EVALUATION OF PLANTS USED FOR THE CONTROL OF ANIMAL ECTOPARASITOSES IN SOUTHERN ETHIOPIA (OROMIYA AND SOMALI REGIONS)

by

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Abstract

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The burden of ticks in semi-arid lands of Ethiopia is not as pronounced as in some more humid areas of the continent. Nevertheless, the increasing recourse to chemicals smuggled by illegal traders has led to serious problems, including poisoning of humans and animals, discontinuous and irrational treatment regimens, tick-resistance to acaricidal products, loss of traditional knowledge and weakening of social structures.

In order to encourage a resumption of the long-established ethnoveterinary practices, a survey on plants locally used in tick control was undertaken, and plant species used in other parts of the continent for the same purpose were considered. On these bases, 28 plant species or varieties were collected in the study area: *Acacia seyal* var. *seyal*, *Adenium somalense*, *Aloe calidophila*, *Aloe parvidens*, *Azadirachta indica*, *Boscia angustifolia*, *Calotropis procera*, *Calpurnia aurea*, *Cissus quadrangularis*, *Commiphora erythraea*, *Cordia africana*, *Croton macrostachys*, *Croton megalocarpus*, *Datura stramonium*, *Euphorbia candelabrum*, *Euphorbia tirucalli*, *Ficus sycomorus*, *Ficus thonningii*, *Lantana camara*, *Maerua triphylla*, *Ocimum suave*, two varieties of *Ricinus communis* (one with green fruits and another with red ones), *Solanum incanum*, *Solanum somalense*, *Sterculia rhynchocarpa*, *Tagetes minuta* and *Vernonia amygdalina*.

In general, leaves were collected and used. However, due to the scarcity of foliar material, the whole plant of *T. minuta* and *O. suave*, the whole stem of *A. somalense* and *C. quadrangularis*, the branches of *E. candelabrum* and *E. tirucalli*, the bark in the case of *A. seyal*, *C. erythraea* and *S. rhynchocarpa*, were examined.

After drying and grinding, the plant material was extracted with hexane and acetone, and made up to different concentrations to test the relevant repellent and toxic properties on adult *Rhipicephalus pulchellus* unfed ticks. For every bioassay, four replications, each using ten ticks, were performed.

For the repellency bioassays, ticks were placed on a rectangular polystyrene platform stuck in a plastic basin and surrounded by water, in order to prevent them from moving away. Two glass rods, each provided with filter paper at the top and at the base, were inserted at opposite edges of the platform. The two filter papers of one rod were impregnated with the testing solution (*i.e.* solvent plus extract) at different concentrations while those of the other rod were treated with the pertinent extractant (hexane or acetone).

Because of their inherent tendency to climb, most of the ticks settled onto the rods (mainly at the top), and their distribution was different depending

on the repellency capacity of the extracts. The relevant data were then converted into repellency indexes using the formula $[(N_c - N_t)/(N_c + N_t)] \times 100$, where N_c refers to the number of ticks on the control rod and N_t to the number of ticks on the test rod (Lwande *et al.*, 1999; Pascual-Villalobos and Robledo, 1998).

For the toxicity bioassays, 1 µl of the extract at different concentrations was placed onto each tick and the mortality or weakening ratio was recorded after 24 hours. Because of the intrinsic toxicity of hexane, only acetone extracts were used for these assays.

Due to the efficacy in extracting volatile compounds, hexane extracts had, for 24 plant species, better repellent properties than acetone extracts. Moreover, at a concentration of 10%, four species had negative repellency indexes with hexane extracts and five with acetone ones. At such concentration, these extracts therefore seemed to attract the ticks rather than repel them. At a concentration of 10%, thirteen hexane and five acetone extracts had repellency indexes > 50. At a concentration of 5%, only five hexane extracts and no acetone ones exceeded this value. Finally, only one species had a repellency index > 50 with the hexane extract at a 1% concentration.

The plants showing good repellency indexes with at least one of the two solvents were *A. calidophila*, *C. quadrangularis*, *C. erythraea*, *C. macrostachys*, *C. megalocarpus*, *D. stramonium*, *L. camara*, *M. triphylla*, *O. suave*, the two varieties of *R. communis* and *T. minuta*. Amomg them, from a practical point of view, it is suitable to concentrate on *O. suave*, *T. minuta* and, to a certain extent, *A. calidophila*.

In fact, *C. quadrangularis*, *C. erythraea*, *C. macrostachys*, *D. stramonium*, *M. triphylla* and the two varieties of *R. communis* had good repellent properties using hexane extracts at 10%, but not at 5%. Because trees like *C. erythraea*, *C. macrostachys*, *C. megalocarpus* and *M. triphylla* are highly valuable in a very dry environment, an excessive exploitation can put them in danger. Since *D. stramonium*, *L. camara* and *R. communis* are toxic plants, their extracts can be a serious threat for both humans and animals. Furthermore, *L. camara* is one of the worst weeds in the world, making it very inappropriate for lands already subject to the problem of bush encroachment.

For all these reasons, *T. minuta* and *O. suave* appear to be the most promising plants; moreover, they are very well known in Southern Ethiopia and occur widely all over the area. On the contrary, *A. calidophila* is limited to just some places and the cultivation of *Aloe* species needs special attention, so it is not very suitable for people with a nomadic lifestyle.

Concerning the toxicity bioassays, *C. aurea* extracts yielded by far the best results. In fact, all the ticks used had severe movement impairment when put in contact with acetone extracts at the concentrations of 20% and 10%. At a 5% concentration, 85% of the ticks had the same symptoms. In a separate test, a

10% water extract had a similar effect on 30 ticks out of 40, demonstrating the ease of extraction and application of the active compounds.

The plant is well known, mainly by the Borana pastoralists, and is resistant to drought. It is also well able to grow in overgrazed areas, and its cultivation does not require special skills.

Some of the extracts of other species gave good or fair results in the toxicity bioassays but, apart from *S. incanum*, only at a very high concentration (20%).

Further studies may include isolation and characterization of the active compounds from the best species, setting up of a suitable plan for livestock treatment, and organization of a production and distribution cycle of appropriate phytomedicines in the pertinent pastoral area.

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TABLE OF CONTENTS

LIST OF FIGURES

1 INTRODUCTION

1.1 ETHNOVETERINARY MEDICINE

Ethnoveterinary medicine is an important branch of indigenous knowledge, orally transmitted from one generation to another in different parts of the world, and very widespread all over Africa (Gueye, 1997).

Indigenous knowledge has been described as "the knowledge used by local people to make a living in a particular environment" (Warren, 1991) or, similarly, as "a body of knowledge built up by a group of people through generations of living in close contact with nature" (Johnson, 1992). Langill (1999) proposed "such knowledge evolves in the local environment, so that it is specifically adapted to the requirements of local people and conditions. It is also creative and experimental, constantly incorporating outside influences and inside innovations to meet new conditions".

Ethnoveterinary research, development and extension, according to McCorkle (1995), is "the holistic, interdisciplinary study of local knowledge and its associated skills, practices, beliefs, practitioners and social structures pertaining to the health care and healthful husbandry of food-, work- and other income-producing animals, always with an eye to practical development applications within livestock production and livelihood systems, and with the ultimate goal of increasing human well-being via increased benefits from stock raising".

According to the World Health Organization (WHO), about 80 percent of the people in developing countries rely on traditional medicines for primary health care (Plotkin, 1992). An analogous pattern is presented by McCorkle *et al.* (1996) for livestock health care. Moreover, it is commonly recognized that further research in the ethnoveterinary area will benefit both developed and developing countries (Danø and Bøgh, 1999).

The presence of traditional drug sellers is very frequent in African markets

Among ethnoveterinary practices, herbal remedies are by far the most used. Well known by traditional healers, their cost is lower and their supply is more sustainable compared to industrial products (Latif, 1992), their side-effects are often very low and their degradation in the environment can be fast. Furthermore, when locally produced, they can result in an additional income-generating activity and enhance the status of local inhabitants, facilitating a self-managed development process.

The importance of herbal medicine has been increasing in recent years and was underlined by the Convention on Biological Diversity, signed in June 1992 by 154 countries during the United Nations Conference on Environment and Development, in Rio de Janeiro. The agreement came into force in December 1993, after final ratification by 30 countries (Haslett, 2003).

As remarked by Danø and Bøgh (1999), "the Convention aims at a commitment to cooperation between the contracting countries with regard to the conservation and sustainable use of the diversity of animals, plants and other living organisms and their habitats; a wider use of traditional herbal medicine can help to fulfil these aims through the organized use of medicinal plants".

Moreover, the Convention makes provision for fair sharing of the earnings deriving from the use of genetic resources. In this way, a country can maintain sovereign rights over its natural goods (Haslett, 2003) and is part of eventual profits gathered from a market exploitation of them.

Nurseries and cultivation of medicinal herbs can also be locally programmed, as well as the organizing of indigenous cooperatives of traditional healers. Such outcomes are in agreement with the principles of sustainable development, *i.e.* "the development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). In this sense, the validation of traditional knowledge empowers local owners to solve their livestock disease problems in a cost-effective way (Schillhorn van Veen, 1997).

A traditional drug seller in Ethiopia

However, a difficulty frequently met in considering ethnoveterinary practices is the absence of scientific appraisal. Thus, proper assessments are very important to check the reliability of indigenous uses of medicinal plants. Toward this aim, the ethnobotanical approach is a very useful way of fulfilling the evaluation, assuming that indigenous uses of plants may imply the presence of biologically active principles in them.

Consequently, thorough scientific study of the relevant traditional practices can lead to a validation of such remedies, and contribute to a more effective control of *inter alia* ectoparasites with the local ethnomedicines.

1.2 LIVESTOCK HEALTH AND THE ECONOMIC IMPORTANCE OF TICKS

The reduction of livestock productivity caused by ectoparasites has been widely documented (De Castro 1987; Norval *et al.*, 1987; Scholtsz *et al.*, 1991; Sutherst and Kerr, 1987). It has been calculated that every adult female of *Rhipicephalus appendiculatus* (a species comparable to *Rhipicephalus pulchellus*) that completes her feeding, can provoke a loss in live-weight gain of 4 g and a milk loss of 7 g in cows (Norval, 1990; Norval *et al.*, 1988). The value of hides is also depreciated by ticks (De Castro, 1997; Mersie and Bekele, 1994).

Moreover, ticks have an immunosuppressive effect on livestock (Inokuma *et al.*, 1993; Wikel, 1999).

In addition to the direct problems mentioned, ticks are vectors of a wide range of pathogens such as viruses, *Rickettsia*, *Ehrlichia*, *Trypanosoma*, *Theileria*, *Anaplasma* and *Babesia* spp. (Horak, 2003; Horak *et al.*, 2003; Rajput *et al.*, 2006).

1.3 *RHIPICEPHALUS PULCHELLUS* (GERSTÄCKER, 1873)

Rhipicephalus pulchellus (Ixodidae) is a three-host tick present in the Horn of Africa and neighbouring regions, from Djibouti to Northern Tanzania (Horak *et al.*, 2003). It is noticeable in Ethiopia (Bergeon and Balls, 1974; De Castro, 1994; Gebre, 1983; Mekonnen, 1996 and 1998; Mekonnen *et al.*, 2001; Morel, 1980; Pegram *et al.*, 1981; Solomon *et al.*, 1998; Zeleke and Bekele, 2004), especially in the south of the country where it is the most common tick (Dioli *et al.*, 2001; Regassa, 2001; Regassa and De Castro, 1993; Personal observations).

It is easily recognized by the typical pattern of the male carapace, which justifies the Latin term *pulchellus* (= beautiful) and instantly differentiates adult males from adult females (Horak, 2003; Kaiser, 1987; Walker, 1995; Walker *et al.*, 2000).

Rhipicephalus pulchellus is a vector of many pathogens: Crimean-Congo Haemorrhagic Fever virus (Hoogstraal, 1979), Nairobi Sheep Disease virus (Eldesten, 1975; Pellegrini, 1950), Kismayo virus (Butenko *et al.*, 1979), Barur virus (Butenko *et al.*, 1981), *Trypanosoma theileri* (Burgdorfer *et al.*, 1973), *Rickettsia conorii* (Pretorius *et al.*, 2004), *Theileria equi*, *Theileria taurotragi*, Kajiado virus and Dugbe virus (Aiello, 2003).

Rhipicephalus pulchellus (adult stage): a female on the left and a male on the right

1.4 TICK CONTROL IN REMOTE PASTORAL AREAS

The various options linked to the struggle against ectoparasites have evolved remarkably in recent decades, leading to a multi-integrated approach that takes into account aspects such as: ecology of the particular parasitic species involved, pathological agents carried by them, immune status of the hosts, environmental features, resistance to acaricidal products, toxicity of the principles, frequency of treatments, cost of the actions and availability of suitable compounds (Latif and Jongejan, 2002; Tatchell, 1992).

Acaricidal treatment on a camel

Nowadays the expression "tick control" is preferred to "tick eradication". In fact, a complete absence of such ectoparasites on the animal is almost impossible to be maintained in pastoral conditions. It is also not suitable as it causes a drop in the relevant immune status and consequently a remarkably increased susceptibility to tick re-infestations and tick-borne diseases (Jongejan, 2002).

Moreover, the misuse of acaricides has induced the development of resistance in ticks (Ali and De Castro, 1993; De Castro and Newson, 1993; Regassa and De Castro, 1993; Shiferaw *et al.*, 1997; Solomon and Kaaya, 1996) and has caused poisoning in both humans and animals (FAO, 1998).

The availability of chemicals and money to purchase such products is also frequently uncertain in remote areas (Latif, 1992).

All these considerations justify using extracts traditionally known and orally transmitted from one generation to the following (Kaposhi, 1992).

This approach is in agreement with the suggestion expressed by the “International Consortium on Ticks and Tick-Borne Diseases", in order to maintain a suitable enzootic balance between the host and the parasite (Jongejan, 2002).

Traditional healers in southern Ethiopia

1.5 SOUTHERN ETHIOPIA (MOYALE AND DIRRE *WEREDAS* OF OROMIYA REGION, AND MOYALE *WEREDA* OF SOMALI REGION)

In 1994, Ethiopia adopted a federal constitution, with the administrative division into regional states.

Moreover, every region of the Federal Republic of Ethiopia was divided into zones, and every zone has several *weredas* (districts). The study area covers three of these *weredas*, all situated in the southern part of the country, at a approximate latitude of between 3 and 5 °N. Two of them (Moyale-Oromiya and Dirre) are in the Borena zone of Oromiya region and one (Moyale-Somali) in the Liben zone of Somali region.

The area measures about 50,000 km^2, and lies at an altitude of between 1,000 and 1,500 metres above sea level. It is characterized by a semi-arid climate, with annual mean temperatures that vary from 19 to 24 °C and annual mean rainfall between 400 and 700 mm.

The rainfall delivery is bimodal, with about 60% of annual precipitation occurring from March to May and about 30% from September to November, while the remaining 10% is distributed over the other months. Usually, one in five years is dry (*i.e.* with less than 75% of average rain). A drought is defined as the occurrence of two or more consecutive dry years (Coppock, 1994).

The three pictures above show markedly diverse conditions of a southern Ethiopian area (El Leh, Moyale Wereda, Somali Region) in different periods: at the end of the rainy season (left); during the dry season (centre); in case of drought (right). It is unavoidable that the presence of ticks in the pasture is strongly dependent on the season.

The vegetation mainly presents mixtures of perennial herbaceous plants and woody trees, but the phenomenon of bush-encroachment, enhanced by over-grazing, is expanding year after year.

The human population is about 500 thousand inhabitants, mainly represented by pastoralists and agro-pastoralists, owning a total number of about 700 thousand cattle, 500 thousand camels, 450 thousand goats, 200 thousand sheep and 150 thousand donkeys (data issued in 2003 from the relevant *Wereda* Administrations).

The main ethnic groups living in the area are the Borana, belonging to the Oromo people, and the Gerri, belonging to the Somali people. Recurrent fights between these groups have been observed over the years, due to disputes concerning land use. Moreover, bomb-attacks and placing of landmines by the Oromo Liberation Front (a military rebel group fighting for independence from the Federal Republic of Ethiopia) have been reported.

A Gerri nomad during the seasonal migration

Due to the remoteness of the area (about 800 kilometres from the capital Addis Ababa), the scarcity of facilities (water, electricity, etc.), the harshness of the climate, the danger of conflict outbreaks, and the limited governmental budget allowed to public services, local veterinary assistance is very weak. In fact, there is no public veterinarian and the few public veterinary assistants and technicians lack funds and facilities, and cannot properly ensure the covering of that large area.

Such a situation frequently leads to self-made livestock treatments by the local owners. Despite the fact that both the Borana and Gerri peoples have a deep knowledge of traditional medicine, an increasing number of smugglers are nowadays spreading the uncontrolled use of chemicals among them. Without the action of properly trained and authorized Community Animal Health Workers, there is a high likelihood of the misuse of industrial drugs.

A Somali Community Animal Health Worker vaccinating a goat

All livestock has a variable presence of ectoparasites including several genera of the Ixodidae, with a large variety of *Rhipicephalus*, *Amblyomma*, *Hyalomma*, and *Boophilus* species.

Even if the problem of tick-borne diseases is not frequently reported in the area, the pastoralists tend to treat the livestock with either natural or synthetic products because the ectoparasites are easily seen on the bodies of the animals.

Nevertheless, treatment mostly takes place in a haphazard way, and misuse of chemicals, frequently illegally imported at high cost from neighbouring Kenya, is increasing year after year.

The re-validation of natural remedies can greatly contribute to controlling the tick burden in a cheaper and more sustainable way, avoiding a broad series of problems, like the danger of poisoning (for both animals and human beings) through the use of chemicals in a non-rational way (that is at the wrong concentration and without protective clothing), the relatively high cost of these drugs, the difficulty in regularly getting suitable products and the possibility of causing resistance.

2 MATERIALS AND METHODS

2.1 PLANT SELECTION

The selection of plants for this study was based on the reports of their ectoparasiticidal or repellent effectiveness by local healers or in the international scientific literature concerning the African continent.

The 28 plants collected are listed as follows, with the local name in brackets:

- *Acacia seyal* var. *seyal* (wachu),
- *Adenium somalense* (olombo),
- *Aloe calidophila* (hargessa),
- *Aloe parvidens* (hargessa barrich),
- *Azadirachta indica* (gedhindi),
- *Boscia angustifolia* (kalkalcha),
- *Calotropis procera* (boa),
- *Calpurnia aurea* (cheka),
- *Cissus quadrangularis* (chobi - dolandolli),
- *Commiphora erythraea* (hagarsu),
- *Cordia africana* (kilta),
- *Croton macrostachys* (makanisa),
- *Croton megalocarpus* (nyapo),
- *Datura stramonium* (qobo),
- *Euphorbia candelabrum* (adama),
- *Euphorbia tirucalli* (ano),
- *Ficus sycomorus* (oda),
- *Ficus thonningii* (dembi),
- *Lantana camara* (midan dubra),
- *Maerua triphylla* (lamaloshigy),
- *Ocimum suave* (anchabi),
- two varieties of *Ricinus communis* (qobo), one with green fruit and the other with red,
- *Solanum incanum* (hiddi),
- *Solanum somalense* (hiddi gaga),
- *Sterculia rhynchocarpa* (qarare),
- *Tagetes minuta* (sunki - mish mish),
- *Vernonia amygdalina* (ebicha).

According to our observations, the local Gerri traditional healers and pastoralists use *Adenium somalense*, *Aloe* spp., *Cissus qudrangularis* and *Sterculia rhynchocarpa* in ectoparasite control, while *Calpurnia aurea* and *Commiphora erythraea* are used by the Borana people. Other researchers have

also performed a general ethnoveterinary survey in the area: Abubeker (2003) gathered information on the ectoparasiticidal use of *Commiphora erythraea* and *Ficus glumosa* among the Borana people, and Kebede (2004) noticed an analogous use of *Azadirachta indica* and *Commiphora incisa* by the Gerri traditional healers. The local use of *Commiphora* spp. as a natural acaricide was confirmed by Solomon Gebre (Personal communications).

