)** | 17 | 8 | **.029** | .526 | 3 | .913 |
| **Social approach (arena)** | 12.3 | 8 | .137 | .648 | 3 | .885 |
| **Imposing(home)** | 34.2 | 8 | **<.001** | .046 | 3 | .997 |
| **Imposing(arena)** | 12.4 | 8 | .131 | 24 | 3 | **<.001** |
| **Passive submission** | 34.9 | 8 | **<.001** | 3.9 | 3 | .265 |
| **threat** | 20.6 | 8 | **.008** | 6.5 | 3 | .132 |
| **Uninhibited attack (home)** | 16.4 | 8 | **.036** | 2.1 | 3 | .550 |
| **Uninhibited attack (arena)** | 9.7 | 8 | .286 | 7.5 | 3 | .057 |
| **Flight/de-escalation** | 21.6 | 8 | **.006** | .809 | 3 | .847 |
| **Stress** | 48.3 | 8 | **<.001** | 7 | 3 | .070 |
| **Play(home)** | 22.9 | 8 | **.003** | 1.1 | 3 | .777 |
| **Play(arena)** | 11.4 | 8 | .177 | 1.6 | 3 | .660 |

Table A3.2) Associations between the number of behaviours shown singly or in their respective groups, and the biting history of the dog: biting family members and biting strangers.

| Behaviour/ Group | M-W-U | Z | Sign. p= | M-W-U | Z | Sign. p= |
|---|---|---|---|---|---|---|
| | Biting family member | | | Biting stranger | | |
| **uncertainty** | 1589 | -1.108 | .268 | 583 | -1.962 | **.050** |
| **attention** | 1567 | -1.188 | .235 | 826 | -0.777 | .437 |
| **Social approach (home)** | 1323 | -2.051 | **.040** | 797 | -0.917 | .359 |
| **Social approach (arena)** | 1739 | -0.581 | .561 | 837 | -0.723 | .470 |
| **Imposing(home)** | 1426 | -1.961 | **.050** | 883 | -0.576 | .564 |
| **Imposing(arena)** | 1684 | -0.798 | .425 | 898 | -1.386 | .663 |
| **Passive submission** | 1818 | -0.303 | .762 | 732 | -1.236 | .217 |
| **threat** | 1396 | -1.795 | .073 | 444 | -2.654 | **.008** |
| **Uninhibited attack (home)** | 1846 | -0.642 | .521 | 894 | -1.374 | .169 |
| **Uninhibited attack (arena)** | 1575 | -2.098 | **.036** | 828 | -1.386 | .166 |
| **Flight/de-escalation** | 1606 | -1.048 | .294 | 674 | -1.520 | .129 |
| **Stress** | 1802 | -0.359 | .720 | 875 | -0.533 | .594 |
| **Play(home)** | 1671 | -0.849 | .396 | 538 | -2.262 | **.024** |
| **Play(arena)** | 1886 | -0.055 | .956 | 860 | -0.609 | .543 |

Table A3.3) Associations between the number of behaviours, shown singly or in their respective group, and the biting history of the dogs: biting other dogs and been bitten by dogs.

| Behaviour/ Group | M-W-U | Z | Sign. p= | M-W-U | Z | Sign. p= |
|---|---|---|---|---|---|---|
| | Biting other dogs | | | Been bitten | | |
| **uncertainty** | 6495 | -0.684 | .494 | 7979 | -0.133 | .895 |
| **attention** | 6748 | -0.215 | .829 | 7704 | -0.605 | .545 |
| **Social approach (home)** | 6842 | -0.042 | .967 | 7977 | -0.136 | .892 |
| **Social approach (arena)** | 6616 | -0.460 | .646 | 7761 | -0.506 | .613 |
| **Imposing(home)** | 5415 | -3.131 | **.002** | 7710 | -0.692 | .489 |
| **Imposing(arena)** | 5834 | -1.968 | **.049** | 7204 | -1.504 | .133 |
| **Passive submission** | 6777 | -0.162 | .871 | 7950 | -0.183 | .855 |
| **threat** | 5729 | -2.110 | **.035** | 7982 | -0.129 | .898 |
| **Uninhibited attack (home)** | 6707 | -0.911 | .363 | 7629 | -2.281 | **.023** |
| **Uninhibited attack (arena)** | 5836 | -3.449 | **.001** | 7279 | -2.408 | **.016** |
| **Flight/de-escalation** | 5789 | -1.992 | **.046** | 7514 | -0.929 | .353 |
| **Stress** | 5673 | -2.207 | **.027** | 7526 | -0.907 | .364 |
| **Play(home)** | 6616 | -0.476 | .634 | 7553 | -0.892 | .372 |
| **Play(arena)** | 5796 | -1.986 | **.047** | 7875 | -0.312 | .755 |

Table A3.4) Correlations (Spearman's rho) between the number of behaviours, shown singly or in the respective groups, compared to the aggression scores for each dog in subtest groups A (meana - people interacting in a "everyday" manner), B (meanb - humans deliberately threatening the dog), C (meanc - loud noise), D (meand - dogs), E (meane - friendly persons, play), F (meanf – strange persons),G (meang - humans deliberately threatening in the dog's home), H (meanh – persons manipulating home), I (meani - people interacting friendly in the dog's home) and the obedience scores.
*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).

| | | mean obedience | meana | meanb | meanc | meand | meane | meanf | meang | meanh | meani |
|---|---|---|---|---|---|---|---|---|---|---|---|
| passive submission | Correlation Coef. | -0,121 | -0,070 | -0,085 | -0,079 | 0,034 | -0,173 | -0,105 | -0,330 | -0,267 | -0,278 |
| | Sig. (2-tailed) | 0,054 | 0,265 | 0,177 | 0,210 | 0,593 | 0,006 | 0,096 | 0,000 | 0,000 | 0,000 |
| | N | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 |
| threat | Correlation Coef. | 0,202 | 0,327 | 0,508 | 0,424 | 0,381 | 0,395 | 0,432 | 0,472 | 0,337 | 0,402 |
| | Sig. (2-tailed) | 0,001 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| | N | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 |
| flight & de-escalation | Correlation Coef. | 0,049 | -0,027 | 0,014 | -0,018 | -0,052 | 0,115 | 0,110 | 0,173 | 0,135 | 0,213 |
| | Sig. (2-tailed) | 0,440 | 0,666 | 0,820 | 0,780 | 0,411 | 0,068 | 0,080 | 0,006 | 0,032 | 0,001 |
| | N | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 |
| stress | Correlation Coef. | 0,150 | -0,006 | 0,177 | 0,122 | 0,225 | 0,052 | 0,070 | 0,035 | -0,040 | 0,049 |
| | Sig. (2-tailed) | 0,017 | 0,920 | 0,005 | 0,052 | 0,000 | 0,413 | 0,268 | 0,576 | 0,530 | 0,434 |
| | N | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 |
| play home | Correlation Coef. | -0,115 | -0,165 | -0,168 | -0,122 | -0,104 | -0,301 | -0,180 | -0,268 | -0,074 | -0,233 |
| | Sig. (2-tailed) | 0,068 | 0,008 | 0,007 | 0,053 | 0,098 | 0,000 | 0,004 | 0,000 | 0,239 | 0,000 |
| | N | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 |
| play arena | Correlation Coef. | -0,180 | -0,057 | 0,068 | 0,019 | 0,175 | -0,057 | -0,019 | -0,042 | -0,072 | -0,065 |
| | Sig. (2-tailed) | 0,004 | 0,368 | 0,282 | 0,769 | 0,005 | 0,366 | 0,766 | 0,502 | 0,254 | 0,302 |
| | N | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 |
| uninhibited attack home | Correlation Coef. | 0,078 | 0,095 | 0,176 | 0,115 | 0,169 | 0,208 | 0,111 | 0,253 | 0,068 | 0,083 |
| | Sig. (2-tailed) | 0,214 | 0,133 | 0,005 | 0,068 | 0,007 | 0,001 | 0,076 | 0,000 | 0,281 | 0,188 |
| | N | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 |
| uninhibited attack arena | Correlation Coef. | 0,067 | 0,125 | 0,197 | 0,195 | 0,198 | 0,129 | 0,092 | 0,080 | 0,109 | 0,085 |
| | Sig. (2-tailed) | 0,288 | 0,046 | 0,002 | 0,002 | 0,002 | 0,040 | 0,142 | 0,201 | 0,082 | 0,175 |
| | N | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 |

Table A 3.4) continued

| | | mean obedience | meana | meanb | meanc | meand | meane | meanf | meang | meanh | meani |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **imposing home** | Correlation Coef. | -0,075 | 0,124 | 0,177 | 0,232 | 0,181 | 0,211 | 0,131 | 0,094 | 0,082 | 0,154 |
| | Sig. (2-tailed) | 0,236 | 0,049 | 0,005 | 0,000 | 0,004 | 0,001 | 0,036 | 0,136 | 0,192 | 0,014 |
| | N | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 |
| **imposing arena** | Correlation Coef. | -0,035 | 0,025 | 0,071 | 0,126 | 0,310 | -0,020 | -0,015 | -0,006 | 0,031 | 0,050 |
| | Sig. (2-tailed) | 0,582 | 0,694 | 0,262 | 0,045 | 0,000 | 0,747 | 0,814 | 0,921 | 0,623 | 0,425 |
| | N | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 |
| **social approach home** | Correlation Coef. | -0,103 | -0,205 | -0,230 | -0,142 | -0,140 | -0,225 | -0,243 | -0,393 | -0,287 | -0,348 |
| | Sig. (2-tailed) | 0,101 | 0,001 | 0,000 | 0,024 | 0,026 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| | N | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 |
| **sochial approach arena** | Correlation Coef. | -0,037 | 0,004 | -0,135 | -0,112 | -0,139 | -0,148 | -0,098 | -0,117 | -0,059 | -0,124 |
| | Sig. (2-tailed) | 0,556 | 0,944 | 0,031 | 0,075 | 0,026 | 0,018 | 0,119 | 0,064 | 0,352 | 0,048 |
| | N | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 |
| **uncerntainty** | Correlation Coef. | 0,219 | 0,144 | 0,196 | 0,218 | 0,026 | 0,274 | 0,225 | 0,391 | 0,282 | 0,363 |
| | Sig. (2-tailed) | 0,000 | 0,021 | 0,002 | 0,000 | 0,680 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| | N | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 |
| **attention** | Correlation Coef. | -0,246 | -0,111 | -0,213 | -0,221 | -0,202 | -0,205 | -0,285 | -0,241 | -0,137 | -0,223 |
| | Sig. (2-tailed) | 0,000 | 0,077 | 0,001 | 0,000 | 0,001 | 0,001 | 0,000 | 0,000 | 0,029 | 0,000 |
| | N | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 | 254 |

