Possible implications of the presence of the raccoon dog (*Nyctereutes procyonoides*) in the Netherlands

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Abstract: The raccoon dog (*Nyctereutes procyonoides*) is not an indigenous species in Europe. Russians introduced the species into European parts of the former Soviet Union between 1929 and 1955 and the species has spread westward to other European countries ever since. Raccoon dogs are nowadays occasionally seen in the Netherlands. With this new species being present in the Netherlands, it is important to identify the consequent implications for ecosystem functioning in the Netherlands. In this paper, we make a first attempt to identify these implications. The raccoon dog is an opportunistic feeder, what makes this species rather insensitive to fluctuations in single food resources and reduces dietary overlap with fox and badger. As a vector of rabies and the fox tapeworm, the presence of raccoon dogs in the Netherlands might have consequences for wild and domestic animals, as well as for people. Additionally, *Trichinella* can be carried by raccoon dogs and this disease thus might reach the Netherlands. Mortality, starvation, hunting, disease and traffic accidents often include animal suffering and are thus animal welfare issues. Further investigations of ecological consequences of the presence of raccoon dogs in Dutch ecosystems will contribute to the management and conservation of natural areas in the Netherlands..

Keywords: raccoon dog, *Nyctereutes procyonoides,* alien species, exotic species, the Netherlands, nature conservation.

Introduction

The raccoon dog (*Nyctereutes procyonoides,* Gray 1834) is not an indigenous species in the Netherlands or Europe in general. However, after being introduced by Russians into European parts of the former Soviet Union, the species has spread westward (Kauhala 1999). Recently, raccoon dogs are present in western European countries, including the Netherlands; Dutch newspapers regularly report sightings and road kills of raccoon dogs (figure 1) (Kauhala 1999, Levie 2003, Anonymous 2007, Mulder & van der Giessen 2007, van den Akker & Nieuwenhuizen 2007). Although we need to be critical on these reports (Buys 2004, La Haye 2004), they led to discussions in the Dutch Parliament in July 2007 about the status of raccoon dogs in the Netherlands, as well as the need for research on this exotic species in the Netherlands. The last decade, progressively more interest is shown in exotic species, also in the Netherlands, for they possibly threaten indigenous species, as is the case in parts of Belgium (Van Den Berge 2008). This growing interest applies for example the common muskrat (*Ondatra zibethicus*) (e.g. Bos & Tuenter 2007, Gaaff et al. 2007) and the raccoon (*Procyon lotor*) (e.g. Lammertsma et al. 2008).

Although the raccoon dog is a well studied species outside central Europe, mainly in Finland and Japan, knowledge about its abundance level, biology and impact on ecosystems in central and western Europe remains scarce (Stier et al. 2003, Wittenberg et al. 2005). In Germany, for example, only until recently no specific data had been available on the species since it was first sighted in the 1960s (Stier et al. 2003). At this moment, the raccoon dog population is growing at an ex-

Figure 1. Regions where 90% of the raccoon dogs observed since 1990 in the Netherlands have been recorded. Altogether: 27 sightings ('not verified' included) and 31 found dead (after: Mulder & van der Giessen 2007).

tremely high rate (figure 2) (Goretzki & Sparing 2006, Zoller 2006), causing concerns for a strong negative influence on the indigenous fauna (Stier et al. 2003). During a five-year telemetry project in Vorpommern (Germany) many biological data of density, food, reproduction etc. are collected concerning their settlement as an exotic species in Germany (Stier 2006a, Stier 2006b).