Heine and Brenzinger (1988) described the ectoparasiticidal use of *Calpurnia aurea* and *Ficus sycomorus* among the Borana people. Teshale *et al.* (2004) published information on the utilization of *Azadirachta indica*, *Euphorbia abyssinica* and *Sterculia alexandri* in southern Ethiopia for the same purpose.

In neighbouring Kenya, Bekalo *et al.* (1996) reported the use of *Adenium obesum*, *Aloe* spp., *Azadirachta indica*, *Commiphora erythraea*, *Commiphora incisa*, *Euphorbia* spp. and *Tagetes minuta* for the control of ectoparasites, and the use of *Azadirachta indica*, *Boscia coriacea*, *Calotropis procera*, *Cissus producta*, *Commiphora erythraea*, *Euphorbia balsamifera* and *Tagetes minuta* as insect repellents.

Few reports confirming the efficacy of these plants could be found. Such consideration provides the motivation for this study.

2.2 PLANT DESCRIPTION

2.2.1 ACACIA SEYAL VAR. *SEYAL (WACHU)*

Fam. Fabaceae (Leguminosae) - Subfam. Mimosoideae

Acacia seyal var. *seyal* is a deciduous tree, about 10 m tall and with a trunk of about 25 cm in diameter, easily recognized by its red bark (whereas the other variety, *fistula*, is characterized by a greenish-yellow bark and the presence of pseudo-galls englobing the thorn bases).

The name of the genus is derived from the Greek word *akis*, meaning "sharp point" and refers to the plant thorns (Wagner *et al.*, 1999), while *seyal* derives from an Arabic word for "torrent", because in Egypt it is frequently associated with small water courses (Hall and McAllan, 1993; Ross, 1977; Souane, n.d.).

The species is widespread on the African continent, from Senegal to Somalia, and from Egypt to Zambia. However *A. seyal* var. *fistula* is more frequently found in the south-east, while *A. seyal* var. *seyal* is more abundant in the north-west. The Rift Valley, which also crosses Ethiopia, can roughly be seen as an overlapping area for the two varieties (Hall and McAllan, 1993; Ross, 1977).

The nitrogen-fixing properties of *A. seyal* have been exploited in silvo-pastoral systems (Hall and McAllan, 1993). It also yields a valuable gum, even though the quality is considered poorer compared to the so-called "arabic gum" secreted by *Acacia senegal* (Booth and Wickens, 1988).

The plant is cultivated by the propagation of scarified seeds (Duke, 1983).

The Borana people of southern Ethiopia extract a red pigment from *A. seyal* var. *seyal* to make paint for wooden handicrafts. The tree is browsed by goats and camels, and also used for firewood, charcoal, sticks for fencing and edible gum (Coppock, 1994). Regarding its medicinal value, the bark is pounded and

boiled together with the roots of *Coleus ignarius* to make a decoction for treating jaundice and snake bites (Abubeker, 2003; Kebede, 2004).

The utilization of *Acacia seyal* as an insecticide has been reported by Ainslie (1937) in Nigeria.

Gum arabic is a complex polysaccharide, mainly composed of arabinose, galactose, D-glucuronic acid and L-rhamnose subunits; it softens and soothes the mucosa and skin, and has an antibiotic and protective action. It is also used in food preparation, as a stabilizer and emulsifier, in both rural and industrial areas (Van Wyk and Wink, 2004). Moreover, *A. seyal* has a high content of tannins (NAS, 1980).

2.2.2 ADENIUM SOMALENSE (OLOMBO)

Fam. Apocynaceae

Adenium somalense is a deciduous succulent shrub, generally no taller than 2 m, native to eastern Africa and southern Arabia (Plaizier, 1980). The lower part of the trunk is swollen, and can retain a large quantity of water, allowing the plant to easily adapt to long dry periods. The sap is toxic, and is used as poison for arrows (Getahun, 1976; Lewis and Elvis-Lewis, 1977). The pink flowers appear when the leaves are shed, and give the characteristic appearance to the plant, so that it is usually called "desert rose", together with the more common species *Adenium obesum*, and is horticulturally greatly valued. However, for most of the year it does not have leaves or flowers. *Adenium somalense* is similar to *A. obesum*, but has thinner lanceolate leaves (Codd, 1963; Court, 2000; Watson and Dallwitz, 1992).

The name of the genus is derived from Aden, the former name of Yemen and nowadays the capital town of the country, while the term *obesum* refers to the swelling shown by the stem in its basal part (Plaizier, 1980).

Adenium obesum and *A. somalense* require a good sunny position, and are easily cultivated in warm climates and well-drained sandy soils. Even if the propagation by seeds is quite quick, showing germination after one week, it often presents some pollination problems. Consequently, propagation by cuttings is usually preferred, while grafting and layering are also possible (Dimmit 2000; Dimmit and Hanson, 1991; Van der Spuy, 1971).

The insecticidal and acaricidal properties of *A. obesum* and *A. somalense* have broadly been reported in Kenya (Bekalo *et al.*, 1996; Kokwaro, 1976; Morgan, 1981), Nigeria (Mgbojikwe and Okoye, 1998) and Senegal (Kerharo and Adam, 1974). Mgbojikwe and Okoye (1998 and 2001) documented the acaricidal properties of an aqueous stem bark extract of *A. obesum* on all stages of *Amblyomma* spp. and *Boophilus* spp.; the authors hypothesized that the

acaricidal effect may be due to an antiacetylcholinesterase activity of the plant.

The Gerri people of Southern Ethiopia use the pith of *A. somalense* to treat tick infestations (Personal observations).

Several cardiac glycosides have been detected as pharmacological active components of *A. obesum* (Mettam *et al.*, 1941); among 30 glycosides isolated from the plant, oleandrigenin beta-gentiobiosyl-beta-D-thevetoside was found to be the main one; neridienone A and 16,17-dihydroneridienone A also have some importance (Yamauchi and Abe, 1990).

Cytotoxic activity has been shown by some cardenolides (somalin, hongheloside A, 16-acetylstrospeside and honghelin) and the flavonol 3-3'-bis (O-methyl) quercetin (Hoffmann and Cole, 1977).

A triterpene (dihydroifflaionic acid) and a flavonol (3-O-methylkaempferol) have also been isolated (Hoffmann and Cole, 1977).

2.2.3 ALOE CALIDOPHILA (HARGESSA) AND ALOE PARVIDENS (HARGESSA BARRICH)

Fam. Asphodelaceae (Aloaceae)

Aloe calidophila

Aloe parvidens

The genus *Aloe* consists of about 360 perennial species distributed mainly in Africa, south of the Sahara, and is almost always characterized by thick, toothed and succulent leaves forming basal rosettes, from which stems rise up to about 1.5-2 m. In the upper part, stems produce red, orange or yellowish (occasionally white), usually branched, inflorescences (Sebsebe *et al.*, 2003).

Aloe calidophila is one of about 40 species of *Aloe* occurring in Ethiopia, and is very well adapted to hot climates. Present also in northern Kenya, it is easily distinguishable from the other species in the area by the particular form of the perianth, which is about 2 cm long with outer segments free for about 1 cm, and by the uniformly dull-green leaves with whitish marginal spines about 4 mm long (Sebsebe *et al.*, 2003).

Aloe parvidens is also found in southern Ethiopia and northern Kenya, and is characterized by brown leaves with whitish spots and small marginal teeth (usually less than 2.5 cm long); the perianth can reach a length of 3 cm (Sebsebe *et al.*, 2003).

The name of the genus means "bitter", referring to the taste of the juice extracted from the leaves. It may be derived from the terms *alsos* (Greek), *alloeh* (Arabic) or *allal* (Hebrew). The names of both species come from Latin: *calidophila* means "liking heat", while *parvidens* ("small tooth") refers to the size of the teeth on the leaves (Jackson, 1990).

The plant is usually reproduced by seeds but, in addition, some *Aloe* species can produce lateral rosettes developing into independent individuals after fragmentation (Sebsebe *et al.*, 2003).

Aloes have been cultivated since ancient times. Some authors assume that, in the 4th century BC, Aristotle suggested to Alexander the Great to conquer

the island of Socotra, because at that time it was the only place in the world where the plant, so valuable for its wound-healing properties, was cultivated (Beckingham, 1983; Vandaveer, 2003).

Several species of *Aloe* are used as insecticide and acaricide in both Kenya (Bekalo *et al.*, 1996) and Ethiopia (Tadesse, 1991 and 1994).

In southern Ethiopia, the Borana people chew the stem and pith of *Aloe* shoots to apply onto a snake-bite site, while the leaves are squeezed to obtain sap for treating ear pain, eye problems, skin wounds and burns (Abubeker, 2003). Moreover, root extracts are used to treat stomach ache, epiphora, cold and flu. In addition, a piece of *Aloe* is frequently placed on top of huts to announce a birth (Coppock, 1994). Leaves of the plant are also used by the Gerri people to treat burns, after drying, burning and mixing with water (Kebede, 2004), and for tick infestations (Personal observations).

The laxative action of *Aloe* species is due to the anthraquinone (1,8-dihydroxyanthracene) glycosides aloin A and B (Robbers *et al.*, 1996; Tyler, 1994), mainly barbaloin (aloe-emodin anthrone C-10 glycoside) (Hay and Haynes, 1956; Ishii *et al.*, 1984), which in the large intestine is hydroxylated into aloinose (a non crystalline sugar) and aloe-emodin (1,8-dihydroxy-3-hydroxymethyl-9,10-anthracenedione), causing an augmentation of the water content (Ishii *et al.*, 1990 and 1994).

Pain-reducing and burn-wound healing effects are due to the presence of a carboxypeptidase, which can inhibit bradykinin (a pain agent) and hamper the production of thromboxane (an anti-wound-healing agent) (Foster *et al.*, 1999; Tyler, 1994).

Regarding the anticancer effects of *Aloe vera*, it has been observed that emodin has a specific *in vitro* and *in vivo* antineuroectodermal tumour activity (Pecere *et al.*, 2000), shows a selective anti-glioma action (Mijatovic *et al.*, 2005), can inhibit cell proliferation and induces apoptosis in human liver cancer cell lines (Kuo *et al.*, 2002). In addition, the plant contains di(2-ethylhexyl)phthalate (DEHP), which can inhibit leukemic cells *in vitro* (Lee *et al.*, 2000).

Acemannan (a carbohydrate fraction obtained from *Aloe vera*) can stimulate the production of cytokine in mouse macrophage cell lines (Zhang and Tizard, 1996) and induces maturation in dendritic cells (Lee *et al.*, 2001). Moreover, a strong immunostimulation is given by aloeride (a polysaccharide present in the plant), which increases NF-kappa B activities (Pugh *et al.*, 2001).

2.2.4 AZADIRACHTA INDICA (GEDHINDI)

Fam. Meliaceae

Azadirachta indica, commonly known as neem, is an evergreen tree, 15-25 m tall, native to south-eastern Asia (Lemmens *et al.*, 1995). It is easily identifiable by its lanceolate leaves, tapering to an acuminate apex, with a very asymmetric base and a coarsely serrate margin (Tewari, 1992).

The plant adapts to a wide range of soils and climates, and can grow from see level up to an altitude of 1,500 m, tolerating high temperatures and long dry seasons (Stoney, 1997; Tewari, 1992). It also grows in impoverished and saline soils, realizing an excellent method of regenerating depleted lands (Moore and Lenglet, 2004).

The first references to *A. indica* may be found in Sanskrit writings that are over 4,000 years old (Larson, 1990). Bark, leaves, twigs and seeds have been widely used in Ayurvedic medicine to treat a wide range of ailments for over 2,500 years (Conrick, 1994; Puri, 1999; Van Wyk and Wink, 2004). The name of the plant is derived from *Azadirach-E-Hind*, which in Arabic means "free-growing tree of India" (Conrick, 1994; Puri, 1999).

Currently, besides many applications as an insecticide and fungicide, neem is frequently utilized in cosmetic preparations, as well as for ruminant and poultry feed, manufacture of implements and furniture, and nitrification of soils (Koul *et al.*, 1990).

Azadirachta indica is cultivated in tropical and subtropical areas all over the world (CABI, 2000; Verkerk and Wright, 1993). It is propagated by seeds, which however have a short viability of a few weeks (Rajiv, 1996; Read and French, 1993). Moreover, dry and unripe seeds rot in the soil. A suitable way to cultivate neem is by germinating the seeds in the sand, transferring the seedlings to clay pots after a month and transplanting them into the ground

when they reach 30-45 cm (Jacobson, 1990). The plant becomes fully productive in about 10 years (NRC, 1992).

In Africa, the ectoparasiticidal and repellent effects of *A. indica* have been described by Matzigkeit (1990) and observed in Gambia and Ghana (Aikins *et al.*, 1994), Madagascar (Bost, 1961), Kenya (Seyoum *et al.*, 2002b); Senegal (Thoen & Thiam, 1990) and Sudan (Agab, 1998).

In southern Ethiopia, the Gerri people crush and soak the leaves of *A. indica* in water, and use it orally or topically for ecto- and endoparasitic treatments (Kebede, 2004). The Borana people treat ectoparasitoses with an infusion of the plant root orally administered or with a topical application of a paste obtained from the leaves (Teshale *et al.*, 2004).

Seyoum *et al.* (2002a) experimented the repellent properties of potted neem on *Anopheles gambiae*, finding only a modest reduction in biting. Better protection is obtained when oil from seeds is used, even if there is not full agreement in the data issued from different researches (Caraballo, 2000; Das *et al.*, 1999; Kant and Bhatt, 1994; Moore *et al.*, 2002; Pandian and Devi, 1998; Pates *et al.*, 2002, Prakash *et al.*, 2000; Sharma and Ansari, 1994; Sharma *et al.*, 1993a and b, and 1995).

Williams and Mansingh (1993) validated the insecticidal properties of a neem seed ethanol extract, 10% concentrate, sprayed onto the adult stage of *Tribolium confusum*, obtaining a mortality of 53%.

Williams (1993) determined that 0.46 mg of a crude ethanol extract of *A. indica* seeds causes a 50% reduction of egg laying and an 80% hatching failure on the tick *Boophilus microplus*, through inhibition of the ovarian proteinic and lipidic sequestration.

Ndumu *et al.* (1999) successfully tested the acaricidal properties of neem oil on the larvae of *Amblyomma variegatum*.

Solomon *et al.* (2000) evaluated three different neem seed extracts *in vitro* and *in vivo* regarding their activities on *Rhipicephalus appendiculatus*, *Amblyomma variegatum* and *Boophilus decoloratus*; the results concerning the reduction of tick attachment, engorgement, fecundity and egg viability, were encouraging. Regarding tick mortality, the authors recorded a considerably stronger effect on immature instars than on adults. Moreover, they found that a 25% diluted neem oil, sprayed onto zebu cattle, significantly reduces the number of immature and adult ticks attaching for 4-5 days.

Mansingh and Williams (2002) compared the effects of crude ethanol extracts of neem seeds, and their hexane and methanol fractions, on *Boophilus microplus* and *Amblyomma cajennense*, finding a considerable reduction of oviposition and egg viability; the authors remarked that there was significantly more effect on *B. microplus* than on *A. cajennense*.

Abdel-Shafy and Zayed (2002) validated a neem seed oil on egg, immature and adult stages of *Hyalomma anatolicum excavatum*, finding hatching failure, incompletely development of larvae and mortality of both larvae and adults.

Azadirachta indica is considered the most prominent phytochemical source of pesticides, and is widely used all over the world (Forster and Moser, 2000). In fact, the active compounds of neem show many modes of action against arthropods, such as antifeedant activity, growth regulation, repellency, reduction of fecundity and oviposition, changes in biological fitness, and blocked development of vector-borne pathogens (Mulla and Su, 1999; NRC, 1992; Schmutterer, 1990a).

The plant contains at least 35 biologically active principles, including triterpenoids, steroids, carotenoids, ketones and phenolic compounds (Jacobson, 1990; Schmutterer, 1990b). In particular, several triterpenoids with arthropodicidal activity have been isolated from the seeds and the leaves (Schaaf *et al.*, 2000; Siddiqui *et al.*, 1992, 2000 and 2002).

The main insecticidal and acaricidal triterpenoids of *A. indica* are limonoids, especially azadirachtin (Isman *et al.*, 1990), constituted by a mixture of seven isomers (Kolb and Ley, 1991; Mulla and Su, 1999; Van Wyk and Wink, 2004; Verkerk and Wright, 1993) with both antifeedant and insect growth regulatory properties, resulting in reproductive and moulting disorders (Ascher, 1993; Blaney *et al.*, 1990, Koul and Isman, 1991; Mordue and Blackwell, 1993). Consequently, the treatment effects are only visible after some time (Schmutterer, 1990b).

Al-Rajhy *et al.* (2003) investigated the use of azadirachtin and neem oil on larval and adult stages of *Hyalomma dromedarii*, a tick affecting camels. In agreement with Solomon *et al.* (2000), they found that *A. indica* shows its acaricidal activity mainly on immature instars, and to a lesser extent on adults.

Other neem compounds with a marked pesticidal activity are salannin, nimbin and meliantriol (Jacobson, 1990; NRC, 1992), which cause reduction of oviposition as well as egg sterility and inhibition of chitin biosynthesis (Ascher, 1993; Blaney *et al.*, 1990) .

It is noteworthy that the abundance of active principles present in *A. indica* strongly reduces the possibility of developing resistance in the targeted organisms (Schmutterer, 1990b).

Apart from the arthropodicidal and repellent properties, neem has shown activities against viruses, fungi, nematodes and snails (Bhatnagar and McCormick, 1988; Locke, 1990; NRC, 1992, Williams, 1995).

From an environmental point of view, the active compounds extracted from the plant are safe for mammals, butterflies, ants, ladybugs, spiders and earthworms (Hoelmer *et al.*, 1990; NRC, 1992; Schmutterer, 1990b).

2.2.5 BOSCIA ANGUSTIFOLIA (KALKALCHA)

Fam. Capparaceae

Boscia angustifolia is a small-medium tree, 6-8 m tall, growing in semi-arid areas of the African continent and strongly drought-tolerant (Coates Palgrave, 1983; Parry, 1989). The elliptic leathery leaves are usually also present on the frequently oblique trunk and main branches; the bark is grey and rough (Dougall and Bogdan, 1958).

Boscia is named after Louis Bosc, a French professor of agriculture who lived in the 18th and 19th centuries, while the term *angustifolia* in Latin means "narrow leaf" (Bothma, 1982).

The plant is frequently browsed by goats, camels and several wild ruminants (Brundin and Karlsson, 1999; Kalikawa, 1990; Nott and Stander, 1991; Skarpe, 1990).

Boscia seeds have a short life expectancy and germinate quickly, but at a rate of less than 30% (Briers, 1988). When cultivated, the seedlings have to be transplanted directly into open ground (Venter and Venter, 1996), because the plant has a very deep taproot development (Canadell *et al.*, 1996). However, *Boscia* species have a slow above-ground growth rate (Cunningham, 2001; Van Wyk, 1984).

In Southern Ethiopia, the Borana people use the wood of the tree to make mortars, pestles and cups, while twigs are used as cleaning utensils (Coppock, 1994).

Boscia coriacea, a related species, has shown acaricidal properties in Zambia (Kaposhi, 1992). Moreover, the insect-repellent properties of the plant have been reported in Kenya by Bekalo *et al.* (1996).