# Appendix 4:

## Supplementary Tables supporting Chapter 4

Table. A4.1) Crosstabulation statistics for methods of reinforcement / means and tools for training. $Chi^2$, df and p 1 are Pearson statistics ; p 2 from Fisher's Exact Test (2-sided), relevant when >25% of expected frequencies are < 5.

| Method / Tool to | Method / Tool | $Chi^2$ | d.f. | p 1 | p 2 |
|---|---|---|---|---|---|
| Verbal reinforcement | Treat | 36.250 | 1 | <.001 | |
| | Play | 32.163 | 1 | <.001 | |
| | Stroking | 73.122 | 1 | <.001 | |
| | Verbal correction | 34.524 | 1 | <.001 | |
| | Verbal punishment | 11.609 | 1 | .001 | |
| | Physical punishment | 4.513 | 1 | | .032 |
| | Flat collar | 8.483 | 1 | .004 | |
| | Choke collar | 11.740 | 1 | .001 | |
| | Prong collar | .488 | 1 | | .445 |
| | Electric collar | .623 | 1 | | >.999 |
| | Halti | 2.226 | 1 | | .204 |
| Treat | Play | 35.171 | 1 | <.001 | |
| | Stroking | 35.464 | 1 | <.001 | |
| | Verbal correction | 5.752 | 1 | .016 | |
| | Verbal punishment | 1.920 | 1 | .166 | |
| | Physical punishment | 1.128 | 1 | .288 | |
| | Flat collar | 8.810 | 1 | .003 | |
| | Choke collar | 3.112 | 1 | .078 | |
| | Prong collar | 3.836 | 1 | . | .062 |
| | Electric collar | .829 | 1 | | >.999 |
| | Halti | 2.959 | 1 | | .110 |
| Play | Stroking | 32.798 | 1 | <.001 | |
| | Verbal correction | 24.811 | 1 | <.001 | |
| | Verbal punishment | 2.347 | 1 | .125 | |
| | Physical punishment | .246 | 1 | .620 | |
| | Flat collar | 10.316 | 1 | .001 | |
| | Choke collar | 3.230 | 1 | .072 | |
| | Prong collar | .048 | 1 | | >.999 |
| | Electric collar | 1.863 | 1 | | .499 |
| | Halti | 1.579 | 1 | | .266 |
| Stroking | Verbal correction | 12.598 | 1 | <.001 | |
| | Verbal punishment | 8.568 | 1 | .003 | |
| | Physical punishment | .950 | 1 | . | .424 |
| | Flat collar | 5.320 | 1 | .021 | |
| | Choke collar | 4.438 | 1 | .035 | |
| | Prong collar | .002 | 1 | | >.999 |
| | Electric collar | .597 | 1 | | >.999 |
| | Halti | 2.130 | 1 | | .356 |
| Verbal correction | Verbal punishment | 4.742 | 1 | .029 | |
| | Physical punishment | 15.077 | 1 | <.001 | |
| | Flat collar | 11.742 | 1 | .001 | |
| | Choke collar | 10.766 | 1 | .001 | |
| | Prong collar | .054 | 1 | | >.999 |
| | Electric collar | 3.431 | 1 | | .136 |
| | Halti | 1.252 | 1 | | .429 |

Table A4.1 continued

| Method / Tool to | Method / Tool | $Chi^2$ | d.f. | p 1 | p 2 |
|---|---|---|---|---|---|
| Verbal punishment | Physical punishment | 15.620 | 1 | < .001 | |
| | Flat collar | .424 | 1 | .515 | |
| | Choke collar | .261 | 1 | .610 | |
| | Prong collar | 6.366 | 1 | | .020 |
| | Electric collar | 4.903 | 1 | | .084 |
| | Halti | .657 | 1 | | .419 |
| Physical punishment | Flat collar | .007 | 1 | .935 | |
| | Choke collar | 1.121 | 1 | | .343 |
| | Prong collar | .099 | 1 | | .546 |
| | Electric collar | 4.629 | 1 | | .159 |
| | Halti | 3.913 | 1 | | .106 |
| Flat collar | Choke collar | 6.820 | 1 | .009 | |
| | Prong collar | .533 | 1 | | .510 |
| | Electric collar | 1.565 | 1 | | .506 |
| | Halti | .670 | 1 | | .473 |
| Choke collar | Prong collar | .151 | 1 | . | > .999 |
| | Electric collar | 1.782 | 1 | | .291 |
| | Halti | 16.820 | 1 | | .001 |
| Prong collar | Electric collar | 12.730 | 1 | | .070 |
| | Halti | .264 | 1 | | > .999 |
| Electric collar | Halti | 16.789 | 1 | | .054 |

Table. A 4.2) Results of Mann-Whitney-U test: Association between mean aggression scores per subgroup and obedience score to whether the dog had received special training/education.

| Test Statistics(a) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Accid. Interact | Threat | Noise | Dog | Play | Strange Person | Threat Home | Manipu-lation | Friendly People | Obedience |
| Mann-Whitney U | 3935,500 | 3918,500 | 3672,500 | 3256,000 | 3946,000 | 3919,000 | 3569,500 | 4009,500 | 3925,000 | 1823,000 |
| Wilcoxon W | 4638,500 | 4621,500 | 4375,500 | 3959,000 | 27599,000 | 4622,000 | 27222,500 | 4712,500 | 4628,000 | 2526,000 |
| Z | -,283 | -,238 | -1,088 | -1,997 | -,254 | -,285 | -1,272 | -,017 | -,326 | -5,341 |
| Asymp. Sig. (2-tailed) | ,778 | ,812 | ,277 | ,046 | ,799 | ,776 | ,203 | ,987 | ,744 | ,000 |
| a Grouping Variable: education characteristic | | | | | | | | | | |

Table. A 4.3) Results of Mann-Whitney-U test: Association between mean aggression scores per subgroup and obedience score to whether the dog had been trained using punishment.

| Test Statistics(a) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Accid. Interact | Threat | Noise | Dog | Play | Strange Person | Threat Home | Manipu-lation | Friendly People | Obedience |
| Mann-Whitney U | 7992,500 | 8028,000 | 7939,500 | 7566,000 | 7771,000 | 8007,500 | 7656,500 | 7674,500 | 7987,500 | 6377,000 |
| Wilcoxon W | 15132,500 | 17208,000 | 17119,500 | 16746,000 | 14911,000 | 17187,500 | 14796,500 | 14814,500 | 17167,500 | 15557,000 |
| Z | -,101 | -,008 | -,209 | -,868 | -,685 | -,053 | -,760 | -,841 | -,116 | -2,852 |
| Asymp. Sig. (2-tailed) | ,919 | ,994 | ,834 | ,385 | ,493 | ,958 | ,447 | ,401 | ,908 | ,004 |
| a Grouping Variable: Punishment used | | | | | | | | | | |

Tab. A 4.4) Results of Mann-Whitney-U test: Association between mean aggression scores per subgroup and obedience score to whether the dog had been trained with choke-, prong- or electric collar.

**Test Statistics(a)**

| | Accid. Interact | Threat | Noise | Dog | Play | Strange Person | Threat Home | Manipu-lation | Friendly People | Obedience |
|---|---|---|---|---|---|---|---|---|---|---|
| Mann-Whitney U | 4939,500 | 4326,500 | 4841,500 | 4694,500 | 4365,000 | 4616,000 | 4736,500 | 4814,000 | 4576,000 | 3774,000 |
| Wilcoxon W | 6115,500 | 25647,500 | 6017,500 | 26015,500 | 25686,000 | 25937,000 | 26057,500 | 26135,000 | 25897,000 | 4950,000 |
| Z | -,015 | -1,381 | -,294 | -,592 | -1,935 | -,881 | -,535 | -,389 | -1,208 | -2,569 |
| Asymp. Sig. (2-tailed) | ,988 | ,167 | ,769 | ,554 | ,053 | ,378 | ,593 | ,697 | ,227 | ,010 |

a Grouping Variable: choke collar,prong collar,electric collar

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# Appendix 5:

## Supplementary Tables supporting Chapter 5

Table A5.1) Testing week four to week seven individually against week eight for social approach behaviour

Multiple Comparisons
Dependent Variable: social approach beh.
Dunnett t (2-sided)

| (I) WEEK | (J) WEEK | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 4 | 8 | -0,24494 | 0,064047 | 0,001 | -0,40325 | -0,08663 |
| 5 | 8 | -0,19531 | 0,064047 | 0,010 | -0,35362 | -0,03701 |
| 6 | 8 | -0,24414 | 0,064047 | 0,001 | -0,40245 | -0,08584 |
| 7 | 8 | -0,10500 | 0,064047 | 0,295 | -0,26331 | 0,05330 |

Based on observed means.
*. The mean difference is significant at the ,05 level.
a. Dunnett t-tests treat one group as a control, and compare all other groups against it.

Table A5.2) Testing week four to week seven individually against week eight for imposing behaviour

Multiple Comparisons
Dependent Variable: imposing behaviour
Dunnett t (2-sided)

| (I) WEEK | (J) WEEK | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 4 | 8 | 0,03589 | 0,034832 | 0,690 | -0,05020 | 0,12198 |
| 5 | 8 | 0,02131 | 0,034832 | 0,930 | -0,06479 | 0,10740 |
| 6 | 8 | -0,04690 | 0,034832 | 0,468 | -0,13299 | 0,03919 |
| 7 | 8 | -0,00416 | 0,034832 | 1,000 | -0,09026 | 0,08193 |

Based on observed means.
a. Dunnett t-tests treat one group as a control, and compare all other groups against it.

Table A5.3) Testing week four to week seven individually against week eight for threat behaviour

Multiple Comparisons
Dependent Variable: threat behaviour
Dunnett t (2-sided)

| (I) WEEK | (J) WEEK | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 4 | 8 | -0,28669 | 0,038184 | 0,000 | -0,38107 | -0,19231 |
| 5 | 8 | -0,20229 | 0,038184 | 0,000 | -0,29666 | -0,10791 |
| 6 | 8 | -0,19141 | 0,038184 | 0,000 | -0,28579 | -0,09703 |
| 7 | 8 | -0,08300 | 0,038184 | 0,102 | -0,17738 | 0,01138 |

Based on observed means.
*. The mean difference is significant at the ,05 level.
a. Dunnett t-tests treat one group as a control, and compare all other groups against it.

Table A5.4) Testing week four to week seven individually against week eight for inhibited attack behaviour

Multiple Comparisons
Dependent Variable: inhibited attack beh.
Dunnett t (2-sided)

| (I) WEEK | (J) WEEK | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 4 | 8 | -0,17274 | 0,035466 | 0,000 | -0,26040 | -0,08508 |
| 5 | 8 | -0,13496 | 0,035466 | 0,001 | -0,22262 | -0,04730 |
| 6 | 8 | -0,08221 | 0,035466 | 0,073 | -0,16987 | 0,00545 |
| 7 | 8 | 0,01135 | 0,035466 | 0,993 | -0,07631 | 0,09901 |

Based on observed means.
*. The mean difference is significant at the ,05 level.
a. Dunnett t-tests treat one group as a control, and compare all other groups against it.