Despite concerns in other countries regarding the implications of the presence of the raccoon dog for ecosystem functioning, the Dutch Minister of Agriculture, Nature and Food Quality states that no research on the raccoon dog's ecological impact will be initiated and the raccoon dog stays an unprotected species and hunting is allowed (Verburg 2007). For successful nature conservation, however, it is important to understand the potential influence of raccoon dogs on ecosystems that become, or already are, inhabited by raccoon dogs, as well as the consequent implications for management. In this paper, we therefore review literature on the biology and ecology of the raccoon dog and try to identify potential points of concern regarding the influ-

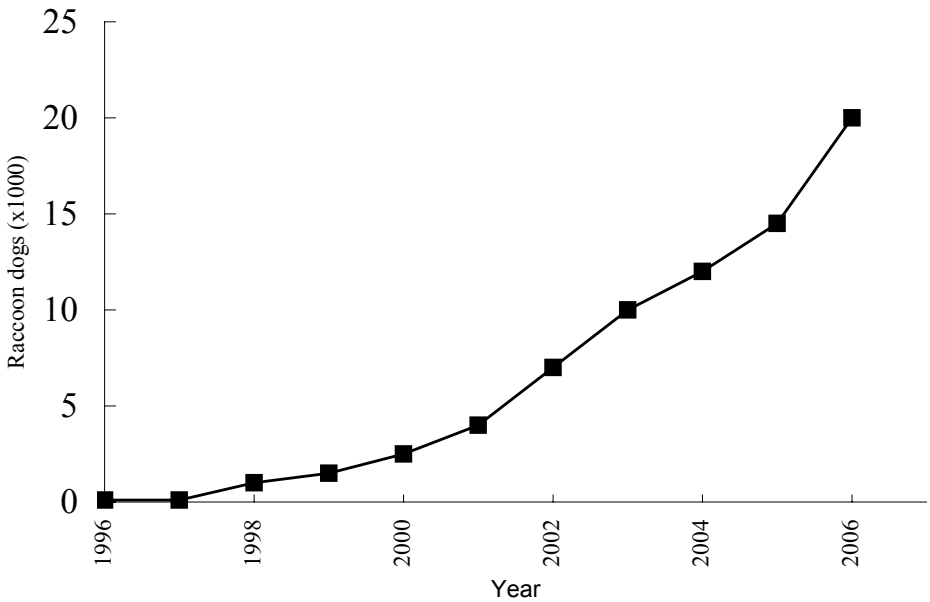

Figure 2. Growing number of raccoon dogs from 1992-2006 in Vorpommern, Germany (adapted from: Zoller 2006).

ence of raccoon dogs on ecosystem functioning in the Netherlands.

Geographical distribution

The raccoon dog originates from China, Korea, south-east Russia, north-east Indochina and Japan (Kauhala 1999). Russians introduced the subspecies *Nyctereutes procyonoides ussuriensis* (more than 9000 individuals) to the Ukraine, Belarus, Russia and Latvia between 1929 and 1955 (Kauhala 1999). The raccoon dog has subsequently spread to other European countries and is now also present in Moldova, Finland, Sweden, the Baltic States, Poland, Romania, Bosnia, Bulgaria, Hungary, Serbia, Germany, Norway, Denmark, France, Switzerland, Austria, Slovenia and the Netherlands (Helle & Kauhala 1991, Kauhala 1999).

The raccoon dog is a highly adaptable species and therefore lives in a variety of habitats. It inhabits both deciduous and coniferous forests, but prefers moist deciduous environments with some forest and thick vegetation and possible den sites in the near proximity of lakes and streams most (Novikov 1962, Corbet 1966, Kauhala 1999, Stier et al. 2003, Saeki & MacDonald 2004, Kauhala et al. 2006, Stier 2006a). The raccoon dog also lives near human settlements (Kauhala 1994, Stier et al. 2003), but avoids close human contact (Stier 2006a).

Social behaviour and reproduction

The raccoon dog is strictly monogamous, forming a pair for life (Corbet 1966, Helle & Kauhala 1993, Kauhala 1994, Stier et al. 2003, Kauhala et al. 2006, Stier 2006a). Male and female move together in their home range, mainly at night (Wittenberg et al. 2005), and share their winter den (Helle & Kauhala 1993). The home ranges of different pairs do not overlap and are stationary from year to year (Kauhala et al. 1993a, Holmala & Kauhala 2006). Latrines may act like landmarks (Ikeda 1984, Kauhala et al. 1998a).