The family Capparaceae contains glucosinolates (thioglucosides), cyanogenic glycosides, alkaloids, saponins and lupeol triterpenoids (Gibbs, 1974; Kjaer *et al.*, 1973; Kondagbo *et al.*, 1973). The biological activity is due to

the release of methyl-isothiocyanate (commonly known as "mustard oil") and methyl-cyanide by enzymatic degradation of a methyl-glucosinolate precursor, glucocapparin, contained in *Boscia* fruits and leaves (Lognay *et al.*, 1994; Seck *et al.*, 1993). The mustard oil is released when the plant is damaged or the plant material is crushed (Ahmed *et al.*, 1972), and has both skin irritant and contact allergenic effects (Mitchell, 1974; Mitchell and Jordan, 1974; Richter, 1980).

Boscia leaves also contain trans-2-hexenal (which determines the green colour) (Lognay *et al.*, 1994), the alkaloids L-stachydrine and 3-hydroxystachydrine (Southon and Buckingham, 1988), as well as the flavonoids rhamnetin-3-O-neo-hesperoside (Harborne and Baxter, 1999) and rhamnocitrin-3-O-neo-hesperoside (Walter and Sequin, 1990).

2.2.6 CALOTROPIS PROCERA (BOA)

Fam. Asclepiadaceae

Calotropis procera is a big perennial shrub, up to 4 m tall, native to Africa and south-western Asia, but nowadays also present in Latin America and the Caribbean Islands (Rahman and Wilcock, 1991). It is easily identifiable by its big (up to 15 x 10 cm), opposite leaves without stalks, flowers with five petals and a central purplish crown, large green fruits (more than 10 cm long) and abundant milky sap oozing out when the plant is chopped (Kleinschmidt and Johnson, 1977; Nicholson, 1991).

The genus name derives from Greek and means "beautiful appearance", while the Latin word *procera* means "tall".

The plant is drought-resistant and salt-tolerant, and is frequently found in sandy soils up to 1,300 m in altitude (Abbas *et al.*, 1992; Bekele-Tesemma *et al.*, 1993). *Calotropis procera* can be easily propagated through stem and root cuttings (Bailey and Bailey, 1976).

There are many uses for this plant in Ayurvedic and other traditional medicines (Rasik *et al.*, 1999). Moreover, *C. procera* is the source of vegetable rennet for the production of *wagashi*, a soft cheese made by the Fulani people in western Africa (Aworh and Muller, 1987; Aworh and Nakai, 1986).

In southern Ethiopia, it can also represent a ceremonial grave marker, while the leaves are used in milk processing (Coppock, 1994).

The ectoparasiticidal effects of the plant (Curasson, 1947) are well known in eastern and southern Africa (Watt and Breyer-Brandwyk, 1962), northern Africa (Boulos, 1983), and western Africa (Ake-Assi, 1992; Bernus, 1969), especially reported in Benin (Adjanohoun *et al.*, 1989), Nigeria (Ainslie, 1937) and Senegal (Ferry *et al.*, 1974). In Kenya, *C. procera* is also used as an insect repellent (Bekalo *et al.*, 1996).

The insecticidal properties of the plant have been successfully validated in Egypt (Morsey, 1997, Moursy *et al.*, 2001).

The latex of *C. procera* is present in the whole plant, and is irritating and caustic to eyes, causing burning pain, epiphora, local anaesthesia, dimming vision, swelling of eyelids and corneal oedema (Crawford, 1958; Dalziel, 1937; Duke-Elder and MacFaul, 1972; Muthayya, 1948; Sugiki, 1966; Wong, 1949). Skin irritation, depilation and cutaneous hypertrophy have also been reported (Behl *et al.*, 1966; Blohm, 1962; Irvine, 1961; Morton, 1962; Nadkarni, 1976; Singh *et al.*, 1978; Williamson, 1956).

From a pharmacological point of view, the latex of *C. procera* contains calotropin (Watt and Breyer-Brandwijk, 1962), a cardioactive glycoside that has shown antidiuretic and expectorant properties, as well as antitumour activity on epidermoid carcinoma cells of the human rhinopharynx (Hansel *et al.*, 1994). The acaricidal effect of calotropin has been documented in Saudi Arabia (Al-Rajhy *et al.*, 2003).

From the latex, calotropains, papain-like proteinases with a marked proteolytic activity that could explain the lethal effect on insect larvae (Markouk *et al.*, 2000; Morsy *et al.*, 2001), have also been isolated (Abraham and Joshi, 1979a and 1979b; Atal and Sethi, 1962; Pal and Sinha, 1980).

The presence of alkaloids, flavonoids, polyphenols, steroids, resinous substances, terpenoids and uscharin in the latex of the plant have been reported (Al-Robai *et al.*, 1993; Ansari and Ali, 1999; Edman, 1993; Hussein *et al.*, 1994; Khan *et al.*, 1988; Khan and Malik, 1989; Kuriachen and Dave, 1989; Melo *et al.*, 2001; Morsy *et al.*, 2001; Pereira, 1988). In particular, the glycosidal cardenolide asclepin has shown a positive inotropic effect on the heart (Patnaik and Kohler, 1978).

Anti-inflammatory (Kumar and Basu, 1994), antipyretic (Dewan *et al.*, 2000), analgesic (Basu and Chaudhuri, 1991), bactericidal (Jain *et al.*, 1996; Kishore *et al.*, 1997; Mann *et al.*, 1997; Singh and Rastogi, 1972), schizonticidal (Sharma and Sharma, 2000), anti-diarrhoeal (Kumar *et al.*, 2001), anti-ulcer (Basu *et al.*, 1997), hepatoprotective (Basu and Sen, 1992), nematocidal (Maqbool *et al.*, 1987), fungicidal and molluscicidal (Larhsini *et al.*, 1997) properties of *C. procera* have also been described.

Akhtar *et al.* (1992) isolated proceragenin, an antibacterial cardenolide, from the plant.

2.2.7 CALPURNIA AUREA (CHEKA)

Fam. Fabaceae (Leguminosae) - Subfam. Papilionoideae

Calpurnia aurea is a small, multi-stemmed tree, 3-4 m tall. The leaves are about 15-25 cm long, each bearing 5-20 pairs of ovate to oblong leaflets, light green and 2-5 cm long, ending with a terminal one. The flowers are bright yellow, in racemes, and the fruits are flat brownish pods.

The genus *Calpurnia* includes several species, some of which are confined to South Africa. *Calpurnia aurea* is the most widespread one, common in many parts of sub-Saharan Africa and also present in southern India.

The name of the genus derives from *Calpurnius*, a Roman poet who tried to imitate the famous Virgil. As this latter was taken to name the genus *Virgilia*, *Calpurnius* was chosen for the morphologically similar genus *Calpurnia*. In Latin, *aurea* means "golden".

The plant is frequently found in forest margins, bushlands or grasslands, especially in overgrazed areas.

Calpurnia is easily cultivated. Germination occurs within two weeks, and can be facilitated by soaking the seeds in warm water. Seedlings can be transplanted after the development of the first pair of true leaves.

The arthropodicidal use of *C. aurea* has been described in South Africa to treat wound worms (Watt and Breyer-Brandwyk, 1962), and in Ethiopia to treat scabies (Jansen, 1981). The people of western Ethiopia, moreover, use the juice of crushed leaves and bark for tick control (Regassa, 2000).

The Borana people of northern Kenya and southern Ethiopia soak leaves of *C. aurea* in cold water to treat lice in humans and calves (Heine and Brenzinger, 1988), and ticks in cattle (Personal conversation with Borana traditional healers, held on 22nd September 2004 near the Ethiopian town of Yabello).

Furthermore, in Ethiopia the plant is used to treat stomach disorders, amoebic dysentery and eye diseases (Abate, 1989). Tadeg *et al.* (2005) reported the antimicrobial effect of *C. aurea* in the treatment of bacterial infections of the skin. Blum and Bekele (2002) recorded the use of the plant as a natural pesticide for grain storage.

The main pharmacologically active compounds of *C. aurea* are the alkaloid calpurmenin and its 13α-(2'-pyrrolecarboxylic acid) ester (Vermin *et al.*, 1979). The alkaloids virgiline and lupanine, as well as their carboxylic esters, have also been recorded (Van Wyk *et al.*, 1991).

2.2.8 CISSUS QUADRANGULARIS (CHOBI - DOLANDOLLI)

Fam. Vitaceae

Cissus quadrangularis is a succulent, perennial, climbing shrub, with quadrangular winged stems, leafless when old; the flowers are greenish-yellow, and the fruits are globose berries (Kirtikar and Basu, 1985).

The plant is native to south-eastern Africa and southern Asia, but nowadays is spread all over Africa. In Ayurvedical medicine it has been known for some time because of its ability to accelerate the healing process of fractures (Chopra *et al.*, 1975; Prasad and Udupa, 1963 and 1972; Udupa and Prasad, 1964a and b).

The genus name derives from Greek and means "ivy", while the Latin term *quadrangularis* refers to the rectangular shape of the stems.

The propagation is easy with seeds. After germination, seedlings must be transplanted to a drier place. Vegetative propagation, through terminal or lateral cuttings, is also possible (Das and Sanyal, 1964).

The insecticidal and acaricidal properties of *C. quadrangularis* have been reported in Burkina Faso (Bessin *et al.*, 1993), Ivory Coast (Bouquet and Debray, 1974), Kenya (Glover *et al.*, 1966; Kokwaro, 1976; Timberlake, 1987), Niger (Adjanohoun *et al.*, 1980), Senegal (Coly, 1994) and Tanzania (Minja, 1999). The stem of *C. quadrangularis* is considered a termite-repellent by the Turkana people of northern Kenya (Ichikawa, 1987), and *Cissus producta*, a related species, is used to repel tsetse (*Glossina*) flies in the same country (Bekalo *et al.*, 1996).

The Gerri people of southern Ethiopia use a paste issued from the stems of *C. quadrangularis* to topically treat livestock against ticks (Personal observations).

The fracture-healing properties of *C. quadrangularis* are due to the considerable presence of carotene, vitamin C, calcium and various anabolic

principles (Adesanya, 1999; Das and Sanyal, 1964; Sen, 1964), with a consequent faster regeneration of connective tissue and bone mineralization (Chopra *et al.*, 1975; Deka *et al.*, 1994; Ekanayake, 1980; Udupa and Prasad, 1964a and 1964b). Moreover, the plant neutralizes the inhibitory effect of cortisone in healing fractures (Prasad and Udupa, 1963 and 1972; Sen, 1964), and shows significant analgesic activity (Singh *et al.*, 1984).

Antioxidant and antibacterial properties have also been described (Chidambara *et al.*, 2003).

The irritating action on the skin caused by *C. quadrangularis* is due to the presence of calcium oxalate, 31-methyl tritiacontanoic acid, taraxeryl acetate, friedelan-3-one, taraxerol and iso-pentacosanoic acid (Chopra *et al.*, 1975).

A hypotensive (acetylcholine-like) water-soluble glucoside has also been recorded (Das and Sanyal, 1964), as well as asymmetric tetracyclic triterpenoids (Bhutani *et al.*, 1984; Gupta and Verma, 1990), β-sitosterol, δ-amyrin and δ-amyrone (Mariam *et al.*, 1947; Udupa *et al.*, 1965).

Sivaswamy *et al.* (1991) documented a mutagenic effect of *C. quadrangularis*. Finally, Mallika and Shyamala Devi (2003 and 2004) reported an ulcer-protective activity, through both the increase of several mucosal defensive factors and the proliferation of ulcer-healing cells.

2.2.9 COMMIPHORA ERYTHRAEA (HAGARSU)

Fam. Burseraceae

Commiphora species are deciduous trees, usually not exceeding the height of a few metres, noticeable mainly in the Horn of Africa and the Arabian peninsula. They are characterized by trifoliate leaves and a greenish, smooth, papery bark, peeling off in thin membranous patches (Gillette, 1991).

The genus name comes from Greek, and means "gum carrier".

Commiphora erythraea is the main source of opopanax, a fragrant resin extracted from *Commiphora* species, which is widely used all over the world in religious ceremonies or, in China and the Middle East, for the preparation of traditional medicines (other important resins are myrrh, obtained from *Commiphora mirrha*, scented myrrh, produced by *Commiphora guidotti*, and olibanum, extracted from several species of *Boswellia*) (Demissew, 1993; Gachathi, 1997; Thulin and Claeson, 1991).

Commiphora species are easily propagated by cuttings. Seedlings require a good watering. The plants need 4 to 5 years before starting the production of resin, and 10 years to reach full development (Coppen, 1995a).

Even if *Commiphora* trees are sometimes endangered by overbrowsing, their natural distribution is quite widespread, so that establishment and maintenance of cultivations are not considered economically justified (Coppen, 1995b).

In southern Ethiopia, the wood of *Commiphora* is carved to make utensils, pots, bowls and camel bells, while the gum and fruits are eaten, the branches are used for fencing, the sap provides glue for arrows and the fibres are woven to make bags for milk containers (Coppock, 1994).

The Masai people of Kenya use topical applications of the sap of *Commiphora* species for tick control and insect repellency. To treat tick infestations in cows, they also orally administer a decoction made with the

bark of the plant (Minja, 1999). Moreover, the use of resins extracted by *Commiphora* trees in Africa as insecticides for termites has been reported by Pooley (1993) and by Watt and Breyer-Brandwijk (1962).

The Borana people of southern Ethiopia use topical applications of *C. erythraea* bark soaked in camel urine with tobacco leaves, to treat tick infestations (Personal observations); for the same purpose, the bark is also crushed and moistened with water to make a paste (Abubeker, 2003). They also have several other medicinal uses for *Commiphora* species: the bark is boiled in water to make a decoction for the oral treatment of fetal membrane retention or to treat camel skin disorders; bark extracts and sap are mixed with the bark of *Boswellia hildebrantii* to treat worm infestations, while the sap alone is diluted with water to make a juice used for eye problems and mange (Abubeker, 2003).

The Somali people of northern Kenya and southern Ethiopia burn the gum of *C. erythraea* to produce smoke that repels mosquitoes (Bekalo *et al.*, 1996); the gum is also used to treat foot-rot, while the leaves are crushed and mixed with water to orally treat trypanosomosis (Kebede, 2004). Regarding the acaricidal use, the Somali people mix one litre of camel urine with a handful of gum resin of *Commiphora incisa* or *C. erythraea*, heat and stir; the paste obtained, is applied to sites where ticks are attached; once they die, the new ones are allegedly repelled for about one week (Bekalo *et al.*, 1996).

The insecticidal properties of the resin extracted from *Commiphora molmol* have been successfully validated by Massoud and Labib (2000) on the larvae of *Culex pipiens* and *Aedes caspius*. Moreover, Massoud *et al.* (2005) documented the acaricidal properties of the same substance on the adult stage of the tick *Argas persicus*.

Furanosesquiterpenes have been indicated as among the main active components of the essential oil of myrrh and opopanax (Brieskorn and Noble, 1983; Dekebo *et al.*, 2002; Khalid, 1983).

Sesquiterpenes with smooth-muscle relaxing properties have been isolated from *C. guidotti* (Andersson *et al.*, 1997).

Irritation of the skin due to the use of aromatic resins has been widely documented (Hjorth *et al.*, 1961; Ishihara, 1977 and 1978; Itoh *et al.*, 1986; Saeed and Sabir, 2004; Tisserand and Balacs, 1995).

2.2.10 CORDIA AFRICANA (KILTA)

Fam. Boraginaceae

Cordia africana is a deciduous tree up to 30 m tall, characterized by very dense foliage consisting of large, dark green, cordiform leaves (Bekele-Tesemma *et al.*, 1993).

Propagation is achieved by soaking seeds in cold water for six hours before planting; germination takes from 40 to 60 days, and the seedlings are transplanted from the nursery after 4 to 6 months (Katende *et al.*, 1995).

The name of the genus derives from Latin and means “heart shaped”.

The Borana people of southern Ethiopia consider this plant important for yielding edible fruits, sticky gum, wood for utensils, and as an indicator for a close water table (Coppock, 1994).

The ectoparasiticidal effects of *Cordia curassavica* have been reported by Lans and Harper (2000).

Cordia species contain flavonoids (Sertie *et al.*, 1990), polyphenols (Marston *et al.*, 1988), anti-androgenic triterpenoids (Dos Santos *et al.*, 2005; Kuroyanagi *et al.*, 2001 and 2003), sesquiterpenes (De Menezes *et al.*, 2001 and 2004), cromenes (Manners, 1983), saponins (Dos Santos *et al.*, 2005), hydroquinones and benzoquinones (Moir and Thomson, 1973).

Particular antifungal and larvicidal properties of *Cordia* species have been referred to the presence of meroterpenoids (De Menezes *et al.*, 2005), naphthoquinones and a naphthoxirene (Ioset *et al.*, 1998).

The plant has shown anti-inflammatory and analgesic effects (Sertie *et al.*, 2005), as well as an antibacterial activity against both Gram-positive and Gram-negative bacteria (Hernandez *et al.*, 2003).

2.2.11 *CROTON MACROSTACHYS (MAKANISA) AND CROTON MEGALOCARPUS (NYAPO)*

Fam. Euphorbiaceae

Croton macrostachys

Croton megalocarpus

Croton macrostachys is a deciduous tree, usually no more than 18 m tall, characterized by an anastomosis-fissured bark and cordiform leaves. *Croton megalocarpus* is a fast-growing tree, with a rough grey bark and broad leaves; it can exceed 30 m in height but is considerably smaller in semi-arid areas (Kokwaro, 1976).

The name of the genus comes from Greek and means "tick", referring to the appearance of the seeds. The names of the two species are also derived from Greek, *macrostachys* meaning "long spike" while *megalocarpus* can be translated as "big fruit".

Besides their presence in the countryside, these plants are often used in gardens and coffee plantations as shade-trees or boundary markers (Thijssen *et al.*, 1993a and 1993b). The use of *C. megalocarpus* seeds as poultry feed has been proposed (Thijssen, 1996).

The propagation can be done through both seeds and seedlings; germination is rapid and pretreatment is not required (Teel, 1984). However, the seeds cannot be stored for long periods because of the high oil content (Egli and Kalinganire, 1988).

The insecticidal properties of *C. macrostachys* have been reported by Bekele *et al.* (2005) in Ethiopia.

Among the Borana of southern Ethiopia, *C. macrostachys* roots, crushed and mixed with curdled milk, are orally given to treat bloat. In cases of venereal diseases, roots and fruits are squeezed to prepare a water infusion. In addition, the shoots are mixed with leaves of *Hagenia abyssinica*, crushed and soaked in water to be administered in the case of taeniasis (Abubeker, 2003).

Moreover, the sap issuing from the leaves of *C. megalocarpus* is used to topically treat bleeding wounds (Teshale *et al.*, 2004).

Prenylbisabolane, an insecticidal diterpene, has been isolated from *Croton linearis* (Smitt and Högberg, 2002).

Epoxychiromodine (a clerodane diterpene) is considered one of the main medicinally active components of *C. megalocarpus* (Addae-Mensah *et al.*, 1988, 1989, 1991 and 1992a). The oil extracted from the plant has shown an Epstein-Barr virus-activating potency (Yanase and Ito, 1984).

Diterpenoids have also been isolated from *C. macrostachys* (Addae-Mensah *et al.*, 1992b; Kapingu *et al.*, 2000). Crotepoxide, a cyclohexane diepoxide extracted from this plant, has shown some antitumoral effects (Hemingwa *et al.*, 1969).

2.2.12 DATURA STRAMONIUM (QOBO)

Fam. Solanaceae

Datura stramonium is an annual shrub, no taller than 1.5 m, characterized by irregularly dentate leaves, white or purplish tubular flowers, and fruit capsules containing blackish, kidney-shaped seeds; native to the northern hemisphere, it is nowadays present in many parts of the world (Van Wyk and Wink, 2004).

The name of the genus comes from Sanskrit, while the species name derives from the Latin word *stramen*, meaning "straw" and referring to the fact that the plant often grows near pens.

For propagation, seeds must be put into a very well-drained seeding mix, because excessive humidity can cause rottenness in the seedlings (Huxley, 1992).