Table A5.5) Testing week four to week seven individually against week eight for attack behaviour

Multiple Comparisons
Dependent Variable: attack behaviour
Dunnett t (2-sided)

| (I) WEEK | (J) WEEK | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 4 | 8 | -0,22292 | 0,035543 | 0,000 | -0,31077 | -0,13506 |
| 5 | 8 | 0,00710 | 0,035543 | 0,999 | -0,08075 | 0,09496 |
| 6 | 8 | -0,03351 | 0,035543 | 0,751 | -0,12136 | 0,05434 |
| 7 | 8 | 0,07968 | 0,035543 | 0,087 | -0,00817 | 0,16753 |

Based on observed means.
*. The mean difference is significant at the ,05 level.
a. Dunnett t-tests treat one group as a control, and compare all other groups against it.

Table A5.6) Testing week four to week seven individually against week eight for flight behaviour

Multiple Comparisons
Dependent Variable: flight behaviour
Dunnett t (2-sided)

| (I) WEEK | (J) WEEK | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 4 | 8 | -0,15337 | 0,030571 | 0,000 | -0,22893 | -0,07780 |
| 5 | 8 | -0,01890 | 0,030571 | 0,928 | -0,09446 | 0,05666 |
| 6 | 8 | -0,02792 | 0,030571 | 0,770 | -0,10349 | 0,04764 |
| 7 | 8 | -0,02644 | 0,030571 | 0,801 | -0,10200 | 0,04912 |

Based on observed means.
*. The mean difference is significant at the ,05 level.
a. Dunnett t-tests treat one group as a control, and compare all other groups against it.

Table A5.7) Testing week five to week seven individually against week eight for play behaviour

Multiple Comparisons
Dependent Variable: play behaviour
Dunnett t (2-sided)

| (I) WEEK | (J) WEEK | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 5 | 8 | -0,25020 | 0,038533 | 0,000 | -0,34213 | -0,15828 |
| 6 | 8 | -0,15493 | 0,038533 | 0,000 | -0,24685 | -0,06300 |
| 7 | 8 | -0,12461 | 0,038533 | 0,005 | -0,21654 | -0,03269 |

Based on observed means.
*. The mean difference is significant at the ,05 level.
a. Dunnett t-tests treat one group as a control, and compare all other groups against it.

# Appendix 6:

## Supplementary Tables supporting Chapter 6

Table A6.1) Testing for between-litter differences in the scores from the different subtest groups

**Test Statistics(a,b)**

| | obedience | Accidental interaction | Threat | Noise | Dog | Strange people | Play | Threat home | Manipulation | Friendly people |
|---|---|---|---|---|---|---|---|---|---|---|
| Chi-Square | 6,683 | 2,800 | 1,293 | 2,800 | 6,885 | ,000 | 2,361 | 2,800 | ,000 | ,000 |
| df | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Asymp. Sig. | ,083 | ,423 | ,731 | ,423 | ,076 | 1,000 | ,501 | ,423 | 1,000 | 1,000 |

a Kruskal Wallis Test

b Grouping Variable: litter

Table A6.2) Testing for between-litter differences in the quantitative display of behaviour from the different behavioural groups and two single behaviours.

**Test Statistics(a,b)**

| | social approach | imposing | passive submission | threat | Unin-hibited attack | flight | stress | play | Uncertainty | attention |
|---|---|---|---|---|---|---|---|---|---|---|
| Chi-Square | ,442 | 6,643 | 7,744 | 2,695 | 2,800 | 1,295 | 12,266 | 3,257 | 4,725 | ,124 |
| df | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Asymp. Sig. | ,931 | ,084 | ,052 | ,441 | ,423 | ,730 | ,007 | ,354 | ,193 | ,989 |

a Kruskal Wallis Test

b Grouping Variable: litter

# References

Abrantes R (1997): Dog language: an encyclopaedia of canine behaviour. Wankan Tankan Publishers, Illinois.

Adamec RE (1991): Individual differences in temporary lobe sensory processing of threatening stimuli in the cat. Physiology and Behaviour **49**, 455-464.

Adams DB (1986): Ventromedial tegmental leasions abolish offence without disturbing predation or defence. Physiology and Behaviour **38**, 165-168.

Adams DB, Flynn JP (1966): Transfer of an escape response from tail shock to brain-stimulated attack behaviour. Journal of Experimental Animal Behavior **9**, 401-408.

Alcock J (1996): Das Verhalten der Tiere aus evolutionsbiologischer Sicht. Gustav Fischer, Stuttgart, Jena, New York.

Allan WE (1986): Pseudopregnancy in the bitch: the current view on etiology and treatment. Journal of Small Animal Veterinary Practice **27**, 419-424.

Althaus T (1978): Die Ontogenese von Verhaltensweisen bei Haus- und Wildhunden. KTBL-Schrift **240**, 116-127.

Althaus T (1982): Die Welpenentwicklung beim Siberian Husky. Dissertation, Universität Bern.

Altmann J (1974): Observational study of behaviour: Sampling Methods. Behaviour **48**, 1-41.

Anderson RK, Forster RE (1995): Promise: The natural behaviour system. Morris Animal Foundation, Englewood, Co.

APBC (2003): Annual review of cases 2003. Association of Pet Behaviour Counsellors. Report; http://www.apbc.org.uk/review_2003/report_03.htm.

Appleby DL, Bradshaw JWS, Casey R (2002): Relationship between aggressive and avoidance behaviour by dogs and their experience in the first six months of life. Veterinary Record **150**, 434-438.

Archer J (1969): Adrenocortical responses to olfactory social stimuli in male mice. Journal of Mammalogy **50**, 839-841.

Archer J (1974): Testosterone and behaviour during extinction in Chicks. Animal Behaviour **22**, 650-655.

Archer J (1976). The organisation of fear and aggression in vertebrates. Perspectives in Ethology. P. Bateson and P. Klopfer. New York, London, Plenum Press. **2**, 231-298.

Askew HR (1996): Treatment of dog behaviour problems. In: Treatment of behavioural problems in cats and dogs. Blackwell Science, Oxford.

Azrin NH (1961): Time-out from positive reinforcement. Science **133**, 382-383.

Azrin NH (1970): Punishment of elicited aggression by a physiological blow. Journal of the Experimental Analysis of Behaviour **14**, 7-10.

Azrin NH, Hake DF, Hutchinson RR (1965b): Elicitation of aggression by a physiological blow. Journal of the Experimental Analysis of Behaviour **8**, 55-57.

Azrin NH, Hutchinson RR (1967): Conditioning of the aggressive behaviour of pigeons by a fixed-interval schedule of reinforcement. Journal of the Experimental Analysis of Behaviour **10**, 395-402

Azrin NH, Hutchinson RR, McLaughlin R (1965a): The opportunity for aggression as an operant reinforcer during aversive stimulation. Journal of the Experimental Analysis of Behaviour **8**, 171-180.

Bandura A, Walthers RH (1963): Social learning and personality development. Holt, Rinehart and Winston, New York,

Banks EM (1962): A time and motion study of prefighting behaviour in mice. The Journal of General Psychology **101**, 165-183.

Bartlett M (1985): A novice look at puppy aptitude testing. Purebred Dogs – American Kennel Gazette, 3/1985, 31-34.

Bateson PPG (1964): Changes in chicks' responses to novel moving objects over the sensitive period for imprinting. Animal Behavior **12**, 479-489.

Beata CA (2001): Diagnosis and treatments of aggression in dogs and cats. In: Recent Advances in Companion Animal Behaviour Problems. Ed. Houpt KA. International Veterinary Information Service (www.ivis.org), Ithaka.

Beaudet R (1993): Social dominance evaluation: observations on Campbell's test. Bulletin of Veterinary Clinical Ethology **1**, 23-29.

Beaudet R, Chalifoux A, Dallaire A (1994): Predictive Value of activity level and behavioural evaluation on future dominance in puppies. Applied Animal Behaviour Science **40**, 273-284.

Beaver BV, Baker MD, Gloster RC, Grant WA, Harris JM, Hart BL, Hattaway DH, Houston T, Koschmann JR, Lockwood R, Rieck D, Sacks JJ, Strauss WS, Strother J (2001). "A community approach to dog bite prevention." Journal of the American Veterinary Medical Association **218**, 1732-1749.

Bekoff M (1972): An ethological study of the development of social interaction in the genus Canis: a dyadic analysis. Ph.D.-thesis, Washington University, St. Louis.

Bekoff M, Byers JA (1982): Kritische Neuanalyse der Ontogenese und Phylogenese des Spielverhaltens bei Säugern: ein ethologisches Wespennest. In: Immelmann: Verhaltensentwicklung bei Mensch und Tier. Das Bielefelder Projekt. Paul Parey Verlag, Hamburg, 415-453.

Belyaev DK (1979): Destabilizing selection as a factor in domestication. Journal of Heredity **70**, 301-308.

Benus RF, Henkelmann C (1998): Litter composition influences the development of aggression and behavioural strategy in male Mus domesticus. Behaviour **135**, 1229-1249.

Benus RF, Koolhaas JM, Van Oortmerssen GA (1987): Individual differences in behavioural reaction to a changing environment in mice and rats. Behaviour **100**, 105-122.

Benus RF, Röndigs M (1996): Patterns of maternal effort in mouse lines bidirectionally selected for aggression. Animal Behaviour **51**, 67-75.

Benus RF, Röndigs M (1997): The influence of the postnatal maternal environment in accounting for differences in aggression and behavioural strategies in Mus domesticus. Behaviour **134**, 623-641.

Bergler R (2000): Gesund durch Heimtiere. Beiträge zur Prävention und Therapie gesundheitlicher und seelischer Risikofaktoren. Deutscher Instituts Verlag, Köln

Berkowitz L (1962): Aggression. McCraw-Hill, New York.

Berkowitz L (1969): The frustration-aggression hypothesis revisited. In: Roots of Aggression, Ed. Berkowitz L, Atherton, New York.

Bernstein NM, Fiske RA (1986): Feline ischemic encephalopathy in a cat. Journal of the American Animal Hospital Association **22**, 205-208.

Bevan W, Daves WF, Levy GW (1960): The relation of castration, androgen therapy and pretest fighting experience to competitive aggression in male C57B1/10 mice. Animal Behaviour **8**, 6-12.

Blackshaw JK (1988): Abnormal behaviour in dogs. Australian Veterinary Journal **65**, 393-394.