In general, pregnancy lasts about two months and once a year the female gives birth to 5-8 cubs in June (Corbet 1966, Asikainen et al. 2002). The mean litter size in southern Finland and also in the original area in south east Asia is nine cubs (Helle & Kauhala 1995). Recent data from the North-East of Germany show an average of ten cubs per litter (Stier 2006a). Since energy requirements for nursing are high, the female usually forages, while the male stays in the den with the cubs, guarding and keeping them warm (Kauhala 1994, Kauhala et al. 1998b). The offspring leave the parental den by 4-5 months and attain sexual maturity at 9-11 months (Novikov 1962).

Reproduction in the raccoon dog is strongly affected by environmental factors, such as climate, length of the growing season and food availability, which affect body mass and fat reserves (Kauhala 1992, Kauhala 1994, Helle & Kauhala 1995). Especially in areas where the juveniles have enough time to gather fat reserves for hibernation, e.g. in temperate climate, a larger proportion of juveniles survives the winter and, when in a good condition, even breeds in the following spring, resulting in a rapid growth rate of the population (Helle & Kauhala 1991, Helle & Kauhala 1995, Thompson et al. 2006). In adult females, body condition mostly affects annual variation in litter size at birth; females with the largest amount of autumnal fat usually produce the most cubs (Helle & Kauhala 1995, Asikainen et al. 2002).

Diet composition

The raccoon dog is truly omnivorous (Kauhala et al. 1993b, Kauhala et al. 1998a) and its diet comprises a wide range of small rodents, ground-dwelling birds and bird eggs, carcasses, fish, insects (including members of *Hemiptera, Coleoptera, Diptera* and *Orthoptera*), earthworms, snails, plant material, berries, cereal grains, fruits, vegetables, hares, voles, shrews, frogs and lizards (Corbet 1966, Kauhala 1992).

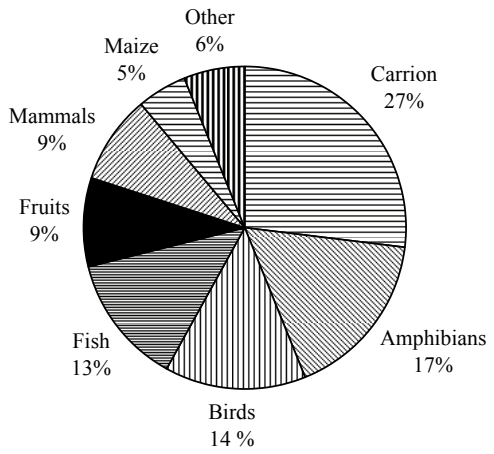

Figure 3. Biomass in 306 raccoon dog stomachs in north-east Germany (adapted from: Stier 2006a).

The diet composition of raccoon dogs differs geographically and temporarily (Kauhala 1992, Kauhala et al. 1993b). In Finland, small mammals are mainly eaten in spring and autumn when food is less abundant than in summer, while plants and birds are important food sources year-round (Kauhala et al. 1993b). Frogs and lizards are predominantly preyed on in late spring and early summer (Kauhala et al. 1993b, Stier 2006a).

Raccoon dogs are also capable of living near human settlements by utilizing man-made food resources, such as garbage cans (Kauhala 1994). This opportunistic and omnivorous foraging behaviour makes the species rather insensitive to fluctuations in single food resources, especially in areas near human settlements (Kauhala 1994). A recent record of the raccoon dog diet composition shows the variety and the importance of carrion, maize and amphibians (figure 3).

Food deprivation in winter

Seasonal changes in body weight are generally related to the availibilty of food. However, this cyclic pattern has also been observed in captive mammals with free access to food all year round (Le Magnen 1983). Farm raised raccoon dogs, having food freely available all year round, also lose their appetite in winter and body weight loss occur voluntary (Korhonen 1988).

Asikainen et al. (2002) studied the effects of food deprivation and hibernation and active winter feeding on the physiology and reproduction of farm-born raccoon dogs. Although food deprivation had no deleterious effects on the health of the study animals, food deprived females had more cubs compared to fed ones (Asikainen et al. 2002). Hence, Asikainen et al. (2002) postulate that the raccoon dog is finely adapted to a long period of food deprivation in winter.