The Borana of southern Ethiopia use its seed-extracts for poisons and wound healing (Coppock, 1994); moreover, the leaves are crushed until greenish fluid oozes out, then mixed with butter made from cow's milk, to prepare a paste that is topically used for the treatment of trichophytosis (Abubeker, 2003).

The insect-repellent use of *D. stramonium* in Africa was already noticed 60 years ago by Curasson (1947). Afterwards, Van Puyvelde *et al.* (1985) documented the acaricidal properties of the plant in Rwanda, and Bekele *et al.* (2005) recorded the insecticidal properties in Ethiopia.

Datura stramonium contains potentially poisonous tropane alkaloids, mainly hyoscyamine, followed by scopolamine (Miraldi *et al.*, 2001; Philipov and Berkov, 2002; Shonle and Bergelson, 2000; Van Wyk and Wink, 2004), showing a parasympatholytic action through the inhibition of muscarinic acetylcholine receptors. Scopolamine also has strong sedative, hypnotic and depressant

properties, and at high doses provokes hallucinogenic effects (Keeler and Kane, 1967; Micke, 1996).

Hyoscyamine is used as spasmolytic and mydriatic, while scopolamine is included in preparations to reduce kinetosis as well as for Parkinson's disease and visceral spasms. The plant is also used as an analgesic, anti-asthmatic and cough sedative (Van Wyk and Wink, 2004).

Because of the high toxicity of its alkaloids, *D. stramonium* is very poisonous for humans and animals, causing symptoms of atropinic intoxication (Chang *et al.*, 1999; Greene *et al.*, 1996; Hayman, 1985; Huxtable, 1992; Thabet *et al.*, 1999).

Withastramonolide and coumarins (umbelliferon and scopolin) are also present in the plant (Van Wyk and Wink, 2004).

2.2.13 EUPHORBIA CANDELABRUM (ADAMA) AND EUPHORBIA TIRUCALLI (ANO)

Fam. Euphorbiaceae

Euphorbia candelabrum

Euphorbia tirucalli

The genus *Euphorbia* comprises succulent plants, and derives its name from *Euphorbus*, a physician who attended to King Juba II of Roman Mauritania about 2,000 years ago (Pliny the Elder, 77). In Greek, the name means "well fed".

Euphorbia candelabrum (which, according to some authors, is synonymous with *Euphorbia ingens*, while others consider the two plants as distinct species) can grow up to 12 m (*ingens*, in Latin, means "tall"). It is characterized by long, segmented, erect branches, looking like a candelabrum, with spines running along the ridges. Native to southern Africa, it is nowadays cultivated all over the world (Van Wyk and Van Wink, 1997).

Euphorbia tirucalli grows up to 10 m tall, with dense, erect branches devoid of spines, displaying a finger or a pencil-like aspect, whence the common name of "finger tree" or "pencil tree" (Duke, 1983). Native to southern and eastern Africa, it is frequently used for fencing houses and is browsed by goats and camels (Personal observations).

Euphorbia species are very resistant to both drought and pests, well adapted to several types of soils (included salty ones) and needing only little maintenance (Gogerty, 1977). Propagation is easily realized through cuttings, provided that the section surface has been sealed by the milky sap and dried before putting the vegetal parts in the growing soil (Calvin, 1980).

Among the Borana of southern Ethiopia, the sap of *Euphorbia candelabrum* is considered having medicinal value in treating skin sores, while the wood is used to make troughs; the sap of *E. tirucalli* is used to heal skin wounds (Coppock, 1994). The Borana of northern Kenya boil the latex of *E.*

candelabrum in water, and drink the preparation or apply it to swollen glands, to reduce lymphoadenitis (Heine and Brenzinger, 1988).

The insect-repellent properties of *E. tirucalli* have been reported by Rimbach (1977) and observed in Madagascar by Decary (1966). Desouter (1991) described the ectoparasiticidal effect of *E. tirucalli* in Rwanda, and Bekele-Tesemma *et al.* (1993) recorded the use of *Euphorbia abyssinica* against tick infestations in Ethiopia.

The Borana people topically apply the sap obtained from the stem of *E. abyssinica* to treat mange infestations (Teshale *et al.*, 2004). Regassa (2000) noticed the acaricidal use of the latex of *Euphorbia obovalifolia* in western Ethiopia. In a series of *in vitro* trials, he also successfully validated the toxicity of the latex on the tick *Boophilus decoloratus*; moreover, in *in vivo* trials made on zebu cattle, he remarked that the plant can reduce the tick burden up to 70% with a daily treatment continued for 5 days.

As known for a long time with other Euphorbiaceae, the latex of both *E. candelabrum* and *E. tirucalli* is a strong irritant to eyes and skin, producing acute pain and temporary blindness (Kinghorn and Evans, 1975; Morton, 1958 and 1981; Opferkuch and Hecker, 1974; Watt and Breyer-Brandwijk, 1962). The irritant action is due to the presence of several unsaturated diterpene esters, like ingenol and 4-deoxyphorbol (Fürstenberger and Hecker, 1977, 1985 and 1986; Kinghorn, 1979; Opferkuch and Hecker, 1974 and 1982; Uzabakiliho and Largeau, 1987); moreover, this latter compound, very abundant in *E. tirucalli*, can also have an immune-suppressant and carcinogenic effect, through the activation of Epstein-Barr virus and Burkitt's lymphoma development (Fürstenberger and Hecker, 1985; Imai *et al.*, 1994; MacNeil *et al.*, 2003; Opferkuch and Hecker, 1982).

2.2.14 *FICUS SYCOMORUS (ODA) AND FICUS THONNINGII (DEMBI)*

Fam. Moraceae

Ficus sycomorus

Ficus thonningii

Ficus sycomorus is a large tree, up to 25 m tall, native to sub-Saharan Africa and southern Arabia. It is characterized by a very broad crown, usually wider than tall, and by the fruits borne on thin branches arising from the trunk or even the stilt roots. The lateral veins of the large, subcordiform, chartaceous leaves reach the margin around the mid of the lamina, so that the tree can be differentiated from *Ficus glumosa* (which has leaves with lateral veins reaching the margin far below the middle of the lamina); moreover, the latter has smaller fruits than *F. sycomorus* (Berg and Wiebes, 1992).

Ficus thonningii is a medium-sized tree, up to 12 m tall, presenting many aerial roots hanging from the trunk and branches. The leaves are very coriaceous, elliptic to obovate, about 4-8 cm long x 3-5 cm wide. Native to southern Asia and Australia, it is also present in several African countries south of the Sahara (Wagner *et al.*, 1999).

The name of the genus derives from Persian, while *sycomorus* comes from the Greek terms *syke* ("fig") and *moron* ("berry"); *thonningii* is named after the Danish botanist Peter Thonning, who lived in the 18th and 19th centuries.

The propagation of these plants can be achieved through both seeds and cuttings (Katende *et al.*, 1995).

The importance of *F. sycomorus* in southern Ethiopia is testified by its presence in the central part of the Oromyia regional flag.

In the Borana culture, *F. sycomorus* is a good indicator for accessible water tables; the fruit is edible and the wood is used to make mortars, drums, beehives and several utensils; seed and root extracts have medicinal value for women in the post-natal period (Coppock, 1994); bark and seeds are crushed

and boiled in water to make a decoction orally administered for the treatment of human contagious skin necrosis (Abubeker, 2003).

The Borana people consider *F. thonningii* as a good indicator for high water tables; sometimes they also use it as ceremonial grave marker; bark extracts can yield a red dye, and the fruit is edible (Coppock, 1994); the bark is crushed and soaked in water to make a paste, which is topically used to reduce swelling of the legs (Abubeker, 2003).

The ectoparasiticidal effects of *Ficus* species have been described by Wilbert (1920) in West Africa. The use of the latex of *Ficus obovalifolia* for tick control in western Ethiopia has been recorded by Regassa (2000); the author validated this observation *in vitro* and *in vivo*, finding results similar to those for *Euphorbia obovalifolia* (see chapter 2.2.13).

The use of *F. sycomorus* by the Borana people to treat sarcoptic infestations has been reported by Heine and Brenzinger (1988), while Abubeker (2003) recorded a similar use of *F. glumosa*.

From the stem bark of *Ficus glomerata*, Hasan *et al.* (1991) isolated an alkaloid with antibacterial activity. Moreover, from the same plant Rahman *et al.* (1994) isolated some compounds (mainly β-sitosterol) that reduce the glucose level in blood through the inhibition of glucose-6-phosphatase and arginase and the activation of glucose-6-phosphate dehydrogenase in the liver, thus producing an anti-diabetic action.

From the sap of *Ficus carica* leaves, Zaynoun *et al.* (1984) isolated two photoactive furocoumarins, psoralen and bergapten, causing dermatitis by photosensitization.

2.2.15 LANTANA CAMARA (MIDAN DUBRA)

Fam. Verbenaceae

Lantana camara is an evergreen shrub, up to 3 m tall, characterized by small clustered flowers with various colours (mainly white, pink, yellow and orange), resulting in more than 50 recognized variants; the fruit is a small black berry, while the leaves are dark green, covered with rough hairs, and emanating an acrid smell when crushed (Duke, 1985; Oliver-Bever, 1986; Sastri and Kavathekar, 1990).

Native to tropical America, *L. camara* is considered one of the worst weeds in the world (Holm *et al.*, 1977; Sharma *et al.*, 1988) and is nowadays widespread in many parts of the planet (Holm *et al.*, 1979).

The plant can be propagated by both seeds and cuttings, and grows well in many environments, including salty soils, without requiring any special attention; it also resists common pests (Singh *et al.*, 1996).

In southern Ethiopia, *L. camara* is sometimes conspicuous in gardens around houses (Personal observations).

Lantana camara is used as a repellent against mosquitoes in Kenya (Ongore *et al.*, 1989), and its efficacy has been documented (Dua *et al.*, 1996; Seyoum *et al.*, 2002a and b, and 2003).

Especially unripe berries, but also the foliage, are considered very poisonous to ingest. Fresh *Lantana* can cause toxic reactions in ruminants starting from 1-2% of the body weight (Bromilow, 2001; Sastri and Kavathekar, 1990).

Severe poisoning in cattle, sheep, water buffaloes, goats, camels, pigs, horses, dogs, rabbits, kangaroos and guinea pigs, as well as human fatalities, have been reported (Black and Carter, 1985; Fourie *et al.*, 1987; Johnson and Jensen, 1998; Riet-Correa *et al.*, 1984; Sharma *et al.*, 1981 and 1988; Tokarnia *et al.*, 1984 and 1999).

The toxicity of the plant is due to the alkaloid lantanin, its pentacyclic triterpene derivatives lantadene A and B, and their reduced forms dihydrolantadene A and icterogenin (Duke, 1985; Ghisalberti, 2000; Seawright, 1965).

Even if, in some acute cases, these compounds can elicit atropine-like reactions and gastrointestinal irritation, the prevalent symptoms in livestock are referable to hepatogenous photosensitization, with marked jaundice and skin lesions after sun exposure (Black and Carter, 1985; Brito and Tokarnia, 1995; Ide and Tutt, 1998; Seawright and Allen, 1972; Sharma *et al.*, 1988 and 1989). Liver and kidneys are the most affected organs (Gopinath and Ford, 1969; Sharma *et al.*, 1981). No antidote is available (McKenzie, 1991; Pass, 1986; Pass and Stewart, 1984).

Lantanoside, lantanone, linaroside and camarinic acid isolated from the plant have shown nematocidal effects (Sharma, 1996).

The antibacterial activity of *L. camara* has been reported in Benin (Ali *et al.*, 2002 and 2003).

Toxic lantanoids and alkaloids from the plant can also have cytotoxic and antitumoral activities (Raghu *et al.*, 2004).

2.2.16 MAERUA TRIPHYLLA (LAMALOSHIGY)

Fam. Capparaceae

Maerua triphylla is a medium-sized tree, up to 15 m tall, with distinctive white laciniate flowers, irregularly crooked trunk, buttressed base, stilt roots and usually three leaves (frequently retuse) on each joint (the reason for adopting the Greek term *triphylla*). It is a typical tree of the African savannah (Hedberg *et al.*, 1982).

The plant can be propagated through seeds (Diallo *et al.*, 1992).

In Tanzania, the leaves are mixed with those of *Boscia salicifolia* and burned; then, the ashes are used against tuberculosis or as an antidote to poisons (Hedberg *et al.*, 1982). Fresh roots are chewed or taken as a decoction to treat snake bites (Kokwaro, 1976). The plant is also used for marasmus and malnutrition (Watt and Breyer-Brandwijk, 1962).

A related species, *Maerua edulis*, is known in Swaziland as a pesticide (Long, 2005).

Terpenoids and glycosides have been extracted from several *Maerua* species (Abdel-Mogib, 1999; Ahmed *et al.*, 1972; Bishay *et al.*, 1990; Ramadan *et al.*, 1998 and 1999).

2.2.17 *OCIMUM SUAVE* (ANCHABI)

Fam. Lamiaceae

Ocimum suave is a perennial, erect shrub, up to 1 m tall (Burkill, 1995), widespread over the open wastelands of tropical Africa and Asia (Hassanali *et al.*, 1990). Also frequently noticed on the sides of country roads, it is characterized by hairy leaves and white to purple flowers arranged in dense clusters along the flowering stalks (Van Wyk and Gericke, 2000).

The name of the genus is derived from Greek, and according to some authors might mean "to be fragrant" (Oliver, 1960), while the name of the species, meaning "pleasant", comes from Latin.

The plant can be propagated by both seeds and cuttings. The germination rate is sometimes low, and the development of seedling-roots takes almost a month. *Ocimum suave* can be cut up to five times per year (Sulistiarini, 1999).

Ocimum species are well known by many rural people in Africa as cosmetics (Van Wyk and Gericke, 2000), for their medicinal value against stomach-ache, cough and influenza (Hassanali *et al.*, 1990), and their repellent and toxic properties against insects (Grainge and Ahmed, 1988; Hassanali and Lwande, 1989; Pandey and Verma 1982; Pandey *et al.*, 1983a and 1983b). In southern Ethiopia, the leaves of *O. suave* are eaten as a stimulant (Coppock, 1994).

Ocimum basilicum and *Ocimum americanum* have shown insect-repellent properties in Kenya (Githinji and Kokwaro, 1993; Seyoum *et al.*, 2002a and b) and Malawi (Irvine, 1955), as well as *Ocimum canum* in Guinea Bissau (Palsson and Jaenson, 1999) and Zimbabwe (Lukwa *et al.*, 1996), and *Ocimum gratissimum* in Tanzania (Minja, 1994). Moreover, *O. canum* has shown good insecticidal effects on mosquitoes in Zimbabwe (Lukwa, 1994).

Ocimum suave is known as an insect repellent in eastern Africa (Kokwaro, 1976), especially in Kenya (Johns *et al.*, 1990; Seyoum *et al.*, 2002b), and has shown good results on maize pests (Hassanali and Lwande, 1989; Hassanali *et*

al., 1990). In several parts of the African continent, branches of *O. suave* are often placed around windows and doors to keep mosquitoes away (Berger, 1994; Stephens *et al.*, 1995; White, 1973); Pålsson and Jaenson (1999) successfully validated this method in Guinea Bissau.

Seyoum *et al.* (2002b and 2003) documented a strong repellent effect of an extract from the leaves of *O. suave* and *Ocimum kilimandscharicum*, thermally expelled on *Anopheles gambiae*; similarly, they remarked a significant repellent effect of intact potted *O. americanum*, but not *O. kilimandscharicum* and *O. suave*, on the same insect. The insect-repellent activities of *O. americanum* have been successfully tested by Tawatsin *et al.* (2001). An analogous effect has been demonstrated by Erler *et al.* (2006) for *O. basilicum*, by Padilha de Paula *et al.* (2003) for *Ocimum selloi* and by Usip *et al.* (2006) for *O. gratissimum*.

The essential oil of *O. basilicum* is larvicidal, producing 100% mortality on *Culex pipiens fatigans* larvae at a concentration of 0.12% (Chavan and Nikam, 1982). The essential oil of *O. canum* has shown ovicidal and larvicidal activities against *Aedes aegypti* and *Anopheles gambiae* (Bassole *et al.*, 2003).

Mwangi *et al.* (1995) demonstrated repellent and acaricidal properties of an oil extracted from the leaves of *O. suave*, experimented on all stages of the tick *Rhipicephalus appendiculatus*.

Ocimum suave has shown antidiarrhoeal activity (Ilory *et al.*, 1996) and, like *Ocimum lamiifolium*, antipyretic effect (Makonnen *et al.*, 2003). The essential oil of *O. gratissimum* has revealed antifungal (Dubey *et al.*, 2000) and antibacterial (Orafidiya *et al.*, 2001) properties. The seed oil of *Ocimum sanctum* has shown chemopreventive activity (Prakash and Gupta, 2000).

The main active component of the volatile oil extracted from *Ocimum* species is eugenol, a phenolic compound with disinfectant, insect-repellent or attractant (depending on the concentration, the species of insects and the mixture of compounds), and insecticidal properties (Chogo and Grank, 1981; Hassanali *et al.*, 1990; Obeng-Ofori and Reichmuth, 1997); in addition, it has an inhibitory effect on the growth of many fungi (Garg and Siddiqui, 1992).

Eugenol and its derivatives (mainly methyleugenol and isoeugenol) are depressant on the central nervous system (De Vincenzi *et al.*, 2000; Sayyah *et al.*, 2002) and are used as anaesthetics in rodents and fishes (Carlini *et al.*, 1981; Ingvast-Larsson *et al.*, 2003), dental cement and analgesics (Bayindir *et al.*, 2003; Lee *et al.*, 2005), fungicides (Dev *et al.*, 2004), insect attractants in eradication programmes (Metcalf *et al.*, 1975; Vargas *et al.*, 2000; Whitworth *et al.*, 2002) and flavouring agents in food preparation (Fenaroli, 1995).

The use of such compounds as fragrances for cosmetics has caused some problems of contact allergy (Safford *et al.*, 1990; Sanchez-Perez and Garcia-Diez, 1999; SCCNFP, 1999). Moreover, they are potentially toxic for liver and carcinogenic (Abdo *et al.*, 2001; NTP, 2000; WHO, 1981).

Mono- and sesquiterpenoids have also been isolated from *O. suave* (Hassanali *et al.*, 1990).

2.2.18 RICINUS COMMUNIS (QOBO)

Fam. Euphorbiaceae

R. communis (green variety)

R. communis (red variety)

Ricinus communis is a perennial, woody shrub of tropical Africa (Alber and Alber, 1993), up to 10 m tall, with characteristic toothed stalked leaves, showing pointed leaflets with slightly serrated margins and prominent central veins; it is easily recognized by the green or reddish (according to variety) pistillate flowers, constituted by three-seeded capsules, about 1-2 cm in diameter, provided with dense spines (Cooper and Johnson, 1994). In temperate zones it grows as an annual.

The Latin name of the genus is based on the seeds resembling ticks (Armstrong, 1982), while *communis* in Latin simply means "common".

Propagation can be realized through both seeds and cuttings. Germination can be accelerated by soaking the seeds in water for one day and nicking them before planting; the growth is rapid (Schery, 1972; Smith, 2002).

In southern Ethiopia, seed extracts of *R. communis* are used for venereal diseases (Coppock, 1994). The Borana people crush and soak the root in water to make an infusion for orally treating fetal membrane retention (Abubeker, 2003), while the Gerri people pound and boil the leaves for the same purpose (Kebede, 2004).

In Africa, the insecticidal and acaricidal properties of *R. communis* have been noticed in Chad (Aniyere, 1994), the Democratic Republic of Congo (Defour, 1994), Niger (Curasson, 1947), Sahel (Bernus, 1969), West Africa (Traore, 1938) and Zimbabwe (Gelfand *et al.*, 1985).