BMVEL (2000): Gutachten zur Auslegung von § 11b des Tierschutzgesetzes (Verbot von Qualzüchtungen). Bundesministerium für Ernährung, Landwirtschaft und Forsten, Bonn.

Boenigk K, Distl O (2004): Untersuchungen zur züchterischen Aussagekraft für die Merkmale der Verhaltenstest beim Hovavart. Gesellschaft zur Förderung kynologischer Forschung e.V., 19. Rundschreiben 6/2004.

Boice R, Pickering A (1973): Shock-elicited behaviours in paired gerbils. Bulletin of the Psychonomic Society **2**, 221-224.

Bondarenko N (1995): Temperament testing – toy or tool. Companion Animal Behaviour Therapy Study Group. CABTSG study day 1995, Birmingham.

Borchelt PL (1983): Aggressive behaviour of dogs kept as companion animals: classification and influence of sex, reproductive status and breed. Applied.Animal Ethology**10**, 45-61.

Borchelt PL, Lockwood R, Beck AM, Voith VL (1983): Attacks by packs of dogs involving predation on human beings. Public Health Report **98**, 57-66.

Borchelt PL, Voith VL (1985): Aggressive behaviour in dogs and cats. Comparative Continuous Education **7**, 949-957.

Borchelt PL, Voith VL (1986): Dominance aggression in dogs. Comparative Continuous Education **8**, 36-44.

Bortz J (1999): Statistik für Sozialwissenschaftler. Springer Verlag, Berlin.

Böttjer A (2003): Untersuchung des Verhaltens von fünf Hunderassen und einem Hundetypus im innerartlichen Kontakt des Wesenstests nach den Richtlinien der Niedersächsischen Gefahrtier-Verordnung vom 05.07.2000. Dissertation. Tierärztliche Hochschule Hannover.

Bowlby J (1982): Attachment and loss. Vol. 1: Attachment. Basic, New York

Bradshaw JWS (1996): An ethologist's view of aggression. Companion Animal Behaviour Study Group, Newsletter 13.

Bradshaw JWS, Goodwin D, Lea AM, Whitehead SL (1996): A survey of behavioural characteristics of pure-bred dogs in the United Kingdom. Veterinary Record **138**, 456-468.

Bradshaw JWS, Lea AM (1992): Dyadic interactions between domestic dogs during exercise. Anthrozoös **5**, 245-253.

Bradshaw JWS, Nott HMR (1995): Social and communication behaviour of companion dogs. In: The domestic dog. Its evolution, behaviour and interactions with people. Ed. Serpell J, Cambridge University Press, 115-130.

Brain PF, Evans CM (1973): Some recent studies on the effects of corticotrophin on agonistic behaviour in the house mouse and the golden hamster. Journal of Endocrinology **57**, 39-40.

Brenoe UT, Larsgard AG, Johannessen KR, Uldal SH (2002): Estimates of genetic parameters for hunting performance traits in three breeds of gun hunting dogs in Norway. Applied Animal Behaviour Science **77**, 209-215.

Broadhurst PL (1975): The Maudsley reactive and nonreactive strains of rats: a survey. Behaviour Genetics **5**, 299-319.

Brown, C.J.; O.D.Murphree, J.E.O.Newton (1978): The effect of inbreeding on human aversion in pointer dogs. Journal of Heredity **69**, 362-365.

Bruns S (2003): Fünf Hunderassen und ein Hundetypus im Wesenstest nach der Niedersächsischen Gefahrtier-Verordnung vom 05.07.2000: Faktoren, die beißende von nicht-beißenden Hunden unterscheiden. Dissertation. Tierärztliche Hochschule Hannover.

Bryant B (1985): The neighbourhood walk: sources of support in middle childhood. Monographs of the Society for Research in Child Development, **50**(3), Serial No.210

BTK (2000): Stellungnahme der Bundestierärztekammer zu "gefährlichen Hunden" anläßlich des Deutschen Tierärztetages in Würzburg. Bundestierärztekammer, Bonn.

Buchholtz C (1993). Das Handlungsbereitschaftsmodell - ein Konzept zur Beurteilung und Bewertung von Verhaltensstörungen. Leiden und Verhaltensstörungen bei Tieren. C. Buchholtz, A. F. Goetschel, B. Hassensteinet al. Stuttgart, Birkhäuzser Verlag: 93-110.

Bundesamt für Veterinärwesen (2000): Argumentarium der Arbeitsgruppe "Gesetzgebung betr. gefährliche Hunde", Bundesamt für Veterinärwesen der Schweiz.

Bürgerschaft der Freien und Hansestadt Hamburg (2001): Antwort des Senats auf eine Große Anfrage bezgl. Gef. Hunde in Hamburg. Drucksache 16/5062.

Campbell WE (1972): A behaviour test for puppy selection. Modern Veterinary Practice **12**, 20-33.

Campbell WE (1974): Which dog breeds develop what behaviour problems? Modern Veterinary Practice **55**, 229-232.

Campbell WE (1975): Behaviour Problems in dogs. American Behaviour Publications, Santa Barbara, California.

Candland DK, Leshner AI (1974): A model of agonistic behaviour: endocrine and autonomic correlates. In: Advances in Limbic and Autonomic Nervous system research, Ed. DiCara L; Plenum, New York.

Carlson NR (2001): Physiology of Behavior. Allyn and Bacon, Boston.

Carlson S (1995): Rhodesian Ridgeback. Kynos Verlag, Mürlenbach.

Carlson S (2000): Rhodesian Ridgeback heute. Kynos Verlag, Mürlenbach.

Christiansen FO, Bakken M, Braastad BO (2001): Behavioural differences between three breed groups of hunting dogs confronted with domestic sheep. Applied Animal Behaviour Science **72**, 115-129.

Cleare AJ, Bond AJ (1994). Effects of alterations in plasma tryptophan levels on aggressive feelings. Archives of General Psychiatry **31**, 1004-1005.

Clifford DH, Boatfield MP, Rubright J (1983): Observations on fighting dogs. Journal of the American Veterinary Medicine Association **183**, 654-657.

Clutton-Brock J (1995): Origins of the dog: domestication and early history. In: The domestic dog. Its evolution, behaviour and interactions with people. Ed. Serpell J, Cambridge University Press, 7-20.

Coccaro EF (1992): Impulsive aggression and central serotonergic system function in humans: an example of a dementional brain behaviour relationship. International Clinical Psychopharmacology **7**, 3-12.

Cole JM, Parker BK (1971): Schedule-induced aggression: access to an attackable target bird as a positive reinforcer. Psychon Science **22**, 33-35.

Collis, GM, McNicholas J (1998): A theoretical basis for health benefits of pet ownership. In: Companion Animals in Human health; Ed: CC Wilson, DC Turner. Sage Publications, Thousand Oaks; 105-122.

Coppinger R, Coppinger L (2001): Dogs. A startling new understanding of Canine origin, behaviour and evolution. Scribner, New York, London, Toronto.

Creer TL, Hitzing EW, Schaeffer RW (1966): Classical conditioning of reflexive fighting. Psychonomic Science **4**, 89-90.

Crosby RM, Cahoon DD (1973): Superstitious responding as an artefact in investigations of shock- elicited aggression. Psychological Record **23**, 191-196.

Culler EA (1938): Recent advances in some concept of conditioning. Psychological Review **45**, 134-153.

Damasio AR (1996): Descartes' error: emotion, reason and the human brain. Papermac, London.

Darwin CR (1859): On the origin of species by means of natural selection. Murray, London.

Davis WM, Khalsa JH (1971): Some determinants of aggressive behaviour induced by morphine withdrawal. Psychonomic Science **24**, 13-15.

Davis SJM, Valla RF (1978): Evidence for domestication of the dog 12,000 years ago in the Natufian of Israel. Nature **276**, 608-610.

Dawkins R (1976): The selfish gene. Oxford University Press.

Derix R, Van Hoof J, De Fries H, Wensing J (1993): Male and female mating competition in wolves: female suppression vs. male intervention. Behaviour **127**, 141-171.

Deutscher Städtetag (1992): zitiert in Deutscher Städtetag 1997

Deutscher Städtetag (1997): Der Stadthund: Anzahl, Steuer, Gefährlichkeit. DST-Beiträge zur Kommunalpolitik, Reihe A, Heft 24.

Diederich C, Giffroy JM (2003): What is behavioural testing in dogs? A bibliographic review. Proceedings of the 37th International Congress of the ISAE, Abano Therme, Italy, 150.

Dodds WJ (1992): Thyroid can alter Behaviour. Dogworld 10.92, 40-42.

Dodman NH, Moon R, Zelin M (1996): Influence of owner personality type on expression and treatment outcome of dominance aggression in dogs. Journal of the American Veterinary Medicine Association **209**, 1107-1109.

Dodman NH, Reisner I, Shuster L, Rand W, Luescher WA, Robinson I, Houpt KA (1996): Effect of dietary protein content on behaviour in dogs. Journal of the American Veterinary Medicine Association **208**, 376-379.

Dollard J, Doob LW, Miller NE, Mowrer OH, Sears RR (1939): Frustration and aggression. Yale University Press, New Haven.

Dressler P (1999): Medienspektakel um Kampfhunde. Diplomarbeit zur Kommunikationswirtin, Hochschule der Künste, Berlin.

Drews C (1993): The concept and definition of dominance in animal behaviour. Behaviour **125**,

Duncan IJH, Wood-Gush DGM (1971): Frustration and aggression in the domestic fowl. Animal Behaviour **19**, 500-504.

Dürre I (1994): Untersuchungen zur postnatalen Verhaltensontogenese in den ersten acht Lebenswochen der Jagdhunderasse Weimaraner. Diplomarbeit, Universität Hamburg.

Eckersdorf B, Golebiewski H, Konopacki J (1996): Kainic acid versus carbachol induced emotional-defensive response in the cat. Behaviour and Brain Research **77**, 201-210.

Eibl-Eibesfeld I (1987): Grundriss der vergleichenden Verhaltensforschung. Piper, München, Zürich.

Falconer DS (1984): Einführung in die quantitative Genetik. Ulmer Verlag, Stuttgart.

Fatjó J (2001): Impulsivity in dogs – assessment and treatment. World Small Animal Veterinary Association, 26th World Congress, Vancouver. Proceedings, 89-90.

Feddersen-Petersen DU (1988): Sozialspiele bei einigen Wildcaniden und Haushunden – spezifisches Gruppen- und Kommunikationsverhalten in statu nascendi. Effem-Forschung für Heimtiernahrung, Report **27**, 1-19.

Feddersen-Petersen DU (1992): Hunde und ihre Menschen. Franck-Kosmos, Stuttgart.