Day length is the basic factor affecting the onset of winter lethargy in raccoon dogs (Kauhala et al. 2007). In Germany, raccoon dogs are known to be active throughout winter (Stier 2006a). Winters in Germany are milder compared to Finland and cold periods with snow are shorter and less frequent, probably shortening winter lethargy and interrupting hibernation (Kauhala et al. 2007).

Densities and competition

In north-east Poland the densities of the raccoon dogs, European badger (*Meles meles*) and the red fox (*Vulpes vulpes*) are 0.37, 0.36 and 0.27 per km², respectively (Goszczynski 1999). In southern Finland, red fox density was estimated to be 0.35 per km², but the density of the raccoon dog (0.76 km²) was higher (Holmala & Kauhala 2006). In Vorpommern (Germany) the density of raccoon dogs is 0.3-0.4 per km², in the preferred area up to 0.9 raccoon dogs per km² (Stier 2006a). Home ranges of red fox and raccoon dog show large overlap (Zoller 2006), although their habitat use is different. The red fox uses more the open areas, while the raccoon dog uses the covered and wet areas most (Zoller 2006). Based on a comparison of home ranges and densities of co-existing medium-sized carnivores, the raccoon dog density in Europe is generally in the same range and often higher than the badger and red fox density (Kauhala et al. 2006, van den Akker & Nieuwenhuizen 2007).

No severe competition for food has been observed between carnivores in Europe and the raccoon dog (Kauhala 1994). The diets of the red fox, European badger and the raccoon dog overlap to some extent, since all three species feed on small mammals, invertebrates, plants and carcasses, suggesting that competition may occur between them (Kauhala et al. 1998a). However, resource partitioning between these species reduces competition (Kauhala 1994, Zoller 2006), i.e. the badger consumes more invertebrates and the red fox more birds and vertebrates than the raccoon dog (Kauhala et al. 1998a) and the raccoon dog has more plants in its diet (Stier 2006a, Stier 2006b, Zoller 2006). Besides, in northern Europe, both the raccoon dog and European badger, with which the raccoon dog might compete most severely, hibernate, reducing competition for food in winter when food is most scarce (Kauhala 1994, Kauhala et al. 1998a, Kauhala 1999).

The red fox, badger and raccoon dog also compete for dens. The raccoon dog often uses old badger or fox dens (Stier 2006b), although both badger and fox tend to chase it away (Kauhala 1994). Raccoon dogs sometimes kill young red foxes and red foxes kill young raccoon dogs (Stier 2006b). Nonetheless, raccoon dogs are sometimes found in the same dens as badgers during the winter (Stier 2006b).

Predation

A study by Kauhala and Auniola (2001) on the diet of raccoon dogs on an island in the Finnish archipelago shows in what way raccoon dogs may affect sea-bird or other animal populations. Raccoon dogs frequently consume waterfowl, especially female eider. It seems improbable, however, that raccoon dogs affect eider populations, because they kill only a small proportion of the eider population (Kauhala & Auniola 2001). On the other hand, Kauhala and Auniola (2001) conclude that it is possible that raccoon dogs affect frog population in the archipelago, because few frogs are found on islands which have been inhabited by raccoon dogs for some years. The same preference for frogs and in general amphibians is found in Vorpommern, Germany (Stier 2006a). In general no severe effect of raccoon dogs on the prey populations are found in Germany, although more research is needed (Stier 2006b).

The colonisation of the raccoon dog in Finland started with a very rapid growth (Kauhala 1992). In the mid 1980s the population size reached its peak. Thereafter, the population size first declined slightly, stabilised afterwards and seems to vary in a density-dependent manner with food supply (Kauhala 1992). It is therefore plausible that the largest effect of the raccoon dog on indigenous fauna occurs in the colonisation-phase when the population size grows to its peak.