Ricinus communis is very toxic because of ricin, a proteinic hydrosoluble toxin present in the whole plant, but mainly in the seeds (Balint, 1974); ricin is enterically absorbed only if the seed shell is broken (Wiley and Oeltmann, 1991). Fowls are more resistant than mammals: while about 5 seeds can be lethal for a cow or horse, up to 80 are required to kill a chicken or duck

(Okoye *et al.*, 1987). Moreover, the toxin is more powerful if inhaled, and more again if parenterally inoculated; in the latter case, the median lethal dose (LD_{50}) is around 1 part per million of the animal mass (Challoner and McCarron, 1990; Knight, 1979; Robertus, 1991). Ricin performs its cytotoxic action through ribosomal inactivation, blocking protein synthesis (Barbieri *et al.*, 1993; Endo *et al.*, 1987; Fernandez-Puentes *et al.*, 1976; Montanaro *et al.*, 1975; Olsnes *et al.*, 1975).

In addition, the plant contains RCA (*Ricinus Communis* Agglutinin), a liposoluble toxin not absorbable through the intestine (Frenoy *et al.*, 1986; Humphreys, 1988; Osweiler, 1996). In the case of parenteral inoculation, hemagglutination produced by this component is added to the cytotoxicity caused by ricin (Wiley and Oeltmann, 1991).

Symptomatic treatment only can be used for *Ricinus* poisoning, because there is no antidote (Ellenhorn *et al.*, 1988).

In 1978, a Bulgarian dissident journalist was killed in London by a ricin-pellet embedded in his leg through a modified umbrella acting as a syringe (BBC, 2003). Furthermore, some reports have indicated that, in Afghanistan, traces of ricin have been found in caves alleged to be controlled by the fundamentalist group *Al Qaeda* (BBC, 2002). At the present time of concern over terrorist attacks, it is feared because of its wide availability in nature, the ease of extraction and the stability (CNN, 2003).

Ricin and RCA have been studied for both cancer diagnosis and treatment (Dabelsteen and Mackenzie, 1978; Fjallskog *et al.*, 1994; Frankel, 1993; Nicolson *et al.*, 1975; Wei and Koh, 1978).

In fact, ricin shows a higher affinity for transformed cells than normal ones, and a consequent strong inhibitory effect on the growth of tumour cells (Lin and Liu, 1986). Moreover, it is also joined to monoclonal antibodies for the production of immunotoxins targeting specific malignant tumour cells (Lazzaro *et al.*, 1995; Vitetta and Thorpe, 1991).

Besides, the different distribution of RCA receptors in cancer tissues compared to normal ones has been proposed as a means to differentiate tumours from other pathologies (Ishiguro and Takahashi, 1989; Zhang, 1989).

As ricin is soluble in water, it can easily be separated and eliminated for medicinal preparations. In this case, the extraction is done by cold pressing, to avoid the toxin from dissolving in the oil (Van Wyk and Wink, 2004). The product obtained is rich in ricinoleic acid, a strong laxative agent (Duke, 1985), which accounts for about 90% of the triglyceride fatty acids in the oil (Van Wyk and Wink, 2004).

Ricinus communis has also shown antifungal activity (Bilgrami *et al.*, 1980).

2.2.19 SOLANUM INCANUM (HIDDI) AND SOLANUM SOMALENSE (HIDDI GAGA)

Fam. Solanaceae

Solanum incanum

Solanum somalense

Solanum incanum is one of about 1,500 *Solanum* species in the world. Widely distributed in the Horn of Africa, it shows characteristic thorny leaves, yellow fruits and blue flowers with yellow pistils.

Solanum somalense shows oblong, entire leaves, without thorns, while the fruits and the flowers are similar to those of *S. incanum*.

The name of the genus comes from the Latin *solamen*, meaning "relief", indicating the narcotic effects of the plant (Jaeger, 1985); *incanum* is a Latin term meaning "white".

Solanum incanum is propagated by seeds, which usually do not germinate quickly; one month is needed to reach a germination rate of 50% (Joshua, 1978).

Among the Borana of southern Ethiopia, the fruit of *S. incanum* is the main part used for medicinal purposes: dissected and pounded in a water infusion, it is orally administered to treat cowdriosis; roasted in wood ash and cut in small pieces, it is applied onto dermatophilosis skin lesions; crushed and boiled in water, it is given *per os* to treat pasteurellosis. Moreover, a root decoction is used to orally treat black leg, while the bark is boiled in water and orally administered in cases of snake bite (Abubeker, 2003).

The Borana people use *S. somalense* to prepare a decoction of roots given *per os* to treat liver fluke; besides, the fluid issued from the fruit is topically applied in cases of foot rot (Abubeker, 2003).

The ectoparasiticidal effects of *Solanum* species in Africa have been described by Van Puyvelde *et al.* (1977), and Ichikawa (1987) reported an insect-repellent use for *Solanum dubium* in Kenya. The use of *Solanum* species for the treatment of ectoparasitoses is well known in Rwanda (Mbarubukeye,

1992), where Van Puyvelde *et al.* (1985) successfully validated the acaricidal activity of a petroleum ether fraction extracted from *Solanum dasyphyllum* fruits. Regassa (2000) recorded the use of *S. incanum* fresh juice in western Ethiopia and documented its acaricidal effect *in vitro* on the tick *Boophilus decoloratus*.

Solanum species contain toxic steroidal alkaloids, such as solanine, solasodine and solanidine (Fukuhara and Kubo, 1991; Van Wyk and Gericke; 2000). Saponins and tannins are also present, and can contribute to the medicinal activity (Van Wyk and Wink, 2004).

Solanum alkaloids act as acetylcholinesterase inhibitors, with consequent impairment of the acetylcholine neuro-mediator function (McGehee *et al.*, 2000; Tanner, 1952). The possibility of poisoning after ingestion is diminished by the poor intestinal absorption of solanine, which is hydrolyzed into solanidine (a less toxic aglycone) by the intestinal flora and eliminated in urine and faeces (Concon, 1988; Groen, 1993). Unripe fruits seem to be more dangerous than ripe ones (Bromilow, 2001; Duke, 1985).

Solanum glycoalcaloids have several adverse effects on humans and animals (Duke, 1985; Mensinga *et al.*, 2005; Phillips *et al.*, 1996), including teratogenicity (Wang, 1993). However, they have not shown genotoxicity (Friedman and Henika, 1992) but, on the contrary, have more recently revealed promising antitumoral properties (Friedman *et al.*, 2005, Lee *et al.*, 2004).

Astringent, antimicrobial and antifungal activities have also been reported (Beaman-Mbaya and Muhammed, 1976; Mahmood and Gundidza, 1994; Tamboura *et al.*, 2000; Van Wyk and Wink, 2004). In addition, *S. incanum* has shown an antihepatotoxic effect (Lin *et al.*, 1988).

2.2.20 *STERCULIA RHYNCHOCARPA* (QARARE)

Fam. Sterculiaceae

Sterculia rhynchocarpa is a small deciduous tree, generally no taller than 10 m, present in semi-arid bush up to an altitude of 1,500 m. It has irregularly and obliquely spreading branches, with dense and heavy foliage (Souane, n.d.); the trunk is frequently slanting and blotchy grey (Luke, 2005). The species shows good efficiency in conserving its water content (Feinner, 1981).

The name of the genus is derived from the Latin god *Sterculius* (Coates Palgrave, 1983), while *rhynchocarpa* in Greek means "fruit shaped like a beak".

Some species of *Sterculia*, mainly *S. urens*, yield gum karaya, a complex polysaccharide of high molecular weight, containing galactose, rhamnose and galacturonic acid, obtained from a bark dried exudate (Brito *et al.*, 2004; Verbeken *et al.*, 2003). It is mainly used in the food industry for its binding and emulsifying properties, making it suitable as a stabilizer, water-holder and water-absorber. In the pharmaceutical industry, it is employed as a bulk laxative and denture adhesive (Kumar *et al.*, 1988; Le Cerf *et al.*, 1990).

The Borana of southern Ethiopia pick the fruits for human consumption, while the fibres are woven to manufacture containers, and bark strips are used for well-ladder construction (Coppock, 1994). They also topically apply the sap or a decoction obtained from the stem of *Sterculia alexandri*, to treat mange infestations (Teshale *et al.*, 2004).

The Gerri people crush and soak the roots of *S. alexandri* in water, to topically treat skin necrosis (Kebede, 2004), and use a water extract of *S. rhynchocarpa* bark and sap for a topical treatment of tick infestations (Personal observations).

The insecticidal use of *Sterculia cordifolia* was reported in Guinea long ago (Saikhou, 1939), and recently an analogous effect has been demonstrated for *Sterculia foetida* by De Vasconcelos *et al.* (2006).

Regarding the biochemical content, *S. foetida* has been investigated more than other *Sterculia* species. Its seed oil has a high content of cyclopropane fatty acids, mainly sterculic acid (Bao *et al.*, 2002 and 2003).

2.2.21 TAGETES MINUTA (SUNKI - MISH MISH)

Fam. Asteraceae

Tagetes minuta is an erect annual herb reaching more than 1 m in height, characterized by pinnate leaves with finely serrate margins and small, whitish-yellow cylindrical flower heads (Soule, 1993; Van Wyk and Gericke, 2000). It is sometimes considered a weed, but it drives away nematodes from the fields (Bromilow, 2001; Leung, 1980). Native to South America (Espinar, 1967; Herrera, 1941; McVaugh, 1943; Perkins, 1912; Reiche, 1903), it is currently found all over the world.

The name of the genus derives from *Tages*, an Etruscan deity with prophetical abilities, who emerged from the ploughed earth. In Roman culture, *Tages* was thought to be a son or grandson of Jupiter (Holm *et al.*, 1997a and b); the Latin term *minuta* means "small".

The plant is propagated by seeds, which germinate within two weeks near the surface of well-drained clay or sandy soils, while slugs and snails are the main problems for seedlings (Brickell, 1990; Huxley, 1992).

Tagetes minuta produces a dye widely used as a wool colouring; moreover, because of its highly aromatic smell, the essential oil of the plant is used in perfumery (Craveiro *et al.*, 1988) and as a flavouring agent in the food industry (Van Wyk and Gericke, 2000).

The Borana people of southern Ethiopia crush and soak the roots of *T. minuta* in water to make a paste topically applied for treating wounds in camels (Coppock, 1994); in addition, the root is boiled and orally administered as a water decoction to solve constipation (Abubeker, 2003). The local name *sunki* means "poison".

Tagetes minuta is used as an ectoparasiticide in eastern and southern Africa (Watt and Breyer-Brandwyk, 1962), particularly in Ethiopia (Getahun, 1976), Kenya (Bekalo *et al.*, 1996; Ichikawa, 1987; Timberlake, 1987) and Uganda

(Heine and König, 1988). The use of the plant as a repellent for insects has been reported in eastern and southern Africa (Watt and Breyer-Brandwyk, 1962), especially in Kenya (Bekalo *et al.*, 1996; Seyoum *et al.*, 2002b) and Zimbabwe (Lukwa *et al.*, 1999).

Both insecticidal and insect-repellent properties of *T. minuta* and other *Tagetes* species have been widely documented (Cestari *et al.*, 2004; Green *et al.*, 1991; Heal *et al.*, 1950; Keita *et al.*, 2000; Laurent *et al.*, 1998; Okoth, 1973; Perich *et al.*, 1994; Sharma and Saxena, 1994; Sukamar *et al.*, 1991; Tyagi *et al.*, 1997; Weaver *et al.*, 1994). Nevertheless, Seyoum *et al.* (2002a) did not record a significant repellent effect of potted *T. minuta* on *Anopheles gambiae*.

Antibacterial (Tereschuk *et al.*, 2003), antiviral (Abad *et al.*, 1999), antifungal (Bii *et al.*, 2000), acaricidal (Ruffinengo *et al.*, 2005) and nematocidal (Ijani and Mbaga, 1988; Oduor-Owino *et al.*, 1993) activities of the plant have also been reported.

Thiophenes are the main insecticidal components of *Tagetes* species (Macedo *et al.*, 1997; Margl *et al.*, 2002; Perich *et al.*, 1995); they are found in the whole plant, but principally in the root (Downum and Towers, 1983; Hogstad *et al.*, 1984; Ketel, 1987), which is the main site of their synthesis (Margl *et al.*, 2002). Other active components are ocimene, limonene, ocimenone, trans-anetol, tagetone and dihydrotagetone (Baser and Malyer, 1996; Daghero *et al.*, 1997; Maradufu *et al.*, 1978; Tomova *et al.*, 2005; Van Wyk and Gericke, 2000; Wells *et al.*, 1993).

2.2.22 *VERNONIA AMYGDALINA (EBICHA)*

Fam. Asteraceae

Vernonia amygdalina is a semi-deciduous tree up to 12 m tall, with simple, alternate, lanceolate leaves up to 15 cm long, with serrate margins (Souane, n.d.). In Africa, the curative effect of this very bitter tasting plant is also known by chimpanzees, which eat the leaves to treat internal parasitic diseases (Biser, 1998; Huffman and Seifu, 1989; Jisaka *et al.*, 1993; Koshimizu *et al.*, 1994).

The genus is named after William Vernon, an English botanist who lived in the 17th and 18th centuries (Wild, 1978), while the Latin term *amygdalina* means "almond-like".

Vernonia amygdalina is propagated by seeds and stem cuttings (Okafor, 1981).

In southern Ethiopia, the leaves and bark of *V. amygdalina* are crushed together and soaked in water, to reduce the bitter taste, before being orally administered in cases of intestinal worm infestations, as well as for purgation and reducing urinary tract inflammation (Abubeker, 2003). In addition, the pith is used as soap and the flowers are considered of great value for honey production (Coppock, 1994).

In Africa, *V. amygdalina* is widely used to treat ectoparasitoses in Burundi (Baerts and Lehmann, 1989 and 1991), the Democratic Republic of Congo (Byavu *et al.*, 1999; Chifundera, 1998; Defour, 1994; Kasonia and Yamolo, 1994; Kasonia *et al.*, 1991 and 1993) and Rwanda (Desouter, 1991; Mbarubukeye, 1992). In western Ethiopia, the juice of crushed leaves is used in tick control (Regassa, 2000).

Vernoniosides (steroid glucosides stigmastane-type) extracted from the leaves of *V. amygdalina*, seem to be responsible for the nematocidal activity

observed in chimpanzees (Jisaka *et al.*, 1992; Kamperdick *et al.*, 1992; Ohigashi *et al.*, 1991) and in plants (Ajayi *et al.*, 1993).

The antimalarial effect of *V. amygdalina* is due to the presence of some sesquiterpene and steroidal components, showing interesting *in vitro* potency against *Plasmodium falciparum* (Phillipson *et al.*, 1993).

The antitumoral properties of the plant (Masaba, 2000) are due to some cytotoxic sesquiterpene lactones, such as vernodaline, vernolide and vernomygdine (Jisaka *et al.*, 1993; Kupchan *et al.*, 1969), as well as some peptides, such as edotides (Izevbigie, 2003).

Luteolin flavonoid compounds, extracted from the leaves of *V. amygdalina*, have shown antioxidant activities (Igile *et al.*, 1994).

Antimicrobial (Akinpelu, 1999), laxative (Awe *et al.*, 1999), analgesic-antipyretic (Okokon and Onah, 2004) and oxytocine-like (Kamatenesi-Mugisha *et al.*, 2005) effects of the plant have also been reported.

2.3 COLLECTION OF PLANTS

The plants used for the extraction were collected in southern Ethiopia in September 2004.

Because of the delay in the rainy season beginning, additional collecting was required all over the area, including some trips to the neighbouring Yabello *wereda* where the effects of the absence of rain were less severe.

Collection of B. angustifolia leaves

Also, as a result of several conversations with both traditional healers and nomadic pastoralists, the number of plants was increased to 28 species or varieties, rather than the 15 listed in the project proposal.

The fact that local people call by the same name different plant species that look similar, made correct identification difficult. Moreover, the same species sometimes have different common names according to people living in different districts.

Therefore, deep inquiry was necessary to determine the exact identification for any plant. Dr. John Githiori (from the International Livestock Research Institute of Nairobi, Kenya) and the "Flora of Ethiopia and Eritrea Project"[1] (providing detailed information, drawings and vernacular names for any plant of the area) were the main sources in the identification process.

For most of these plants, the leaves were collected. However, because of the scarcity of foliar material, bark was preferred in the cases of *A. seyal*, *C. erythraea* and *S. rhynchocarpa*. Moreover, the branches of *E. candelabrum* and *E. tirucalli* were used, as well as the whole stem of *A. somalense* and *C. quadrangularis*, and the whole plant of *T. minuta* and *O. suave*. Due to the practical aims pursued by this work, the choice of vegetal part collected was made by considering what is easily available in sufficient quantities all over the year in the area.

Gloves were worn during the collection in order to avoid any contamination, especially due to fungi. To ensure an adequate ventilation, the plant material was transported in paper bags and scattered on paper sheets to dry in the shade at room temperature.

[1] The "Flora of Ethiopia and Eritrea Project" started in 1980 and is still in process. It is carried out by the Botanical Museum and Library of Copenhagen (Denmark), the National Herbarium of Addis Ababa (Ethiopia), the Swedish International Development Agency (SIDA) through its Department of Research Cooperation (SAREC), the Department of Systematic Botany of Uppsala (Sweden) and the Royal Botanic Gardens of Kew (United Kingdom).

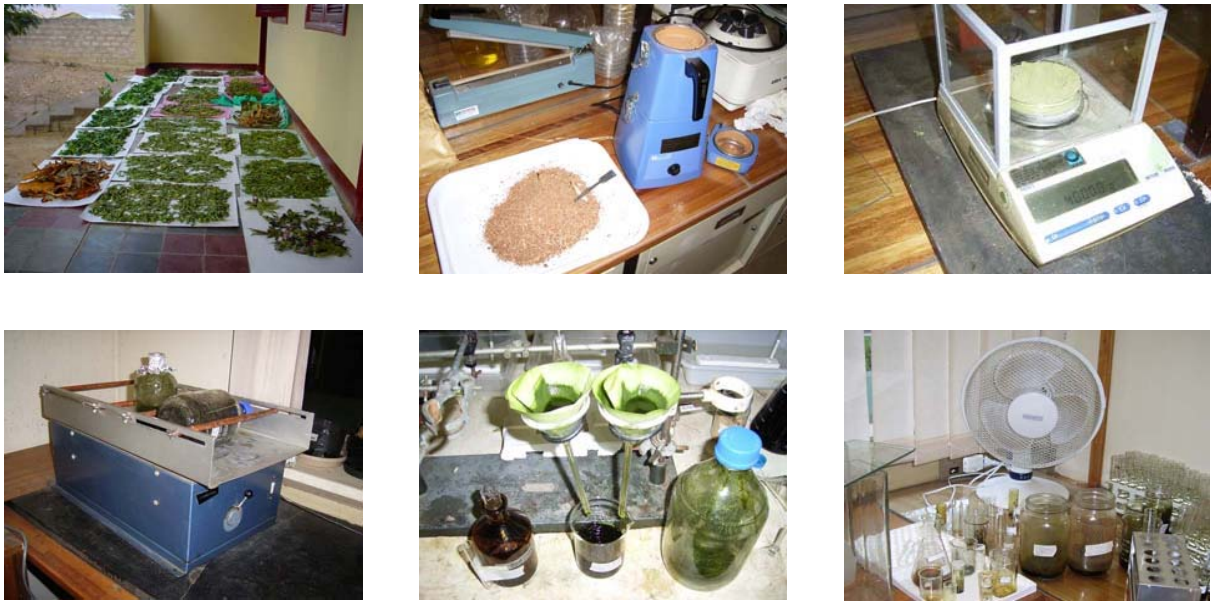
2.4 EXTRACTION OF PLANT MATERIAL

After collecting and drying, plant material was ground to a fine powder and extracted with hexane, acetone or water. In order to better enhance the potential acaricidal or acari-repellent properties of the plant species, water was discarded after some preliminary tests because of the poor efficacy of the relevant extracts for the larger part of the plants.