Feddersen-Petersen DU (1994a): Vergleichende Aspekte der Verhaltensentwicklung von Wölfen und Haushunden verschiedener Rassezugehörigkeit: neue Ergebnisse und Ausblicke zur Ontogenese und Phylogenese sowie der Domestikation und Züchtung im ethischen Aspekt. In: Verhalten, Informationswechsel und organismische Evolution. Zu Person und Wirken Günther Tembrocks, Ed. Wessel KF und Naumann F. Berliner Studien zur Wissenschaftsphilosophie & Humanontogenetik. Bd.7. Kleine Verlag, Bielefeld.

Feddersen-Petersen DU (1994b): Fortpflanzungsverhalten beim Hund. Gustav Fischer, Jena, Stuttgart.

Feddersen-Petersen DU (1994c): Ethologische Untersuchungen zu Fragen des Normalverhaltens, zur Ermittlung sozialer Umweltansprüche und zur Präzisierung des Begriffes der "tiergerechten Haltung" von Haushunden. Kleintierpraxis **39**, 669-684.

Feddersen-Petersen DU (1995): Interactions of dog and owner: Inter- and intraspecific communication? 2nd ESVCE-Symposium, Braunschweig.

Feddersen-Petersen DU (1996): Verhaltensstörung beim Hund und ihre Behandlung. Der Praktische Tierarzt **77**, 1068-1080.

Feddersen-Petersen DU (2004): Hundepsychologie – Sozialverhalten und Wesen, Emotionen und Individualität. Kosmos Verlag Stuttgart.

Feddersen-Petersen DU, Hoffmeister U (1990): Untersuchungen zur Verhaltensentwicklung zweier Retrieverrassen Report-Dossier, Effem-Forschung für Heimtiernahrung.

Feddersen-Petersen DU, Ohl F (1995): Ausdrucksverhalten beim Hund. Gustav Fischer, Jena, Stuttgart.

Filipenko ML, Alekseyenko OV, Beilina AG, Kamynina TO, (2001): Increase of tyrosine hydroxylase and dopamin transporter mRNA levels in ventral tegmental area of male mice under influence of repeated aggression experience. Brain Research and Molecular Brain Research **96**, 77-81.

Filipenko ML, Beilina AG Alekseyenko OV, Dolgov VV, Kudryavtseva NN (2002): Repeated experience of social defeats increases serotonin transporter and monoamine oxidasa A mRNA levels in raphe nuclei of male mice. Neurological Science Letters **321**, 25-28.

Fisher GT, Volhard W (1985): Puppy personality profile. Purebred Dogs – American Kennel Gazette, 3/1985, 36-42.

Fleig D (1983): Kampfhunde II. Kynos, Mürlenbach/Eifel.

Flynn JP (1967): The neural basis of aggression in cats. In: Neurophysiology and Emotion, Ed. Glass DC. Rockefeller University Press, New York, 40-60.

Flynn JP, Vanegas H, Foote W, Edwards S (1970): Neural mechanisms in a cat´s attack on a rat. In: The neural control of behaviour; Ed.: R.F.Whalen et al., Academic Press, New York.

Fox MW (1971a): Behaviour of wolves, dogs and related canids. Jonathan Cape, London.

Fox MW (1971b): Socio-infantile and socio-sexual signals in Canids: a comparative and ontogenetic study. Zeitschrift für Tierpsychychology **28**, 185-210.

Fox MW (1972): Socio-ecological implications of individual differences in wolf litters: a developmental and evolutionary perspective. Behaviour **41**, 298-313.

Fox MW, Stelzner D (1966): Behavioural effects of differential early experience in the dog. Animal Behaviour **14**, 273-281.

Frank H, Frank MG (1982): On the effects of domestication on canine social development and behavior. Applied Animal Ethology **8**, 507-525.

Freak MJ (1968): Abnormal behaviour during pregnancy and parturition in the bitch. In: Abnormal behaviour in Animals, Ed. Fox MW. WB Saunders, Philadelphia, 464-475.

Freedman DG, King JA, Elliot O (1961): Critical periods in the social development of dogs. Science **133**, 1016-1017.

Freud S (1950): Gesammelte Werke. Imago Publishers, London.

Friedmann E (1995): The role of pets in enhancing human well-being: physiological effects. In: The Waltham Book of Human-Animal Interaction: Benefits and responsibilities of pet ownership; Ed. Robinson, I. Pergamon Press; 33-54

Galef BG (1970): Stimulus novelty as a factor in the intraspecific pain-associated aggression of domesticated rats. Psychoneuronic Science **18**. 21.

Gallup GG (1965): Aggression in rats as a function of frustrative nonreward in a straight alleyway. Psychoneuronic Science **3**, 99-100.

Gattermann R (1993): Wörterbücher der Biologie: Verhaltensbiologie. UTB-Gustav Fischer, Jena.

George EC (1995): Beitrag zur frühen Verhaltensontogenese von Bullterriern. Dissertation, Universität Hannover.

Goddard ME, Beilharz RG (1982): Genetic and environmental factors affecting the suitability of dogs as guide dogs for the blind. Theoretical and Applied Genetics **62**, 97-102.

Goddard ME, Beilharz RG (1984): A factor analysis of fearfulness in potential guide dogs. Applied Animal Behaviour Science **12**, 253-265.

Goddard ME, Beilharz RG (1985): A multivariate analysis of the genetics of fearfulness in potential guide dogs. Applied Animal Behaviour Science **15**, 247-260.

Goodwin D, Bradshaw JWS, Wickens SM (1997). Paedomorphosis affects agonistic visual signals of domestic dogs. Animal Behaviour **53**, 297-304.

Gordon JF (1973): The Bull Terrier. Gifford, London.

Graeff FG, Quintero S, Gray JA (1980): Median raphe stimulation, hippocampal theta rythm and threat-induced behavioural inhibition. Physiology of Behaviour **25**, 253-261.

Gramm U (1999): Beitrag zur frühen Verhaltensontogenese der Hunderasse Fila Brasileiro. Inauguraldissertation, Universität Hannover.

Gray JA (1987): The psychology of fear and stress. Cambridge University Press.

Gray JA, Buffery AWH (1971): Sex differences in emotional and cognitive behaviour in mammals including Man: adaptive and neural bases. Acta Psychologica **35**, 89-111.

Gwatkin RDS (1934): Dogs and human migrations. Journal of the South African Veterinary Medical Association **5**, 39.

Guy NC, Luescher UA, Dohoo SE, Spangler E, Miller JB, Dohoo IR, Bate LA (2001a): Demographic and aggressive characteristics of dogs in a general veterinary caseload. Applied Animal Behaviour Science **74**, 15-28.

Guy NC, Luescher UA, Dohoo SE, Spangler E, Miller JB, Dohoo IR, Bate LA (2001b): Risk factors for dog bites to owners in a general veterinary caseload. Applied Animal Behaviour Science. **74**, 29-24.

Hamilton WD (1964): The evolution of social behaviour. Journal of Theoretical Biology **7**, 1-52.

Hare B, Tomasello M (2005): Human-like social skills in dogs? Trends in Cognitive Science **9** (9), 439-444.

Hart BJ (1976): Canine behaviour. Canine Practice **2**, 10-14.

Hart BJ (1981): Effects of neutering and spaying on the behaviour of dogs and cats: questions and answers about practical concerns. Journal of the American Veterinary Medical Association **198**, 1204-1205.

Hart BL, Hart LA (1985): Canine and feline behavioral therapy. Lea and Febiger, Philadelphia.

Haskell MJ, Coerse NCA, Forkman B (1999): Frustration-induced aggression: the effects of thwarting access to food and water in the domestic hen. Proceedings of the 33rd International Congress of the International Society for Applied Ethology, Lillehammer, 119.

Hawley TC (1957): The Rhodesian Ridgeback. The origin, history and standard of the breed. Published by the author, Allíwal North, South Africa.

Hayes JG, Daley MF, Chenmey CD (1969): Effects of induced aggression on a low fixed-ration schedule of food reinforcement. Psychoneuronal Science **17**, 259-260.

Hebb DO (1946): On the nature of fear. Psychological Review **53**, 259-276.

Hediger H (1950): Wild animals in captivity. Butterworth, London.

Herre W, Röhrs M (1990): Haustiere – zoologisch gesehen. Fischer, Stuttgart, new York

Hessing MJC, Hagelso AM, Schouten WGP, Wiepkema PR, van Beek JAM (1994): Individual behavioural and physiological strategies in pigs. Physiology of Behaviour **55**, 39-46.

Hewson CJ, Luescher UA (1996): Compulsive disorders in dogs. In: Eds. Voith VL & Borchelt PL, Readings in Companion Animal Behavior. Veterinary Learning systems, Philadelphia.

Heine C (2000): Verhaltensontogenese von Welpen der Rasse Border Collie in den ersten acht Lebenswochen. Inauguraldissertation, Universität Hannover.

Hinde RA (1970): Animal behaviour: a synthesis of ethology and comparable psychology. McGraw-Hill, New York.

Hinde RA (1973): Das Verhalten der Tiere. Suhrkamp Verlag, Frankfurt am Main.

Hiby E, Rooney NJ, Bradshaw JWS (2004): Canine training methods: their use, effectiveness and interaction with domestic dog behaviour ands welfare. Proceedings; International Society for Anthrozoology (ISAZ), 13th conference, Glasgow.

Hollander E, Rosen J (2000): Impulsivity. Journal of Psychopharmacology **14**, (Supplements), S 39-44.

Hollis KL (1984): The biological function of Pavlovian conditioning: the best defense is a good offense. Journal of Experimental psychology: Animal behaviour Processes **10**, 413-425.

Holst E von (1957): Die Auslösung von Stimmungen bei Wirbeltieren durch "punktförmige" elektrische Erregung des Stammhirns. Die Naturwissenschaften **44**, 549-551.

Horisberger U (2002): Medizinisch versorgte Hundebissverletzungen in der Schweiz. Opfer – Hunde – Unfallsituationen. Inauguraldissertation, Universität Bern.

Hutchinson RR, Azrin NH, Hunt GM (1968): Attack produced by intermittent reinforcement of a concurrent response. J Journal of the Experimental Analysis of Behaviour **11**, 489-495.

Hutchinson RR, Renfrew JW, Young GA (1971): Effects of long-term shock and associated stimuli on aggressive and manual responses. Journal of the Experimental Analysis of Behaviour **15**, 141-166.

Immelmann K, Barlow GW, Petrinovich L, Main M (1982): Verhaltensentwicklung bei Mensch und Tier: Ergebnisse und Ausblicke. In: Verhaltensentwicklung bei Mensch und Tier. Das Bielefelder Projekt. Ed. Immelmann K. Paul Parey, Berlin.

Immelmann K, Pröve E, Sossinka R (1996): Einführung in die Verhaltensforschung. Blackwell Wissenschafts-Verlag, Berlin, Wien.