Diseases

The raccoon dog is a vector of the fox tapeworm (*Echinococcus multilocularis*), in a larval stage causing the potentially serious disease *Alveolar echinococcosis*, which exhibits a tumor-like growth, initially starting in the liver (Eckert & Deplazes 1999, Wittenberg et al. 2005, Kauhala et al. 2006, Romig et al. 2006, Thompson et al. 2006).

Together with the fox, the raccoon dog is one of the most important European wild animal hosts for classic rabies (Kauhala 1999, Bourhy et al. 1999, Finnegan et al. 2002, Johnson & Fooks 2005). Rabies has become more abundant in wildlife in the eastern and northern parts of Europe in the past few years and the proportion of raccoon dog infections has increased (WHO 2007). The spatial spread of rabies occurs through neighbour-to-neighbour infection and dispersal of infected animals (Holmala & Kauhala 2006). Especially juvenile raccoon dogs can disperse over long distances (Holmala & Kauhala 2006).

The raccoon dog also carries *Sarcoptic mange* (distributed by *Sarcoptes scabei*) and *Trichinella* (Oivanen et al. 2002), and therefore may be an important vector of these parasites (Kauhala

1999). *Trichinella* is found in many carnivorous and omnivorous species. The disease was found to be widespread in wildlife from all parts of Finland (Oivanen et al. 2002). Because the raccoon dog is still spreading westward in Europe, *Trichinellosis* is also thought to be spreading westwards (Oivanen et al. 2002).

Road kills and hunting

Raccoon dogs can be involved in traffic accidents in a density-dependent way. Thousands of road kills of raccoon dogs are reported from Japan with spring and autumn peaks and possibly early morning and evening peaks of mortality (Saeki & MacDonald 2004).

Hunting occurs for population control. Research in Finland by Helle & Kauhala (1991) indicates that mostly juveniles are killed during autumn, of which many will normally not survive the subsequent winter. To be efficient in population control, hunting should occur in late winter and spring and should focus on reproductive animals (Helle & Kauhala 1991). However, if hunting increases total mortality and the population is pressed below carrying capacity, this may lead to a compensating increase in litter size and thus increased productivity of the raccoon dog (Helle & Kauhala 1991, Helle & Kauhala 1995).

Since the raccoon dog is an alien species in the Netherlands, hunting is allowed to prevent the species from growing in number, avoiding fauna forging. Broekhuizen (2007) indicates that it is useless to authorise hunting to prevent the raccoon dog from settling in the Netherlands, especially when there are no indications that a control programme is needed.

Animal welfare

The invasion of an exotic species causes a large number of changes in the life, the environment and the survival of the exotic species itself (Saeki & MacDonald 2004). It is expected to have an impact on the lives and survival of competitors (badgers and foxes), survival of prey species and also on humans (road crossings may cause traffic accidents). Mortality, starvation, hunting, disease and traffic accidents often include animal suffering and are thus animal welfare issues (Sainsbury et al. 1995), of which the severity may be calculated in terms of the amount of harm to welfare caused, the duration and number of animals affected (Kirkwood et al. 1994). For the Netherlands no sufficiently data are yet available to make such calculations.

Discussion

It seems likely that the raccoon dog already is present in the Netherlands or will inhabit the Netherlands in the near future. The Netherlands has a similar or milder climate compared to north-eastern parts of Europe, where the raccoon dog is very abundant. From the history of its distribution in Germany, it can be learned that the population size of raccoon dogs can build up very rapidly after a slow start at low numbers (Stier et al. 2003, Zoller 2006).

A high reproduction rate of the raccoon dog can be expected because of the long growth season due to mild winters in the Netherlands, the monogamous breeding system of the raccoon dog, its omnivorous nature and a period of winter lethargy. Its omnivorous and opportunistic feeding behaviour makes the raccoon dog independent of any specific food items, especially in areas near human settlements. Winter lethargy makes the animal almost entirely independent of food availability during the most unproductive period of the year. These factors contribute to a good physical condition of females, both juveniles and adults, resulting in a high growth rate of the population (Helle & Kauhala 1995). Thompson et al. (2006) suggested that there will be a great opportunity for the racoon dog to increase in number and continue to extend its range in Europe, because

of the effect of the European climate on the reproductive capacity of the raccoon dog.