Acetone was selected because of its good property to dissolve many hydrophilic and lipophilic components, its easy miscibility with water, its rapid volatility and low toxicity, so that the interference with the ecto-parasiticidal effects of vegetal active principles is negligible (Eloff, 1998), while hexane was used in the repellency bioassays because of its good capacity to extract highly non-polar volatile compounds, frequently responsible for repellency phenomena.

A 10% dilution of the plant material (20 g in 200 ml of solvent) was mechanically shaken for 20 minutes, the supernatant was filtered out with Whatman (Number 1) filter paper, and the filtrate was placed in a desiccating chamber at room temperature.

The dried extracts were then diluted in the same extracting solvent, at the ratio (20%, 10%, 5% or 1%) required for the bioassays.



From left to right, and from top to bottom: drying of leaves and barks, grinding of plant material, weighing of ground material, shaking of material added to the extractant, filtration of material, drying of extracts.

2.5 MAINTENANCE OF TICKS

For every bioassay, *Rhipicephalus pulchellus* unfed adult ticks, disregarding the sex, were used. During the laboratory phase of the research, ticks were kept in a glass chamber, closed by a removable cover, at an average temperature of 20 ± 5 °C. Moreover, an average humidity of 80 ± 10% was maintained by a potassium chloride saturated solution placed on the floor of the chamber.

The ticks were stored in vials closed with cotton wool, in order to allow normal air exchange; the vials were set on a square glass plate, placed at the base of the chamber on four small bearings, so that the edges of the plate were at a distance of 1.5 cm from the walls (see picture on the right).

In this way, the saturated saline solution on the floor could also prevent the ticks from reaching the walls, in case of accidentally escaping the vials.

After one and a half months, the solution was completely renewed to restore the appropriate humidity rate.

2.6 BIOASSAYS

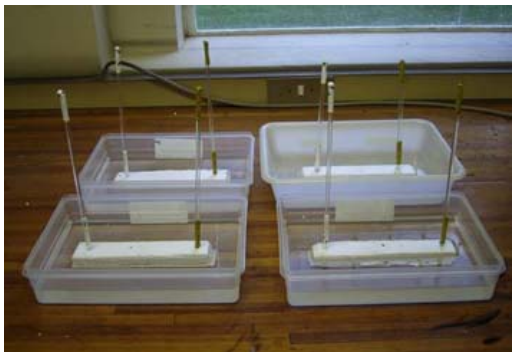
The bioassays were carried out at room conditions, with an average temperature of 20 ± 5 °C, and an average humidity of 50 ± 10%. For all the bioassays, four replications, each with ten ticks, were performed.

The ticks were carefully handled by means of small forceps, in order to avoid any damage to their bodies, which could compromise the test results.

2.6.1 REPELLENCY BIOASSAY

According to Nchu (2004), a tick repellent can be defined as "a substance whose stimulus elicits avoidance response in ticks and/or prevents ticks from setting on a vantage position of a glass-rod for a specified time period". Moreover, a climbing repellency bioassay "is based on the climbing behaviour of host-seeking ticks: except for the genus *Amblyomma*, most ticks climb to vantage positions on grass waiting for the vertebrate hosts" (Nchu, 2004).

Ticks of the genus *Rhipicephalus* show a clear tendency to climb, also noticeable with common glass-rods frequently used in laboratory conditions (Browning, 1976).



Repellency Bioassay: four replications were done for all extracts

In the bioassay used here, two glass rods (30 cm long, and with a diameter of 6 mm) were centrally inserted at a distance of 2 cm from the opposite edges of a rectangular polystyrene platform (20 cm long, 5 cm wide and 3 cm tall). Both the top and bottom parts of the rods were covered (for a length of 5 cm) with a slip of Whatman (Number 1) filter paper, 5 x 3 cm, stuck by means of an inert adhesive material.

Both filter slips of the first test rod were uniformly impregnated with 1 ml of the testing solution (solvent plus extract), while the two filter slips of the other rod were impregnated with 1 ml of the extracting solvent only. In order to avoid contamination, every operation was performed wearing latex gloves.

The platform was fixed centrally in a rectangular basin (30 x 20 cm, with a depth of 5 cm), to which water was added to almost reach its height, in order to prevent the ticks from moving away. Ten ticks were placed in the central part of the platform (see illustration on the right), equidistant from the two glass rods.

The number of ticks remaining on the platform, or climbing on each glass rod, was recorded after 30, 60, 90 and 120 minutes, also taking into consideration their arrangement (bottom slip, middle part, top slip) on the rods.

In general, the ticks settled within the first hour or hour and a half, and only a few movements were recorded later. Moreover, because of their climbing behaviour, they showed a tendency to prefer the filter paper fixed to the top of the rod rather than stay on the bottom one.

The ticks showed a clear tendency to settle on the top of the rods, whether only on the control rod (left) or, in the case of a non-repellent extract, also on the test rod (right). The few ticks recorded on the middle part (uncovered) of the rods were usually just moving from the bottom to the top (centre).

Only a small number of ticks were noticed on the glass rod between the two filter papers at the time of recording the position. In these cases, they were generally just moving from one filter paper to another (usually from bottom to top), so it was decided to disregard the differences of position, and to consider the total number of ticks settled on a specific rod.

All the repellency bioassays started with hexane and acetone extracts at a concentration of 10%, then, in the case of repellency indexes higher than 50, the extracts were also tested at 5% and 1%.

2.6.2 TOXICITY BIOASSAY

In the toxicity bioassay applied, 1 µl of the testing solution was dropped onto each of ten ticks, before storing them in a vial provided with a perforated stopper. The mortality rate was recorded after 24 hours.

Because of the toxicity of hexane, only acetone extracts were employed for the tests. In order to check if acetone was well tolerated by the ticks, a control bioassay was performed using only the solvent, and there were no symptoms of toxicity.

Immersion tests were discarded because of the toxic effects of acetone, observed with this methodology (Chagas *et al.*, 2003; Freitas and Fernandes, 2005; Gonçalves *et al.*, 2007). On the contrary, the solvent does not show toxicity when topically applied onto ticks, as the contact time is short (Porter *et al.*, 1995; Williams, 1993). Moreover, Nchu *et al.* (2005) did not record acaricidal effects of acetone employed in three different contact toxicity bioassays.

In the case of some extracts, many ticks had abnormal, non-viable movements, even when the mortality rate was low. The ticks were considered *dead* when they did not respond to human breath (CO_2) after 30 seconds, or as *weak* when they showed some difficulty in movement or as *very weak* when they revealed a quasi-inability to move or did so in an uncoordinated way.

All the toxicity bioassays started with acetone extracts at a concentration of 20%, then, when the percentages of affected ticks were ≥ 50, the extracts were also tested at 10%. In this latter case, two extracts caused a visible symptomatology in at least half of the ticks, so they were also tested at concentrations of 5% and 1%.

3 RESULTS

As indicated in chapter 2.1, the plants for the present research were selected after both locally inquiring among the rural people and consulting the data published in the international literature. All the plants used by the local communities in the control of ectoparasites had already been reported in the international literature, even if sometimes the specific uses or the ectoparasites targeted were different. As far as our results are concerned, we did not find a significant difference in efficacy between the plants also used by the local people in ectoparasite-control and those selected only after a literature review.

All the results refer to a total number of 40 ticks, *i.e.* four replications with ten ticks each.

3.1 REPELLENCY BIOASSAYS

The results of the repellency bioassays are summarized in Table 1 and in Graphs 1 to 3, and specified in the Annexes (Tables 4 to 21).

The repellency index was calculated using the formula:

$$[(N_c - N_t)/(N_c + N_t)] \times 100$$

where N_c refers to the number of ticks on the control rod and N_t to the number of ticks on the test rod (Lwande *et al.*, 1999; Pascual-Villalobos and Robledo, 1998).

In order to facilitate legibility, the indexes were approximated to the closest whole number, as the first and second decimals were not significant.

Hexane gave better results than acetone for 24 out of 28 plants, while in the cases of *A. indica*, *M. triphylla* and the two varieties of *R. communis*, the results were better with acetone extracts.

At a concentration of 10%, four plants (*A. indica*, *C. procera*, *C. aurea* and *F. sycomorus*) had negative repellency indexes with the hexane extracts and five (*C. procera*, *C. aurea*, *C. macrostachys*, *C. megalocarpus* and *F. sycomorus*) with the acetone ones. In these cases, an attraction by the plant extracts could be hypothesized, at least for *C. procera*, *C. aurea* and *F. sycomorus*.

In a few cases, the reaction changed to a negative repellency index at lower concentrations. This may indicate the complicated situation relating to attraction of ticks or may be an artefact. A remarkable finding was that a 10% hexane extract of *C. megalocarpus* led to a 93% repellency index and a 10% acetone extract of the same plant material led to a -14% repellency index. It

could be interesting to compare the chemistry of these two extracts in further studies.

At a concentration of 10%, the average repellency index for the hexane extracts was 46 compared to 19 for the acetone ones; at this concentration, 13 plants (*A. calidophila*, *C. quadrangularis*, *C. erythraea*, *C. macrostachys*, *C. megalocarpus*, *D. stramonium*, *L. camara*, *M. triphylla*, *O. suave*, the two varieties of *R. communis*, *T. minuta* and *V. amygdalina*) had repellency indexes > 50 with the hexane extracts, and 5 (*L. camara*, *M. triphylla*, *O. suave* and the two varieties of *R. communis*) with the acetone ones.

At a concentration of 5%, only 5 plants (*A. calidophila*, *C. megalocarpus*, *L. camara*, *O. suave* and *T. minuta*) had repellency indexes > 50 with the hexane extracts, and no plant with the acetone ones.

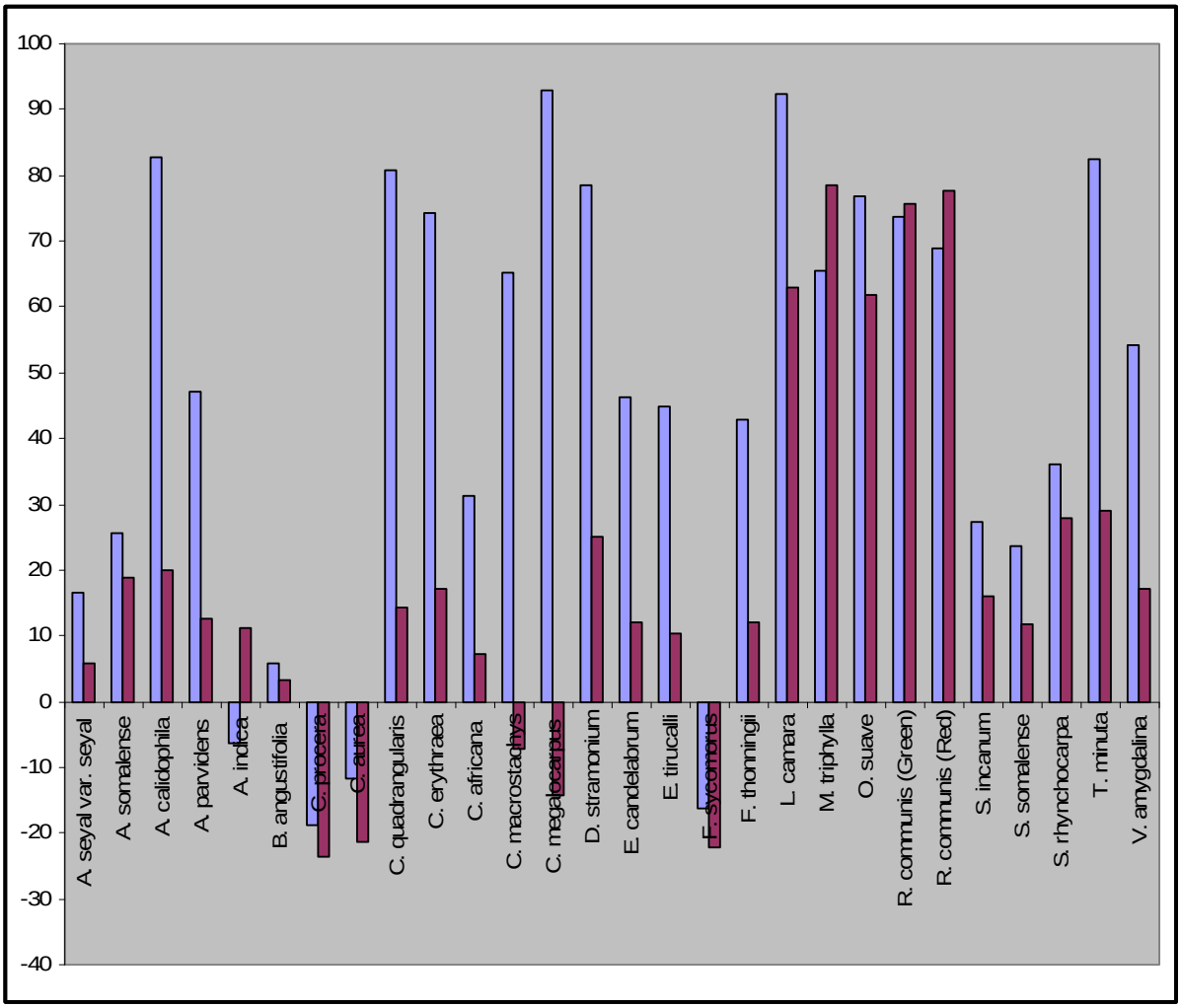
Finally, only the hexane extract of *T. minuta* had a repellency index > 50 at a concentration of 1%.

3.1.1 TABLE 1 - Repellency Indexes (alphabetical summary for all plant species)

PLANT	REPELLENCY TEST					
	HEXANE			*ACETONE*		
	10%	5%	1%	10%	5%	1%
	R.I.	R.I.	R.I.	R.I.	R.I.	R.I.
Acacia seyal* var. *seyal	17			6		
Adenium somalense	26			19		
Aloe calidophila	83	79	38	20		
Aloe parvidens	47			12		
Azadirachta indica	-6			11		
Boscia angustifolia	6			3		
Calotropis procera	-19			-24		
Calpurnia aurea	-12			-21		
Cissus quadrangularis	81	25	-8	14		
Commiphora erythraea	74	35	19	17		
Cordia africana	31			7		
Croton macrostachys	65	43	-4	-7		
Croton megalocarpus	93	77	23	-14		
Datura stramonium	79	31	21	25	26	17
Euphorbia candelabrum	46			12		
Euphorbia tirucalli	45			10		
Ficus sycomorus	-16			-22		
Ficus thonningii	43			12		
Lantana camara	92	60	21	63	36	15
Maerua triphylla	66	17	-11	79	19	-4
Ocimum suave	77	64	26	62	31	33
***Ricinus communis* (Green)**	74	38	3	76	43	12
***Ricinus communis* (Red)**	69	29	-7	78	40	15
Solanum incanum	27			16		
Solanum somalense	24			12		
Sterculia rhynchocarpa	36			28		
Tagetes minuta	82	76	54	29	33	8
Vernonia amygdalina	54	31	24	17		

R.I. = Repellency Index

3.1.2 GRAPH 1 - Repellency Indexes (10% concentration)

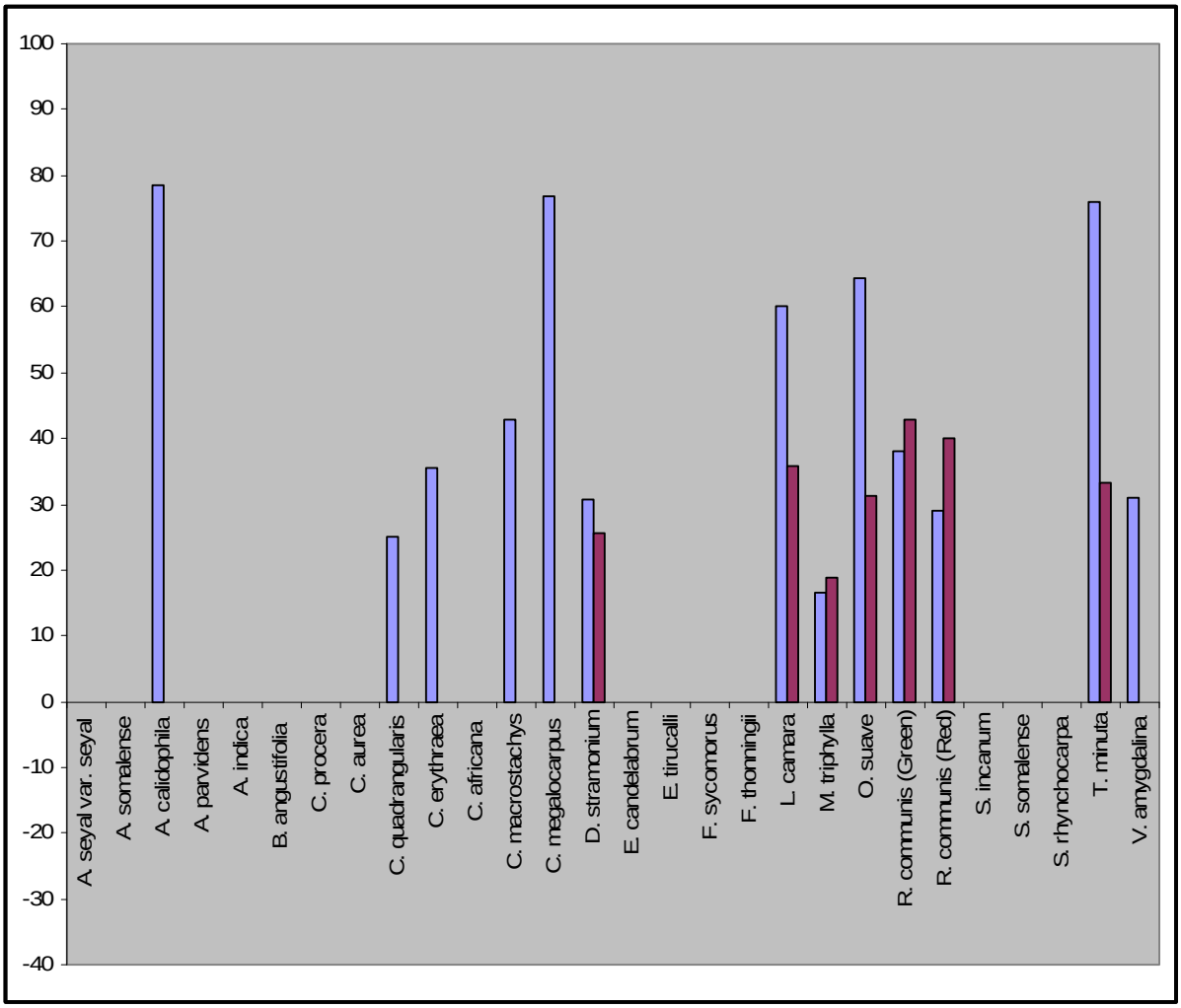


Repellency Indexes (R.I.) with hexane (blue) and acetone (red) extracts at concentrations of 10% (the relevant data are shown in the tables below)

PLANT	Hex. 10% R.I.	Acet. 10% R.I.
A. seyal var. *seyal*	17	6
A. somalense	26	19
A. calidophila	83	20
A. parvidens	47	12
A. indica	-6	11
B. angustifolia	6	3
C. procera	-19	-24
C. aurea	-12	-21
C. quadrangularis	81	14
C. erythraea	74	17
C. africana	31	7
C. macrostachys	65	-7
C. megalocarpus	93	-14
D. stramonium	79	25

PLANT	Hex. 10% R.I.	Acet. 10% R.I.
E. candelabrum	46	12
E. tirucalli	45	10
F. sycomorus	-16	-22
F. thonningii	43	12
L. camara	92	63
M. triphylla	66	79
O. suave	77	62
R. communis (Green)	74	76
R. communis (Red)	69	78
S. incanum	27	16
S. somalense	24	12
S. rhynchocarpa	36	28
T. minuta	82	29
V. amygdalina	54	17