IVH (2002): Industrieverband Heimtierbedarf, Pressedienst.

Jagoe A, J Serpell (1996): Owner characteristics and interactions and the prevalence of canine behaviour problems. Applied Animal Behaviour Science **47**, 31-42.

Jeffreys MDW (1953): The origin of the Rhodesian Ridgeback, Africana Notes and News **XI** (1).

Jones AC, Gosling SD (2005): Temperament and personality in dogs (Canis familiaris): A review and evaluation of past research. Applied Animal Behaviour Science **95**, 1-55.

Juhr NC, Brand U, Behne D (2003): Zinkstoffwechsel – ein Faktor bei Aggressionsverhalten des Hundes? Berliner Münchner Tierärztliche Wochenschrift **116**, 265-268.

Kenttämies H, Nordrum NV, Brenoe UT, Smeds K, Johannessen KR, Bakken M (2002): Selection for more confident foxes in Finland and Norway: Heritability and selection response for confident behaviour in blue foxes (*Alopex* lagopus). Applied Animal Behaviour Science **78**, 67-82.

Kiley-Worthington M (1987): Pferdepsyche – Pferdeverhalten. Müller-Rüschlikon, Cham/Zug.

Kizer KW (1979): Epidemiological and clinical aspects of animal bite injuries. JACEP, **8**, 134-141.

Knutson JF (1970): Aggression during the fixed-ratio and extinction components of a multiple schedule of reinforcement. Journal of the Experimental Analysis of Behaviour **13**, 221-223.

Konorski J (1967): Integrative activity of the brain: an interdisciplinary approach. Chicago University Press.

Koolhaas JM, Van den Brink THC, Roozendaal B, Boorsma F (1990): Medial amygdala and aggressive behaviour: Interaction between testosterone and vasopressin. Aggressive Behaviour **16**, 223-229.

Krebs JR, Davies NB (1996): Einführung in die Verhaltensökologie. Blackwell Wissenschafts-Verlag, Berlin, Wien.

Kreiner M (1989): Untersuchungen von Leistungs- und Wesensparametern von Vorstehhunden. Dissertation, Universität Gießen.

Kudryavtseva NN (2000): Agonistic behaviour: a model, experimental studies, and perspectives. Neuroscience and Behavioral Physiology **30**, 293-305.

Kudryavtseva NN, Bondar NP (2002): Anxiolytic and anxiogenic effects of diazepam in male mice with different experience of aggression. Bulletin of Experimental Biology and Medicine **133**, 372-376,

Kudryavtseva NN, Bondar NP, Alekseyenko OV (2000): Behavioural correlates of learned aggression in mice. Aggressive Behaviour **26**, 386-400.

Kudryavtseva NN, Bondar NP, Avgustinovich DF (2002): Association between experience of aggression and anxiety in male mice. Behaviour and Brain Research **133**, 83-93.

Kuhne F, Struwe P (2005): Auffällig gewordene Hunde in Berlin und Brandenburg – ihre Repräsentanz in offiziellen Statistiken und in der Hundepopulation", Proceedings DVG-Kongress, Nürtingen, 24.02.2005.

Kung C, Chang SY, Satow Y, Van Houten J, Hansma H (1975): genetic dissection of behaviour in Paramecium. Science **188**, 898-904.

Lack D (1939): The behaviour of the robin. Parts I and II. Proceedings of the Zoological Society of London A **109**, 169-219.

Lagerspetz K (1964): Studies on the aggressive behaviour of mice. Annals of the Finnish Academy of Science B **131**, 3.

Land Brandenburg, Ministry of Inner Affairs (2000): Letter to the German Ministry of Inner Affairs, concerning dog bite incidents; 30.11.2000.

Landsberg G, Hunthausen W, Ackermann L (1997): Canine Aggression. In: Handbook of behaviour problems of the dog and cat. Butterworth-Heinemann, Oxford.

Legrand R, Fielder R (1973): Role of dominnace submission relationships in shock-induced fighting of mice. Journal of Comparative Physiology and Psychology **82**, 501-506.

Leyhausen P (1982): Tierschutz-Thesen. In: Ethologische Aussagen zur artgerechten Nutztierhaltung. Tierhaltung **13**, 7-12.

Liebermann DA (2000): Learning, behaviour and cognition. Brooks/Cole, Pacific Grove, Ca.

Lindsay SR (2000): Handbook of applied dog behaviour and training, Vol I. Iowa State University Press.

Lindsay SR (2001): Handbook of applied dog behaviour and training, Vol II. Iowa State University Press.

Linnoila VM, Virkkunen M (1992): Aggression, suicidality and serotonin. Journal of Clinical Psychiatry **53**, 46-51

Lockwood R (1979): Dominance in wolves: useful construct or bad habit? In: The Behaviour and Ecology of Wolves, Ed. E.Klinghammer, Garland STPM, New York, 225-244.

Lockwood R, Rindy K (1987): Are "pit bulls" different? An analysis of the pit bull terrier controversy. Anthrozöos **1**, 2-8.

Lorenz K (1964): Das sogenannte Böse; Zur Naturgeschichte der Aggression. Borotha-Schoeler, Wien.

Luescher AU, McKeown DB, Halip J (1991): Stereotypic or obsessive-compulsive disorders in dogs and cats. Veterinary Clinic of North America: Small Animal Practice **21**, 401-413.

Lund JD, Agger JF, Vestergaard KS (1996): Reported behaviour problems in pet dogs in Denmark: age distribution and influence of breed and gender. Preventive Veterinary Medicine. **28**, 33-44.

Lundberg U (1987). "Soziometrie biologischer Dominanzstrukturen." Biologische Rundschau 25: 355-368.

Lundberg U (1988). "Aspekte des Bindungsbegriffes in der Verhaltensbiologie." Zoologisches Jahrbuch für Physiologie **92**, 417-428.

Lyon DO, Ozolins D (1970): Pavlovian conditioning of shock-elicited aggression: A discrimination procedure. Journal of the Experimental Analysis of Behaviour **13**, 325-331.

MacDonald K (1987): Development and stability of personality characteristics in pre-pubertal wolves: implications for pack organisation and behaviour. In: Man and Wolf: Advances, Issues and Problems in Captive Wolf research, Ed. Frank H. Dr.W.Jung Publication, Dordrecht, 293-312.

Macfarland DJ (1966): The role of attention in the disinhibition of displacement activity. Quart. Journal of Experimental Psychology **18**, 19-30.

Mackenzie SA, Oltenacu EAB, Houpt KA (1986): Canine behavioural genetics – a review. Applied Animal Behaviour Science. **15**, 365-393.

Mark VH, Ervin FR, Sweet WH (1972): Deep temporal lobe stimulation in man. In: The neurobiology of the amygdala, Ed. Eleftheriou E, Plenum Press New York, 485-507.

Marler P (1956): Studies of fighting in chaffinches. (3) Proximity as a cause of aggression. Animal Behaviour **4**, 23-30.

Marshall I, Weistock M (1971): Quantitative method for assessing one symptom of the withdrawal syndrome in mice after chronic morphine administration. Nature **234**, 223-224.

Martin P, Bateson P (1996): Measuring Behaviour. An introductory guide. Cambridge University Press.

Matthewson S (1961): Gonadotropic hormones affect aggressive behaviour in starlings. Science **134**, 1522-1523,

Mayford M, Abel T, Kandel ER (1995): Transgenic approaches to cognition. Current Opinion in Neurobiology **5**, 141-148.

Maynard-Smith J (1982): Evolution and the theory of games. Cambridge University Press, Cambridge.

McConnel PB (2002): The other end of the leash. Ballantine Books, New York.

Mech LD (1970): The wolf: the ecology and behaviour of an endangered species. Natural History Press, New York.

Mech LD (1999): Alpha-status, dominance and job-sharing in a pack of wolves (Canis lupus). Canadian Journal of Zoology **77**, 1196-1203.

Melzack R, Wall PD (1996): The challenge of pain. Penguin, Harmondsworth.

Menzel R, Menzel R (1937): Welpe und Umwelt. Zeitschrift für Hundeforschung **3**, 1-65.

Meric SM (1989): Diagnosis and management of feline hyperthyroidism. Compendium of Continuous Education in Practical Veterinary Medicine **11**, 1980-1982.

Mertens PA, Dodman ND (1996): Die Diagnose von Verhaltensproblemen bei Hund, Katze, Pferd und Vogel: Charakteristika von 323 Fällen (Juli 1994-Juni 1995); Teil I: Hund. Kleintierpraxis **41**, 197-206

Miczek KA, Weerts EM, Vivian JA, Barros HM (1995): Aggression, anxiety and vocalisation in animals: $GABA_A$ and 5-HT anxiolytics. Psychopharmacology **121**, 38-56.

Mittmann A (2002): Untersuchung des Verhaltens von 5 Hunderassen und einem Hundetypus im Wesenstest nach den Richtlinien der Niedersächsischen Gefahrtierverordnung vom 05.07.2000. Dissertation, Tierärztliche Hochschule Hannover.

Moyer KE (1968): Kinds of aggression and their physiological basis. Communications in Behavioural Biology Part A **2**, 65-87.

Moyer KE (1987): Violence and aggression. Paragon House, New York.

Mugford RA, Novell NW (1971): Endocrine control over production and activity of the anti-aggression pheromone from female mice. Journal ofEndocrinology **49**, 225-232.

Murphree OD, Angel C, DeLuca DC, Newton JEO (1977): Longitudinal studies of genetically nervous dogs. Biological Psychiatry **7**, 23-29.

Myles S (1991): Trainers and chokers: how dog trainers affect behaviour problems in dogs. Veterinary Clinics of North America: Small Animal Practice **21**, 239-246.

Neilson JC, Eckstein RA, Hart BL (1997): Effects of castration on problem behaviours in male dogs with reference to age and duration of behaviour. Journal of the American Veterinary Medical Association **211**, 180-182.

Nelson RJ, Demas GE, Huang PL, Fishman MC, Dawson VL, Dawson TM, Snyder SH (1995): behavioural abnormalities in male mice lacking neuronal nitric oxide synthase. Nature **378**, 383-386.

Netto WJ, Planta DJU (1997): Behavioural testing for aggression in the domestic dog. Applied Animal Behaviour Science **52**, 243-265.

NMELF (2000): Niedersächsisches Ministerium für Ernährung, Landwirtschaft und Forsten: Wesenstest für Hunde. http://www.ml.niedersachsen.de/master70,,C746785_DO_0655,00html

NMELF (2003): Niedersächsisches Ministerium für Ernährung, Landwirtschaft und Forsten: Niedersächsisches Gesetz über das Halten von Hunden (NhundG). Nds. GVBL, 367.

Ödberg FO (1986): The jumping stereotypy in the bank vole (*Clethrionomys* glareolus). Behaviour Processes **14**, 155-173.