When the raccoon dog is living in a milder climate, such as in the Netherlands, the population growth rate can be very high (Helle & Kauhala 1995) and the probable increase of movements during winter may accelerate the spread of rabies and other diseases and parasites (Kauhala et al. 2006). Moreover, because raccoon dog density will probably increase with rising temperatures (Helle & Kauhala 1995), there will be more raccoon dogs transmitting the parasite, even in winter (Kauhala et al. 2006). The fox tapeworm is present in the Netherlands; the presence of the raccoon dog as a new and important vector of this parasite might be a point of concern in the Netherlands. Although not yet present in the Netherlands, rabies also might be a point of possible concern in the next future.

Research on home ranges and densities of medium-sized carnivores shows that the raccoon dog density in Europe is in the same order of magnitude and often higher than the density of the badger and red fox (Kauhala et al. 2006). Expectations for the eventual population density of raccoon dogs in the Netherlands should take these data into account, along with the found association between raccoon dogs and badgers in home range and den use. Hunting may adversely influence population dynamics and development. Species population management by hunting should be considered very careful. Hunting may in fact even increase productivity of the raccoon dog (Helle & Kauhala 1991, Helle & Kauhala 1995).

Conclusion

In this paper, through reviewing literature and subsequently identifying possible issues of concern for nature management and conservation, we hope to have made a first step to a better understanding of the ecology and biology of the raccoon dog, as well as its probable role on ecosystem functioning in the Netherlands.

For successful nature conservation, we need to understand the biology of the raccoon dog and strive to avoid possible problems that might arise when raccoon dogs become abundant. Despite the recent statement of the Minister of Agriculture, Nature and Food Quality about the status of the raccoon dog in the Netherlands - “unprotected species and hunting allowed” -, further structural investigations of settlement, dispersal and ecological consequences of the presence of raccoon dogs in different Dutch ecosystems will greatly benefit nature conservation in the Netherlands, as already stated before by Broekhuizen (2007).

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Samenvatting

Mogelijke implicaties van de aanwezigheid van de wasbeerhond (*Nyctereutes procyonoides*) in Nederland

De wasbeerhond (*Nyctereutes procyonoides*) is geen inheemse diersoort in Europa. De soort is tussen 1929 en 1955 geïntroduceerd in Europese delen van de voormalige Sovjet Unie. Daarvandaan heeft de wasbeerhond zich verspreid naar andere Europese landen. Uit ons literatuuronderzoek blijkt dat de wasbeerhond sinds 1990 ook regelmatig in Nederland is waargenomen. Met deze nieuwe soort in Nederland is het van belang om mogelijke problemen in het functioneren van ecosystemen tijdig te signaleren. In dit artikel geven wij daartoe een eerste aanzet. De wasbeerhond staat bekend als een opportunist, waardoor voedselconcurrentie met de vos en de das nauwelijks is te verwachten. Als een vector voor rabiës en de vossenlintworm kan de aanwezigheid van de wasbeerhond in Nederland consequenties hebben voor wilde dieren, gedomesticeerde dieren en mensen. Ook is de wasbeerhond drager van de *Trichinella*-parasiet en door de uitbreiding van deze soort naar West-Europa zou deze parasiet in de toekomst ook Nederland kunnen bereiken. Bij een invasie van de wasbeerhond kunnen mortaliteit, honger, afschot, ziektes en verkeersongelukken het lijden van dieren veroorzaken. Daarom zal een invasie, maar ook een plotselinge exponentiële toename door natuurlijke aanwas, op de voet moeten worden gevolgd waarbij ook dierenwelzijnaspecten moeten worden betrokken. Verder onderzoek naar de invloed van de wasbeerhond op Nederlandse ecosystemen is van belang voor natuur, natuurbeheer en natuurbescherming.

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