3.1.3 GRAPH 2 - Repellency Indexes (5% concentration)

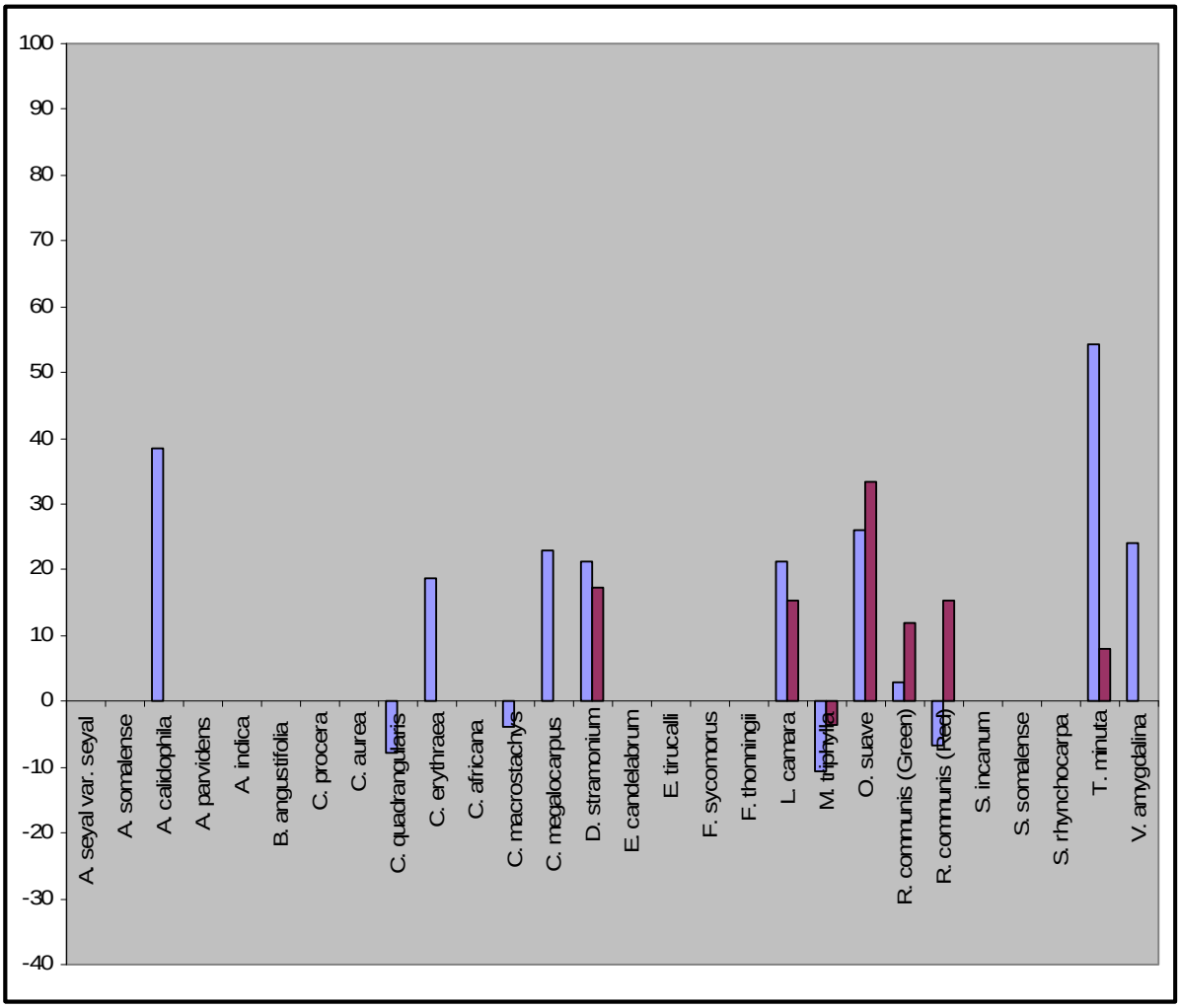


Repellency Indexes (R.I.) with hexane (blue) and acetone (red) extracts at concentrations of 5% (the relevant data are shown in the tables below)

PLANT	Hex. 5% R.I.	Acet. 5% R.I.
A. seyal var. *seyal*		
A. somalense		
A. calidophila	79	
A. parvidens		
A. indica		
B. angustifolia		
C. procera		
C. aurea		
C. quadrangularis	25	
C. erythraea	35	
C. africana		
C. macrostachys	43	
C. megalocarpus	77	
D. stramonium	31	26

PLANT	Hex. 5% R.I.	Acet. 5% R.I.
E. candelabrum		
E. tirucalli		
F. sycomorus		
F. thonningii		
L. camara	60	36
M. triphylla	17	19
O. suave	64	31
R. communis (Green)	38	43
R. communis (Red)	29	40
S. incanum		
S. somalense		
S. rhynchocarpa		
T. minuta	76	33
V. amygdalina	31	

3.1.4 GRAPH 3 - Repellency Indexes (1% concentration)



Repellency Indexes (R.I.) with hexane (blue) and acetone (red) extracts at concentrations of 1% (the relevant data are shown in the tables below)

PLANT	Hex. 1% R.I.	Acet. 1% R.I.
A. seyal var. *seyal*		
A. somalense		
A. calidophila	38	
A. parvidens		
A. indica		
B. angustifolia		
C. procera		
C. aurea		
C. quadrangularis	-8	
C. erythraea	19	
C. africana		
C. macrostachys	-4	
C. megalocarpus	23	
D. stramonium	21	17

PLANT	Hex. 1% R.I.	Acet. 1% R.I.
E. candelabrum		
E. tirucalli		
F. sycomorus		
F. thonningii		
L. camara	21	15
M. triphylla	-11	-4
O. suave	26	33
R. communis (Green)	3	12
R. communis (Red)	-7	15
S. incanum		
S. somalense		
S. rhynchocarpa		
T. minuta	54	8
V. amygdalina	24	

3.2 TOXICITY BIOASSAYS

The results of the toxicity bioassays are summarized in Table 2 where, for every plant and concentration, the numbers of ticks appearing as normal (N), weak (W) or very weak (VW), as well as the total of ticks alive (TA, corresponding to N + W + VW), are followed by the number of ticks dead (D). Then, in Table 3, the plants are ranked according to the percentage of ticks decidedly affected (DA), *i.e.* dead plus very weak.

3.2.1 TABLE 2 - Toxicity bioassays (summary of all plants)

PLANT	Acetone 20%					Acetone 10%					Acetone 5%					Acetone 1%				
	Alive				D	Alive				D	Alive				D	Alive				D
	N	W	VW	TA		N	W	VW	TA		N	W	VW	TA		N	W	VW	TA	
A. seyal* var. *seyal	12	5	19	36	4	33	5	0	38	2										
A. somalense	31	2	0	33	7															
A. calidophila	9	0	0	9	31	29	0	3	32	8										
A. parvidens	20	0	10	30	10	37	0	0	37	3										
A. indica	19	0	0	19	21	40	0	0	40	0										
B. angustifolia	20	0	0	20	20	39	0	0	39	1										
C. procera	0	20	0	20	20	30	0	0	30	10										
C. aurea	0	0	20	20	20	0	0	28	28	12	0	6	34	40	0	31	8	0	39	1
C. quadrangularis	4	0	5	9	31	40	0	0	40	0										
C. erythraea	16	4	10	30	10	28	3	2	33	7										
C. africana	40	0	0	40	0															
C. macrostachys	0	0	15	15	25	34	0	6	40	0										
C. megalocarpus	0	0	29	29	11	34	0	0	34	6										
D. stramonium	18	0	7	25	15	33	2	0	35	5										
E. candelabrum	0	0	17	17	23	36	0	0	36	4										
E. tirucalli	4	0	6	10	30	29	2	4	35	5										
F. sycomorus	38	0	0	38	2															
F. thonningii	30	0	0	30	10															
L. camara	0	0	6	6	34	33	0	0	33	7										
M. triphylla	36	0	0	36	4															
O. suave	36	0	2	38	2															
***R. communis* (Green)**	18	0	0	18	22	25	0	0	25	15										
***R. communis* (Red)**	23	0	0	23	17															
S. incanum	11	0	0	11	29	20	0	0	20	20	32	0	1	33	7	38	0	0	38	2
S. somalense	27	0	0	27	13															
S. rhynchocarpa	8	0	0	8	32	30	4	4	38	2										
T. minuta	20	0	0	20	20	28	0	0	28	12										
V. amygdalina	0	30	5	35	5	36	2	0	38	2										

N = Normal ; W = Weak ; VW = Very Weak ; TA = Total Alive (N+W+VW) ; D = Dead

3.2.2 TABLE 3 - Toxicity bioassays (summary of all plants, ranked according to the percentage of ticks decidedly affected)

PLANT	Acetone 20%				Acetone 10%				Acetone 5%				Acetone 1%			
	N	W	DA	%	N	W	DA	%	N	W	DA	%	N	W	DA	%
C. aurea	0	0	40	**100**	0	0	40	**100**	0	6	34	**85.0**	31	8	1	**2.5**
L. camara	0	0	40	**100**	33	0	7	**17.5**								
C. macrostachys	0	0	40	**100**	34	0	6	**15.0**								
C. megalocarpus	0	0	40	**100**	34	0	6	**15.0**								
E. candelabrum	0	0	40	**100**	36	0	4	**10.0**								
E. tirucalli	4	0	36	**90.0**	29	2	9	**22.5**								
C. quadrangularis	4	0	36	**90.0**	40	0	0	**0.0**								
S. rhynchocarpa	8	0	32	**80.0**	30	4	6	**15.0**								
A. calidophila	9	0	31	**77.5**	29	0	11	**27.5**								
S. incanum	11	0	29	**72.5**	20	0	20	**50.0**	32	0	8	**20.0**	38	0	2	**5.0**
A. seyal* var. *seyal	12	5	23	**57.5**	33	5	2	**5.0**								
***R. communis* (Green)**	18	0	22	**55.0**	25	0	15	**37.5**								
D. stramonium	18	0	22	**55.0**	33	2	5	**12.5**								
A. indica	19	0	21	**52.5**	40	0	0	**0.0**								
T. minuta	20	0	20	**50.0**	28	0	12	**30.0**								
C. procera	0	20	20	**50.0**	30	0	10	**25.0**								
C. erythraea	16	4	20	**50.0**	28	3	9	**22.5**								
A. parvidens	20	0	20	**50.0**	37	0	3	**7.5**								
B. angustifolia	20	0	20	**50.0**	39	0	1	**2.5**								
***R. communis* (Red)**	23	0	17	**42.5**												
S. somalense	27	0	13	**32.5**												
V. amygdalina	0	30	10	**25.0**	36	2	2	**5.0**								
F. thonningii	30	0	10	**25.0**												
A. somalense	31	2	7	**17.5**												
M. triphylla	36	0	4	**10.0**												
O. suave	36	0	4	**10.0**												
F. sycomorus	38	0	2	**5.0**												
C. africana	40	0	0	**0.0**												

N = Normal ; W = Weak ; DA = Decidedly Affected (Dead + Very Weak)
% = Percentage of decidedly affected ticks out of total number used for each plant extract

3.3 SPECIFIC AND COMPARATIVE RESULTS

3.3.1 ACACIA SEYAL VAR. *SEYAL*

The bark extracts of *A. seyal* var. *seyal* had scant effectiveness in the bioassays, either for repellency or toxicity. In fact, the repellency indexes were 17 with a 10% hexane extract and 6 with a 10% acetone extract (see Tables 1 and 4, and Graph 1).

The toxicity tests gave better results. More than half of the surviving ticks were unable to move at a concentration of 20% in the acetone extract, even if the mortality was only in the ratio of one to nine. Nevertheless, at a concentration of 10% in acetone, more than 80% of the ticks used in the toxicity bioassay were alive and apparently normal (see Tables 2 and 3).

The report on the use of *A. seyal* var. *seyal* as an acaricide dates back several decades (Ainslie, 1937) (see Chapter 2.2.1), and refers to the smoke resulting from burning its wood. Our results are in agreement with the poor attention given by the international literature to the plant as a source of acaricidal or acari-repellent preparations.

3.3.2 ADENIUM SOMALENSE

The stem extracts of *A. somalense* had scarce efficacy in repellency and toxicity bioassays. The repellency indexes were 26 with a 10% hexane extract and 19 with a 10% acetone extract (see Tables 1 and 4, and Graph 1).

Regarding the toxicity test with the acetone extract at a concentration of 20%, only 7 ticks died, and two others showed some sign of weakness (see Tables 2 and 3).

As already remarked (see Chapter 2.2.2), *A. somalense* is used by the Gerri traditional healers in tick control (Personal observations), and *A. obesum* is utilized by some Kenyan peoples to treat lice infestations and to repel fleas (Bekalo *et al.*, 1996).

Our results are not in agreement with the use of the plant in the Horn of Africa as an arthropodicide and arthropod-repellent (Bekalo *et al.*, 1996; Kokwaro, 1976; Morgan, 1981), and with the validation, made by Mgbojikwe and Okoye (2001), concerning the acaricidal effect of an aqueous stem bark extract of *A. obesum* on all stages of *Amblyomma* and *Boophilus* species.

In our trials we used the whole stem, while the local populations give preference to the soft inner part of the stem swollen base, and Mgbojikwe and Okoye used the stem bark. The discrepancy in the effects might be due to the fact that, even if we did our best to preserve the plant material in good condition, some weeks after the collection we noticed a marked change in the colour of the pith of *A. somalense*; the darkening of this part might go along with a partial inactivation of its active compounds.

3.3.3 *ALOE CALIDOPHILA* AND *ALOE PARVIDENS*

The leaves of *A. calidophila* had good effectiveness in the repellency tests. In fact, the hexane extracts at concentrations of 10% and 5% gave high repellency indexes (respectively 83 and 79), dropping to 38 at a concentration of 1%. With the acetone extract at a concentration of 10%, the repellency index was only 20 (see Tables 1 and 5, and Graphs 1 to 3).

Concerning the toxicity tests, good results were noticed at a concentration of 20% in acetone (31 ticks dead) but not at 10% (only 8 ticks dead, with a further 3 very weak) (see Tables 2 and 3).

Aloe parvidens was less effective than *A. calidophila*, especially in the repellency tests, with indexes of 47 and 12 in the bioassays with, respectively, hexane and acetone extracts at 10% (see Tables 1 and 4, and Graph 1).

In toxicity tests, the result was fair at a concentration of 20% in acetone (10 ticks dead plus 10 showing stiff movements), but only 3 ticks died at a concentration of 10% (see Tables 2 and 3).

Aloe species are locally used by the Gerri people to treat tick infestations (Personal observations), and similar uses have been reported in other parts of Ethiopia by Tadesse (1991 and 1994) and in Kenya by Bekalo *et al.* (1996) (see Chapter 2.2.3).

According to Sebsebe *et al.* (2003), there are some 40 *Aloe* species in Ethiopia, with marked differences in distribution. Our observations are in agreement with this remark, as we noticed that frequently few kilometres of displacement are sufficient for a complete change of the *Aloe* species growing in the area.

Because of the differences discerned in the activities of the two aloes that we investigated, we think that the suitability of the acaricidal or acari-repellent exploitations of a specific *Aloe* species in a certain area, should be carefully evaluated.

3.3.4 *AZADIRACHTA INDICA*

The leaves of *A. indica* gave very poor results in repellency tests, with a negative repellency index (-6) in the bioassay with hexane extract at a concentration of 10%, and a low repellency index (11) in the bioassay with acetone extract at the same concentration (see Tables 1 and 6, and Graph 1).

The result of the toxicity test with acetone extract at a concentration of 20% was better, with 21 ticks dead, but not at a concentration of 10%, where all the ticks appeared in good condition after 24 hours (see Tables 2 and 3).

As shown in the chapter 2.2.4, the scientific literature provides plenty of examples of ectoparasiticidal and arthropod-repellent uses of *A. indica*, including local utilizations in both southern Ethiopia and western Kenya. Moreover, its repellent and acaricidal properties have also been documented.

The fact that our results with *A. indica* leaf extracts on *R. pulchellus* adult ticks were very poor concerning the repellent properties, and only just fair concerning the toxic ones, may be due to various reasons.

Firstly, as shown by Seyoum *et al.* (2002a), the arthropod-repellent activities of neem leaves are quite poor, while several studies show that these effects are considerable when extracts from seeds are used (see Chapter 2.2.4). In addition, also the arthropodicidal validations performed by Mansingh and Williams (2002), Williams (1993), and Williams and Mansingh (1993), were carried out using *A. indica* extracts from seeds.

Moreover, in our bioassays we recorded the toxic effects after 24 hours, while the main arthropodicidal neem compounds normally require a longer time to show their relevant properties. In fact, Abdel-Shafy and Zayed (2002) found a progressive increase in the toxicity of a neem seed oil on unfed adult ticks, up to 15 days post treatment.

Finally, Solomon *et al.* (2000) demonstrated that the acaricidal effect of neem oil is substantial on ticks at the larval and nymphal stage, but significantly lower at the adult stage. Likewise, Al-Rajhy *et al.* (2003) found an acaricidal activity of neem oil considerably higher on larvae than on adults, and successful tests by Ndumu *et al.* (1999), regarding the acaricidal properties of neem oil against *Amblyomma variegatum*, were carried out only on larvae.

3.3.5 BOSCIA ANGUSTIFOLIA

The leaves of *B. angustifolia* had very low effectivity in the repellency tests, with a repellency index of 6 with the hexane extract at a concentration of 10%, and a repellency index of 3 with the acetone extract at the same concentration (see Tables 1 and 6, and Graph 1).

Regarding the toxicity tests, fair effectiveness was noticed with the acetone extract at a concentration of 20% (20 ticks dead), while at a concentration of 10% only one tick died (see Tables 2 and 3).

The insect-repellent properties of *B. coriacea*, noticed by Bekalo *et al.* (1996) in north-western Kenya (see Chapter 2.2.5), were not confirmed in our experiments using leaves of *B. angustifolia* on ticks.

As the Turkana people observed by Bekalo *et al.* drive away mosquitoes by burning a mixture of leaves of *Boscia coriacea*, *Salvadora persica*, *Cadaba rotundifolia* and *Calotropis procera*, the activity of one plant cannot be distinguished from the others. Moreover, a considerable repellent effect may be due to the smoke itself. Particular information is not provided by the work done by Kaposhi (1992) in Zambia.

3.3.6 CALOTROPIS PROCERA

Both the hexane and acetone leaf extracts of *C. procera* gave negative results in the repellency tests. In fact, at a concentration of 10%, the repellency indexes were -19 with the hexane extract and -24 with the acetone one, meaning that these extracts appear to attract rather than repel the ticks (see Tables 1 and 6, and Graph 1).

The effectiveness was fair in the toxicity tests, with 20 ticks dead and the remaining 20 weak at a concentration of 20% in acetone, while 10 ticks died at a concentration of 10% (see Tables 2 and 3).

In spite of the abundant literature testifying to the widespread use of *C. procera* as an insecticide, acaricide or insect repellent (see Chapter 2.2.6), our bioassays did not show repellency or strong toxicity of the plant against *R. pulchellus*.

Al-Rajhy *et al.* (2003) found good results of a cardenolide extracted from *C. procera*, in toxicity tests performed against both larvae and adults of the tick *Hyalomma dromedarii*. Morsy *et al.* (2001) examined the insecticidal effects of the latex of *C. procera* on the larvae of *Musca domestica*. Moursy (1997) found that the ethanol leaf extract of *C. procera* is more toxic against larvae, pupae and adults of the fly *Sarcophaga haemorrhoidalis* than water, acetone and petroleum ether extracts. The differences of the protocols applied do not allow proper comparisons among all these researches.