O'Farrel V (1986): Manual of Canine Behaviour. BSAVA Publications, Cheltenham, Glos.

O'Farrel V, Peachy E (1990): Behavioural effects of ovariohysterectomy on bitches. Journal of Small Animal Practice **31**, 595-598.

Okarma H (1997): Der Wolf: Ökologie, Verhalten, Schutz. Parey, Berlin.

Osthaus B, Lea SE, Slater AM (2004): Dogs (Canis lupus familiaris) fail to show understanding of means-end connections in a string-pulling task. Animal Cognition online. http://www.springerlink.com/app/home/contribution.

Overall KL (1995): Sex and aggression. Canine Practice **20(3)**, 16-18.

Overall KL (1997): Canine Aggression. In: Clinical Behavioural Medicine for Small Animals. Mosby, St. Louis.

Overall KL (2001): Drugs, aggression and anxiety: a rational and humane approach. World Small Animal Veterinary Association, 26th World Congress, Vancouver, Proceedings, 85-88.

Overall KL, Love M (2001). "Dog bites to humans - demography, epidemiology, injury and risk." Journal of the American Veterinary Medical Association **218**, 1923-1934.

Panksepp J (1998): Affective neuroscience: the foundation of human and animal emotions. Oxford University Press, Oxford.

Pavlov IP (1927): Conditioned reflexes (Transl. Anrep GV). Oxford University Press.

Peeke HVS, Herz MJ, Gallagher JE (1971): Changes in aggressive interaction in adjacently territorial convict cichlids Chichlasoma nigrofasciatum: A study of habituation. Behaviour **40**, 43-54.

Peeke HVS, Veno A (1973): Stimulus specificity of habituated aggression in the stickleback Gasterosteus aculeatus. Behavioural Biology **8**, 427-432.

Pentürk S, Yalcin E (2003): Hypochoilesterolaemia in dogs with dominance aggression. Journal of Veterinary Medicine **50**, 339-342.

Pfaffenberger JC (1963): The new knowledge of dog behaviour. Howell Book House, New York.

Pfaffenberger JC, Scott JP, Fuller JL, Ginsberg BE, Bielfelt SW (1976): Guide dogs for the blind: their selection, development, and training. Elsevier, Amsterdam-Oxford-New York.

Pfleiderer-Högner M (1979): Möglichkeiten der Zuchtwertschätzung beim Deutschen Schäferhund anhand der Schutzhundprüfung I. Dissertation, Ludwig-Maximilians- Universität, München.

Planta DJU (2001): testing dogs for aggressive biting behaviour: The MAG-test (sociable acceptable behaviour test) as an alternative for the Aggression-test. Proceedings of the Third International Congress on Veterinary Behavioural Medicine. Vancouver, Canada,142-144.

Planta DJU, Netto WJ (1999): Behavioural testing for aggression in the domestic dog. Proceedings of the Second World Meeting on Ethology, Lyon, 18-27.

Plomin R (1982): Behavioural-genetics and temperament. Ciba Foundation Symposia **89**, 155-167.

Podberscek AL (1994): Dog on a tightrope: The position of the dog in British society as influenced by press reports on dog attacks (1988-1992). Anthrozoös **7**, 232-241.

Podberscek AL (1995). Rage syndrome and the English Cocker Spaniel. 2nd ESVCE Symposium, Braunschweig.

Podberscek AL (1996): Aggression and the English Cocker Spaniel. Companion Animal Behaviour Study Group, Newsletter 13.

Podberscek AL (1997): Dominance aggression versus rage: Diagnose und Therapie. ATF-Seminar Verhaltenstherapie bei Hund und Katze, Bonn

Podberscek AL, Blackshaw J (1991): Dog attacks on children. Report from two major city hospitals. Australian Veterinary Journal **68**, 248-249.

Poole TB (1973): The aggressive behaviour of individual polecats *Mustela putorius, M. furo*, and hybrids towards familiar and unfamiliar opponents. Journal of Zoology **170**, 395-414.

Preuschoft S, van Schaik CP (2000): Dominance and communication; conflict management in various social settings. In: Natural Conflict Resolution, Eds. Aureli P, De Waal FBM. University of California Press, 77-105.

Pusey AE, Packer C (1992): Infanticides in lions. In: Infanticide and Parental Care. Ed. Parmigiani S, vom Saal F, Svare B. Harwood Academic Press, London.

Quatermain D, Stone EA, Charbonneau G (1996): Acute stress disrupts risk assessment behaviour in mice. Physiol. Behaviour **59**, 937-940.

Räber H (2001): Enzyklopädie der Rassehunde. Band I und II. Kosmos-Verlag, Stuttgart.

Raiser H (1979): Der Schutzhund. Die Ausbildung von Gebrauchshunden für den Schutzdienst. Paul Parey Verlag, Berlin.

Redlich, J. (1998): Verhaltensontogenese von Haushunden ( Canis lupus f. familiaris) der Rasse American Stafforshire Terrier. Dissertation, Universität Hannover.

Redmond DE, Huang YH (1979): New evidence for a locus coeruleus norepinephrin connection with anxiety. Life Science **25**, 2149-2162.

Reid PJ, Penny N (2001): Predicting canine behaviour through early assessment. Proceedings of the Third International Congress on Veterinary Behavioural Medicine. Vancouver, Canada, 92-95.

Reisner I (1991): The pathophysiologic basis of behaviour problems. Veterinary Clin. North Am. Adv. Comp. Animal Behaviour **21**, 207-224.

Reynolds GS, Catania AC, Skinner BF (1963): Conditioned and unconditioned aggression in pigeons. Journal of the Experimental Analysis of Behaviour **6**, 73-74.

Riesenberg S, Tittmann A (2003): Verhaltenstest zur Darstellung der Auswirkungen von Haltungs- und Aufzuchtbedingungen in einem Hundehandelsbetrieb auf die Sozialisation und Habilitation von Hundewelpen – Betrachtung unter tierschutzrechtlichen Aspekten. Kleintierpraxis **48**, 317-388.

Roberts CL, Blase K (1971): Elicitation and punishment of intraspecific aggression by the same stimulus. Journal of the Experimental Analysis of Behaviour **15**, 193-196.

Robinson I (1995): Associations between man and animals. In: The Waltham Book of Human-Animal Interaction: Benefits and responsibilities of pet ownership; Ed. Robinson I. Pergamon Press; 1-6

Rogers J, Hart LA, Boltz RP (1993): The role of pet dogs in casual conversations of elderly adults. Journal of Social Psychology **133**, 265-277.

Roll A (1994): Aggressive Auseinandersetzungen unter Hunden – eine Analyse der Täter, Opfer und Halter. Dissertation, Universität München.

Roll A, Unshelm J (1997): Aggressive conflicts among dogs and factors affecting them. Applied Animal Behaviour Science. **52**, 229-242.

Rolls ET (1999): The brain and emotion. Oxford University Press.

Rooney NJ (1999): Play behaviour of the domestic dog, Canis familiaris, and its effect upon the dog-human relationship. PhD-thesis, University of Southampton

Rooney NJ, Bradshaw JWS (2002): An experimental study of the effects of play upon the dog-human relationship. Applied Animal Behaviour Science. **75**, 161-176.

Rooney NJ, Bradshaw JWS, Robinson IH (2000): A comparison of dog-dog and dog-human play behaviour. Applied Animal Behaviour Science. **66**, 235-248.

Rooney NJ, Gaines SA, Bradshaw JWS (2003): How predicitve are puppy tests?: Evidence from a puppy walking programme for military search dogs. Proceedings of the 37$^{th}$ International Congress of the ISAE, Abano Therme, Italy, 41.

Rottenberg S (2000): Vergleichende Untersuchung zum Sozialverhalten einer Gruppe von Pudelwölfen in der zweiten Nachzuchtgeneration. Dissertation, Veterinärmedizinische Fakultät der Universität Bern.

Ruefenacht S, Gebhardt-Henrich S, Miyake T, Gaillard C (2002): A behaviour test on German shepherd dogs: heritability of seven different traits. Applied Animal Behaviour Science. **79**, 113-132.

Sacks JJ, Sinclair L, Gilchrist J, Golab GC, Lockwood R (2000). "Breeds of dogs involved in fatal human attacks in the United States between 1979 and 1998." Journal of the American Veterinary Medical Association **217,** 836-840.

Saudou F, Amara DA, Dierich A, LeMeur M, Ramboz S, Segu L, Buhot MC, Hen R (1994): Enhanced aggressive behaviour in mice lacking 5-$HT_{1B}$ receptor. Science **265,** 1875-1878.

Schenkel R (1947): Ausdrucksstudien an Wölfen. Behaviour **1,** 81-129.

Schenkel R (1967): Submission: its features and function in the wolf and the dog. American Zoologist **7,** 319-329.

Schenker C (1982): Welpentests – ein Blick in die Zukunft? Schweizer Hundesport **98,** 402-409.

Schleger A (1983): Geschichte und Entwicklung des Bullterriers. Genetisch begründete Fitneßminderung einer einseitig gezeüchteten Hunderasse. Dissertation, Universität Wien.

Schmidt HD (1957): Zur Sozialpsychologie des Haushundes. Zeitschrift für Psychologie **161,** 255-281.

Schoenecker B, Heller KE (2001): Indication of a genetic basis of stereotypies in laboratory-bred bank voles (*Clethrionomys* glareolus). Applied Animal Behaviour Science. **68,** 339-347.

Schöning B (2000a): Behavioural ontogenesis of the Rhodesian Ridgeback. Masters Thesis, University of Southampton.

Schöning B (2000b):Warum beißt der Hund? Eine Übersicht zum Aggressionsverhalten von Hunden. Deutsches Tierärzteblatt **48,** 904-913.

Schöning B (2000c): Tests zum Lernverhalten und Frustrationsverhalten. Wesenstest für Hunde. Niedersächsisches Ministerium für Ernährung, Landwirtschaft und Forsten, Hannover.

Schulte W (1988): Die Bullterrier. Albrecht Philler, Minden

Schwaibold U, Pillay N (2001): Stereotypic behaviour is genetically transmitted in the African striped mouse *Rhabdomys* pumilio. Applied Animal Behaviour Science. **74,** 273-280.

Scott JP (1950): The social behaviour of dogs and wolves: An illustration of socialbiological systematics. Annals of the New York Academy of Sciences **51,** 1009-1021.

Scott JP (1960): Aggression. Chicago University Press.

Scott JP, Fuller JL (1965): Genetics and the social behavior of dogs. University of Chicago Press, Chicago, London.

Scott JP, Marston M (1950): Critical periods affecting the development of normal and maladjustive behaviour in puppies. Journal of Genetic Psycology. **77**, 26-60

Scott JP, Stewart JM, DeGhett VJ (1974): Critical periods in the organisation of systems. Developmental Psychobiology **7**, 489-513.

Seiferle EL (1972): Wesensgrundlagen und Wesensprüfungen des Hundes. Schweizer Kynologische Gesellschaft, Kaltbrunn.

Seiferle EL, Leonhardt E (1984): in Erni S, Druck AG (Eds.): Wesensgrundlagen und Wesensprüfungen des Hundes. Schweizer Kynologische Gesellschaft, Kaltbrunn.

Serpell J, Jagoe JA (1995): Early experience and the development of behaviour. In: The Domestic Dog, its evolution, behaviour and interactions with people. Ed. J. Serpell. Cambridge University Press, 79-103.

Serpell J, Hsu Y (2001): Development and validation of a novel method for evaluating behaviour and temperament in guide dogs. Applied Animal Behaviour Science **72**, 347-364.

Shermann CG, Reisner IR, Taliaferro LA, Houpt KA (1996): Characteristics, treatment and outcome of 99 cases of aggression between dogs. Applied Animal Behaviour Science **47**, 91-108.

Siegel A, Brutus M (1990): Neural substrates of aggression and rage in the cat. In: Progress in psychobiology and physiological psychology, Vol. 13; Eds. Eppstein AN, Morrison AR. San Diego Academic Press, 135-233.

Slabbert JM, Odendaal JSJ (1999): Early prediction of adult police efficiency – a longitudinal study. Applied Animal Behaviour Science **64**, 269-288.

Southwick CH (1967): An experimental study of intragroup agonistic behaviour in rhesus monkeys. Behaviour **28**, 182-209.

Spruijt BM, van den Bos R, Pijlman FTA (2001): A concept of welfare based on reward evaluating mechanisms in the brain: anticipatory behaviour as an indicator for the state of reward systems. Applied Animal Behaviour Science **72**, 145-171.

Squire LR, Kandel ER (1999): Gedächtnis: die Natur des Erinnerns. Spektrum Akademischer Verlag, Heidelberg, Berlin.

Stephen JM, Ledger RA (2003): Owners are reliable observers of their own dog's behaviour. Proceedings of the 37th International Congress of the ISAE, Abano Therme, Italy, 190.

Stur I, Kreiner M, Mayerhofen G (1989): Untersuchungen über die Beurteilung von Wesensmerkmalen des Hundes. Wiener Tierärztliche Monatsschrift **76**, 290-293.

Svartberg K (2002): Shyness-boldness predicts performance in working dogs. Applied Animal Behaviour Science. **79**, 157-174.

Svartberg K, Forkman B (2002): Personality traits in the domestic dog (*canis familiaris*). Applied Animal Behaviour Science. **79**, 133-155.

Swanson HH (1973): Sex differences in the agonistic behaviour of the Mongolian gerbil. Journal of Endocrinology **57**, 37-39.

Tabel C (1998): Der Jagdgebrauchshund. Erziehen, Abrichten und Führen. BLV-Verlagsgesellschaft, Stuttgart.

Takeuchi Y, Ogata N, Houpt KA, Scarlett J (2001): Differences in background and outcome of three behavior problems of dogs. Applied Animal Behaviour Science. **70**, 297-308.

Tellegen A, Horn JM, Legrand RG (1969): Opportunity for aggression as a reinforcer in mice. Psychoneuronic Science **14**, 104-105.

Theby V, Hares M (2003): Agility. Kosmos Verlag, Stuttgart

Thorne FC (1944): The inheritance of shyness in the dog. Journal of Genetic Psychology **65**, 275-279.

Tinbergen N (1963): The herring gull's world. Collins, London.

Tschanz B (1993): Erkennen und Beurteilen von Verhaltensstörungen mit Bezugnahme auf das Bedarfskonzept. Leiden und Verhaltensstörungen bei Tieren. C. Buchholtz, A. F. Goetschel, B. Hassenstein et al. Stuttgart, Birkhäuser Verlag: 65-76.

Ulrich RE (1966): Pain as a cause of aggression. American Zoologist **6**, 643-662.

Ulrich RE, Azrin NH (1962): Reflexive fighting in response to aversive stimulation. Journal of the Experimental Analysis of Behaviour **5**, 511-520.

Umlauf K (1993): Sozialbeziehungen innerhalb einer Gruppe von Pudelwölfen in der 2. Nachzuchtgeneration. Diplomarbeit, Universität. Kiel.

Van den Berg L, Schilder MBH, Knol BW (2003): Behavior genetics of canine aggression: behavioral phenotyping of Golden Retrievers by means of an aggression test. Behavioural Genetics **33** (5), 469-483.

Van de Poll NE, Smeet J, van Oyen HG, van der Swan SM (1982): Behavioural consequences of agonistic experiences in rats: sex differences and the effects of testosterone. Journal of Comparative Physiology and Psychology. **96**, 893-903.

Van de Poll NE, Taminiau MS, Endert E, Louwerse AL (1988): Gonadal steroid influence upon sexual and aggressive behaviour of female rats. International Journal of Neuroscience **41**, 271-286.

Vanderlip SL, Vanderlip JE, Myles S (1985): A socialising program for laboratory-raised canines. Laboratory Animal **14**, 33-36.

Van der Staay FJ, Steckler T (2002): The fallacy of behavioural phenotyping without standardisation. Genes, Brain and Behaviour **1**, 9-13.

Van Hoof JARAM, Wensing JAB (1987): Dominance and its behavioural measures in a captive wolf pack. In: Man and Wolf, Ed.H.Frank, Dr.W.Junk Publishers, Dordrecht, 219-251.

Van Oortmerssen GA, Bakker TCM (1981): Artificial selection for short and long attack latency in wild Mus musculus domesticus. Behavioural Genetics **11**, 115-126.

Van Oortmerssen GA, Benus RF, Slyter F (1992): Studies on wild house mice. IV: On the heredity of testosterone and readiness to attack. Aggressive Behaviour **18**, 143-148.

Van Oortmerssen GA, Busser J (1989): Disruptive selection on aggression as a possible force in evolution. In: House mouse aggression: a model for understanding the evolution of social behaviour. Eds. Brain PF, Mainardi D, Parmigiani S. Harwood Academic Publishers, Chur.

VDH Welpenstatistik (2003): In: VDH Geschäftsbericht zum Jahr 2003. VDH, Dortmund.

VDH Welpenstatistik (2004): In: VDH Geschäftsbericht zum Jahr 2004. VDH, Dortmund.

Venzl E (1990): Verhaltensentwicklung und Wesensmerkmale bei der Hunderasse Beagle. Dissertation, Universität München.

Vernon W, Ulrich RE (1966): Classical conditioning of pain-elicited aggression. Science **152**, 668-669.

Vilá C, Savolainen P, Malonado JE, Amorim IR, Rice JE, Honeycutt RL, Crandell KA, Lundeberg, J, Wayne RK (1997): Multiple and ancient origins of the domestic dog. Science **276**, 1687-1689.

Voith VL (1980): Intermale aggression in dog. Modern Veterinary Practice **61**, 256-258.

Voith VL (1981): Diagnosing dominance aggression. Modern Veterinary Practice **62**, 717-718.

Voith VL (1989): Behavioral disorders. In: Ettinger JS (Ed.), Textbook of veterinary internal medicine. WB Saunders, Philadelphia.

Voith VL, Wright JC, Danneman PJ (1992): Is there a relationship between canine behaviour problems and spoiling activities, anthopomorphism and obedience training? Applied Animal Behaviour Science. **34**, 263-272,

Von der Schulenburg A (2000): Auflistung der an Bissvorfällen beteiligten Hunderassen in Hamburg in den Jahren 1998 und 1999. Behörde für Arbeit, Gesundheit und Soziales, Hamburg, Vermerk G 8130/590-30.1/2.

Walker R (1997): Seasonal representation of cases of fighting between male and female dogs within the home. Gesellschaft für Tierverhaltenstherapie-Seminar, Wetzlar.

Weisse W (1990): Molosser. Kynos, Mürlenbach/Eifel.

Williams JL, Friend TH, Nevill CH, Archer G (2004): The efficiacy of a secondary reinforcer (clicker) during acquisition and extinction of an operant task in horses. Applied Animal Behaviour Science. **88**, 331-341.

Willis FN (1966): Fighting in pigeons relative to available space. Psychoneuronic Science **4**, 315-316.

Willis MB (1989): Genetics of the dog. Howell Book House, New York.

Willis MB (1991): The German shepherd dog: a genetic history. Witherby, London.

Willis MB (1995): Genetic aspects of dog behaviour with particular reference to working ability. In: The Domestic Dog, its evolution, behaviour and interactions with people. Ed. Serpell J. Cambridge University Press; 51-64.

Wilson CC, Netting FE (1987): The pet attitude inventory. Anthrozöos **1**, 76-84

Wilson D, Clark A, Coleman K, Dearstyne T (1994): Shyness and boldness in humans and other animals. Trends in Ecology and Evolution **9**, 442-446.

Wilsson E, Sundgren E (1997): The use of a behaviour test for the selection of dogs for servic and breeding. I: Method of testing and evaluation of test results in the adult dog, demands on different kinds of service dogs, sex and breed differences. Applied Animal Behaviour Science. **53**, 279-295.

Wilsson E, Sundgren E (1998): Behaviour test for 8-week old puppies – heritabilities of tested behaviour traits and its correspondence to later behaviour. Applied Animal Behaviour Science. **58**, 151-162.

Wolfe M, Ulrich R, Dulaney S (1971): Agonistic behaviour of organised and disorganised cotton rat populations. Science **160**, 98-99.

Woolpy JH, Ginsberg BE (1967): Wolf socialisation: a study of temperament in a wild social species. American Zooogist. **7**, 357-363.

Wright JC (1980): The development of social structure during the primary socialisation period in German Shepherds. Developmental Psychobiology **13**, 17-24.

Wright JC, Nesselrote MS (1987): Classification of behaviour problems in dogs: distribution of age, breed, sex and reproductive status. Applied Animal Behaviour Science **19**, 169-178.

Wynne-Edwards VC (1962): Animal dispersion in relation to social behaviour. Oliver and Boyd, Edinburgh.

Young MS (1985): What do "puppy tests" test? Paper presented at the annual meeting of the Animal Behaviour Society, Raleigh, NY.

Zahavi A (1979): Ritualisation and the evolution of movement signals. Behaviour **72**, 77-81.

Zimen E (1971): Wölfe und Königspudel. Piper, München.

Zimen E (1981): The Wolf: a species in danger. Delacorte Press, New York.

Zimen E (1988): Der Hund. Bertelsmann, München.

Zimen E (1990): Der Wolf. Verhalten, Ökologie und Mythos. Knesebeck und Schuler, München.