3.3.7 CALPURNIA AUREA

The repellency bioassays with the leaves of *C. aurea* led to negative repellency indexes with both the hexane and acetone extracts at a concentration of 10% (-12 and -21, respectively) (see Tables 1 and 7, and Graph 1). On the contrary, the toxicity tests showed very strong effectiveness of the plant.

In fact, even though the number of ticks dead was never very high (20 at a concentration of 20% in acetone, 12 at a concentration of 10%, none at a concentration of 5% and 1 at a concentration of 1%), all the surviving ticks at a concentration of 20% and 10% had pronounced weakness and incoordination of movement, making them unable to walk. These effects were also observed for 34 out of the 40 surviving ticks at a concentration of 5%, and some signs of distress in moving were shown also by the remaining six. Finally, weakness of movement was observed for 8 out of the 39 surviving ticks at a concentration of 1% (see Tables 2 and 3).

In order to deepen the knowledge about such good effectiveness of this plant, we performed an additional bioassay using a 10% water extract, recording similar difficulty in moving for 30 ticks out of 40.

The considerable results shown in our toxicity bioassays with *C. aurea* are in agreement with its acaricidal usage in Ethiopia and South Africa (see Chapter 2.2.7).

3.3.8 CISSUS QUADRANGULARIS

The repellent effectiveness of the stems of *C. quadrangularis* was very good with the hexane extract at a concentration of 10% (repellency index of 81), but it decidedly dropped with lower concentrations: at a concentration of 5% the repellency index was only 25, and was negative (-8) at a concentration of 1%. The acetone extract at 10% did not have good effectivity, and the repellency index was only 14 (see Tables 1 and 8, and Graphs 1 to 3).

Also regarding the toxicity tests, the results were only good with a very high concentration of the acetone extract: at 20%, 31 ticks died (and 5 of the 9 surviving ones showed a great weakness), but at 10% all the ticks survived without signs of distress (see Tables 2 and 3).

Our bioassays are in agreement, at least concerning high concentrations, with the use of *C. quadrangularis* as an insecticide, acaricide and insect repellent (see Chapter 2.2.8).

3.3.9 COMMIPHORA ERYTHRAEA

The bark of *C. erythraea* had good repellent properties in the extract with hexane at 10% (repellency index of 74), but not at lower concentrations (repellency index of 35 at 5%, and 19 at 1%). The repellency index with acetone extract at 10% was only 17 (see Tables 1 and 9, and Graphs 1 to 3).

Toxicity was fair at a concentration of 20% in acetone (10 ticks dead, with 10 very weak and 4 weak among the surviving ones), while at the subsequent dilution (10%) only 7 ticks died, 2 were recorded as very weak and 3 as weak (see Tables 2 and 3).

The utilizations of *C. erythraea* in the control of ectoparasites, as well as the insecticidal and acaricidal properties of *C. molmol* reported by Massoud and Labib (2000) and Massoud *et al.* (2005), primarily refer to the use of the gum from the plant (see Chapter 2.2.9). In the Borana case, the fact that the rural people mix *C. erythraea* bark with tobacco leaves makes it difficult to evaluate the acaricidal effect of each species alone.

3.3.10 CORDIA AFRICANA

The leaf extracts of *C. africana* did not give good results for either repellency or toxicity. In fact, the repellency indexes were 31 in the bioassay with the hexane extract at 10% and 7 with the acetone extract at the same concentration (see Tables 1 and 7, and Graph 1).

Concerning the toxicity test, all the ticks used in the bioassay were alive and appeared in good condition after 24 hours (see Tables 2 and 3).

The poor results obtained in both repellency and toxicity bioassays with the leaf extracts of *C. africana*, are in agreement with the scarcity of reports regarding the use of the plant in ectoparasite-control (see Chapter 2.2.10).

3.3.11 *CROTON MACROSTACHYS* AND *CROTON MEGALOCARPUS*

The hexane extracts obtained from the leaves of *C. megalocarpus*, and to a certain extent also from *C. macrostachys*, had good repellent properties. In fact, the repellency indexes at concentrations of 10%, 5% and 1% in hexane were respectively 93, 77 and 23 for *C. megalocarpus*, and 65, 43 and -4 for *C. macrostachys*. Concerning the acetone extracts, on the contrary, the repellency indexes were negative at a concentration of 10% (-14 for *C. megalocarpus* and -7 for *C. macrostachys*) (see Tables 1, 10 and 11, and Graphs 1 to 3).

As regards the toxic properties, the two plant extracts gave good results at a concentration of 20% in acetone, but not at 10%. In fact, all the ticks surviving (29 for *C. megalocarpus* and 15 for *C. macrostachys*) in the bioassays with acetone extracts at 20% showed stiff movements, so they were recorded as very weak. In the bioassays with acetone extracts at 10%, regarding *C. megalocarpus* 34 ticks survived without signs of distress, while in the case of *C. macrostachys* all the ticks survived, but 6 of them, showing stiff movements, were recorded as very weak (see Tables 2 and 3).

Croton species are not widely used as ectoparasiticides or as repellent for arthropods (see Chapter 2.2.11). Nevertheless, our results were encouraging, even if the toxic properties of the extracts from the leaves of *C. macrostachys* and *C. megalocarpus* were considerable only at a concentration of 20%. Concerning the repellency bioassays, the fact that we recorded good activity only with hexane extracts, may explain the lack of reports on the repellency use of these plants in rural practice.

3.3.12 *DATURA STRAMONIUM*

The leaves of *D. stramonium* gave good results in the repellency tests with extracts in hexane, but just fair with those in acetone. In fact, while the bioassays with hexane extracts at 10%, 5% and 1% had repellency indexes of 79, 31 and 21 respectively, those with acetone extracts had indexes of 25, 26 and 17 (see Tables 1 and 12, and Graphs 1 to 3).

Regarding the toxicity tests, acetone extract at 20% caused the death of 15 ticks, while 7 of the 25 surviving ones were recorded as very weak because of their stiff movements. At a concentration of 10%, only 5 ticks died, and 2 of

the 35 surviving ones showed some difficulty in moving, but to a smaller extent than in the previous case (see Tables 2 and 3).

Datura stramonium is known as an insect repellent (Curasson, 1947), acaricide (Van Puyvelde *et al.*, 1985) and insecticide (Bekele *et al.*, 2005) (see Chapter 2.2.12). In our bioassays, both the repellent and toxic properties of the plant were confirmed, at least at high concentrations.

3.3.13 *EUPHORBIA CANDELABRUM* AND *EUPHORBIA TIRUCALLI*

The extracts from the two plants gave similar results in both repellency and toxicity tests. The repellency indexes with the extracts in hexane at a concentration of 10% were 46 for *E. candelabrum* and 45 for *E. tirucalli*, while with the extracts in acetone at the same concentration, the repellency indexes were respectively 12 and 10 (see Tables 1, 7 and 13, and Graph 1).

With regard to the toxicity tests, acetone extracts from the two plants gave good results only at a concentration of 20%, with stickiness and marked weakness showed by all the 17 ticks surviving in the test with *E. candelabrum*, and by 6 of the 10 ticks surviving in the test with *E. tirucalli*. At a concentration of 10%, all 36 surviving ticks in the case of *E. candelabrum* did not show any sign of distress; in the case of *E. tirucalli*, 4 ticks were very weak and 2 weak out of the 35 surviving ones (see Tables 2 and 3).

The good results obtained for *E. candelabrum* and *E. tirucalli* in our toxicity bioassays at a concentration of 20% in acetone, support the ectoparasiticidal use of these plants in Ethiopia (Bekele-Tesemma *et al.*, 1993; Teshale *et al.*, 2004) and Rwanda (Desouter, 1991). Their repellent properties were less interesting, even if there are some reports (Decary, 1966; Rimbach, 1977) describing the rural use of *E. tirucalli* as an insect repellent (see Chapter 2.2.13).

3.3.14 *FICUS SYCOMORUS* AND *FICUS THONNINGII*

The leaf extracts of *Ficus sycomorus* did not have repellent properties, giving negative repellency indexes in both the bioassays with hexane and with acetone at 10% (respectively -16 and -22). Slightly better results were obtained for the leaf extracts of *Ficus thonningii*, with repellency indexes of 43 in the test with hexane at 10% and 12 in the test with acetone at the same concentration (see Tables 1 and 13, and Graph 1).

Extracts from both trees were not very toxic. Only 2 ticks died in the bioassay with *F. sycomorus* leaf extract in acetone at 20%, and only 10 in the case of *F. thonningii* (see Tables 2 and 3).

In spite of the use of *F. sycomorus* and *F. glumosa* by the Borana people to treat some ectoparasitoses (Abubeker, 2003; Heine and Brenzinger, 1988), the

leaf extracts of *F. sycomorus* and *F. thonningii* did not give good results in our repellency and toxicity bioassays. According to Abubeker (2003), the acaricidal paste is prepared by injuring the bark of *F. glumosa* to produce a sap (see Chapter 2.2.14).

During our survey, we remarked that the Borana people frequently use a wide variety of preparations to treat general skin problems, disregarding the specific effect but focusing only on the relief of some symptoms, like itch or pain. Therefore, the local use of topical applications of a paste issued from *F. sycomorus* or *F. glumosa* bark to treat some ectoparasitoses, might be justified by a merely antiphlogistic or symptomatological effect, even without exerting an acaricidal or acari-repellent activity. Moreover, these remedies might have some efficacy toward a bacterial secondary invasion, which is a common complication of skin problems in people with a nomadic lifestyle.

3.3.15 LANTANA CAMARA

The leaf extracts of *Lantana camara* had excellent repellent properties in the bioassays with hexane (at a concentration of 10%, 5% and 1%, the repellency indexes were respectively 92, 60 and 21), while with acetone, the repellency indexes were lower (63, 36 and 15) (see Tables 1 and 14, and Graphs 1 to 3).

Concerning the toxicity tests, the results were good with the acetone extract at 20% (the 6 surviving ticks showed signs of great distress), but not at a lower concentration (the 33 ticks surviving in the bioassay with the acetone extract at 10% appeared normal) (see Tables 2 and 3).

The excellent activity observed with the use of *L. camara* extracts in our repellency bioassays confirms the results published by Dua *et al.* (1996) and Seyoum *et al.* (2002a and b), referring to tests on mosquitoes. Moreover, we also found good efficacy of the plant in the toxicity bioassays, even if only at a concentration of 20%. Its feared toxicity and behaviour as a very invasive weed, may explain the scarcity of reports concerning the rural use of *L. camara* (see Chapter 2.2.15).

3.3.16 MAERUA TRIPHYLLA

The acetone leaf extracts of *Maerua triphylla* had better repellent properties than the hexane ones. In fact, the repellency indexes at concentrations of 10%, 5% and 1% were respectively 79, 19 and -4, in the first case, and 66, 17 and -11 in the second case (see Tables 1 and 15, and Graphs 1 to 3).

The toxic properties of the plant appeared negligible, with only 4 ticks dead in the toxicity test with acetone extract at 20%, while all the others seemed to be normal (see Tables 2 and 3).

Maerua triphylla is not a plant well-known in ethnoveterinary practices. In our bioassays, it gave fair results only in the repellency tests, mainly using acetone extracts, and only at a concentration of 10%.

3.3.17 OCIMUM SUAVE

The whole plant was used in the bioassays with *Ocimum suave*. The results were good in the repellency tests but not in the toxicity ones. With the extracts in hexane at 10%, 5% and 1%, the repellency indexes were respectively 77, 64 and 26, while with the extracts in acetone at the same concentrations, the indexes were 62, 31 and 33 (see Tables 1 and 16, and Graphs 1 to 3).

In the toxicity test with acetone extract at 20%, only 2 ticks died, while 2 others were very weak (see Tables 2 and 3).

The good results obtained in our repellency bioassays with both the hexane and acetone extracts of *O. suave*, are in full agreement with the large number of reports concerning the arthropod-repellent use of *Ocimum* species and the related validations (see Chapter 2.2.17).

Reports concerning the toxic properties of the plant on arthropods are substantially fewer than those regarding the repellent activity, and generally the toxicity has only been validated on the eggs or larvae of insects (Bassole *et al.*, 2003; Chavan and Nikam, 1982). On the other hand, Mwangi *et al.* (1995) noticed the acaricidal effects of an oil extracted from the leaves of *O. suave* on all stages of the tick *Rhipicephalus appendiculatus*.

3.3.18 RICINUS COMMUNIS

Extracts from the leaves of the two varieties of *Ricinus communis* used in the tests yielded similar results: good repellent properties (a little better in the case of acetone extracts) at high concentration (10%) and moderate toxicity. The repellency indexes of the green variety were respectively 74, 38 and 3 for the hexane extracts at concentrations of 10%, 5% and 1%, and 76, 43 and 12 for the acetone extracts. As regards the red variety, the repellency indexes were 69, 29 and -7 for the hexane extracts and 78, 40 and 15 for the acetone ones (see Tables 1, 17 and 18, and Graphs 1 to 3).

In the toxicity tests regarding the green variety, 22 ticks died with acetone extract at 20%, and 15 at 10%. In the case of the red variety, 17 ticks died with acetone extract at 20% (see Tables 2 and 3).

The results of our bioassays, mainly concerning those for repellency, are in agreement with the reports on the plant use in ectoparasite control (see Chapter 2.2.18).

3.3.19 *SOLANUM INCANUM* AND *SOLANUM SOMALENSE*

The leaf extracts of both *Solanum incanum* and *Solanum somalense* did not have good repellent properties. In fact, the repellency indexes of *S. incanum* were 27 in the bioassay with hexane extract at 10% and 16 in the test with acetone extract at the same concentration. The two indexes for *S. somalense* were respectively 24 and 12 (see Tables 1 and 19, and Graph 1).

Solanum incanum had better toxic properties than *S. somalense*. In fact, in the bioassays with acetone extracts at 20%, the first caused the death of 29 ticks, while for the latter only 13 ticks died. Moreover, concerning *S. incanum*, half of the ticks died with acetone extract at 10%, 8 ticks were decidedly affected at 5% and two ticks died at 1% (see Tables 2 and 3).

The good activities of the leaf extracts of *S. incanum* in our toxicity bioassays are in agreement with the data issued by Regassa (2000) and by Van Puyvelde *et al.* (1985) (see Chapter 2.2.19). *Solanum somalense*, however, did not have remarkable acaricidal properties in our toxicity bioassay.

3.3.20 *STERCULIA RHYNCHOCARPA*

The bark extracts of *Sterculia rhynchocarpa* did not have good repellent properties. In fact, the repellency indexes were 36 for the hexane extract at 10% and 28 for the acetone one at the same concentration (see Tables 1 and 19, and Graph 1).

Good results were recorded in the toxicity test at a concentration of 20% in acetone, with 32 ticks dead, but not at a concentration of 10% (only 2 ticks dead, with 4 others appearing weak and 4 very weak) (see Tables 2 and 3).

The insecticidal effect of *Sterculia foetida* noticed by De Vasconcelos *et al.* (2006) (see Chapter 2.2.20) is in agreement with the acaricidal activity observed in our bioassay with the use of *S. rhynchocarpa* acetone extract at a concentration of 20%.

3.3.21 *TAGETES MINUTA*

The hexane extract of the whole plant of *Tagetes minuta* had excellent repellent activity, but not the acetone one. In the former case, at concentrations of 10%, 5% and 1%, the repellency indexes were respectively 82, 76 and 54, while in the latter case they were only 29, 33 and 8 (see Tables 1 and 20, and Graphs 1 to 3).

The toxicity tests with acetone extracts gave only moderate results. In the bioassay at a concentration of 20%, half of the ticks died, and only 12 in the test at a concentration of 10% (see Tables 2 and 3).

The largely reported and validated toxic and repellent properties of *T. minuta* against arthropods (see Chapter 2.2.21) were confirmed in our

bioassays, even if we found that the repellent activity of the plant is the more interesting one, especially considering its preservation at low concentrations. The fact that such an excellent property is not noticeable with acetone extracts, should be carefully considered in practical applications.

3.3.22 VERNONIA AMYGDALINA

The leaf extracts of *Vernonia amygdalina* had fair repellent properties. In the bioassays with hexane extracts at concentrations of 10%, 5% and 1%, the repellency indexes were respectively 54, 31 and 24, and in the bioassay with acetone extract at 10%, the repellency index was 17 (see Tables 1 and 21, and Graphs 1 to 3).

Regarding the toxicity test with acetone extract at 20%, only 5 ticks died, but 30 of the others were noticed as weak and 5 very weak. At a concentration of 10%, only 2 ticks died and 2 others showed signs of weakness (see Tables 2 and 3).

The fair tick-repellent property and limited toxic activity shown in our bioassays seem not to justify the wide use of *V. amygdalina* in the control of ectoparasitoses, reported in the international literature (see Chapter 2.2.22).

4 DISCUSSION

The goal of the present study was to perform a basic screening of the acaricidal and acari-repellent plants of southern Ethiopia, in order to provide field operators and researchers with scientifically documented data that may direct practical applications and offer leads to further studies. To ensure the convenient applicability of the results, not only the biological activity, but also botanical, ecological, economical and socio-cultural factors, as well as the availability of solvents to yield active extracts, have to be considered.

In general, no plant extract gave very good results in both repellency and toxicity tests.

The local use of some plants in ectoparasite-control was only partially supported by these results. In fact, *A. calidophila*, *C. aurea*, *C. quadrangularis*, *C. erythraea*, *E. candelabrum*, *E. tirucalli* and *S. rhynchocarpa* had repellent and/or toxic properties on the ticks that can justify their local use. On the contrary, *A. somalense*, *A. parvidens*, *A. indica* and *F. sycomorus* did not have remarkable effects in our bioassays. As indicated in chapters 3.3.2, 3.3.3, 3.3.4 and 3.3.14, such discrepancy can be explained in different ways.

The plant material of *A. somalense* might have suffered an alteration involving inactivation of the possible acaricidal or acari-repellent compounds.

The different results that we noticed between *Aloe calidophila* and *A. parvidens* should be carefully considered. The distribution of *circa* 40 species of *Aloe* is very dissimilar in the study area. The people contacted during our survey differentiate only between “spotted” and “non-spotted” aloes, but the various species may have different acaricidal and acari-repellent properties from one another.

The low activity shown by *A. indica* in our bioassays may be due to the fact that we used extracts from the leaves, instead of oil from the seeds, and that we tested the plant on adult ticks and not on larvae or nymphae. Moreover, we recorded the toxic effects after 24 hours, while the main arthropodicidal neem compounds require a longer time to fully exert their activities.

The use of *F. sycomorus* by the Borana people to treat mange and scabies might be justified by a symptomatological effect.

In addition, a possibility not evaluated in this study is that the acaricidal or acari-repellent action may be mainly indirect. For instance, if parts of the extracts are absorbed by the host and affect its blood, making it unpalatable to the ticks, the relevant plant species may still be useful to pastoralists.

Regarding the repellency bioassays, *A. calidophila*, *C. quadrangularis*, *C. erythraea*, *C. macrostachys*, *C. megalocarpus*, *D. stramonium*, *L. camara*, *M. triphylla*, *O. suave*, the two varieties of *R. communis* and *T. minuta* had the highest activity levels, with at least one of the two solvents.

However, considering ecological and socio-environmental aspects, it should be better to concentrate especially on *O. suave* and *T. minuta*, although *A. calidophila* may also deserve attention to a certain extent.

In fact, *C. quadrangularis*, *C. erythraea*, *C. macrostachys*, *D. stramonium*, *M. triphylla* and the two varieties of *R. communis* had good repellent properties using hexane extracts at 10%, but not at 5%.

Possibly, medium-sized trees, like *M. triphylla* and the two *Croton* species evaluated, should not be further exploited because of their scarcity in such a dry region. Also *C. erythraea*, even if more widespread in the area, could become threatened if excessively exploited.

In spite of its good effectiveness, *L. camara* should be preferably disregarded because of its high invasive potential, which could become a serious problem in an environment where agricultural activities are already dealing with huge difficulties and where bush encroachment is increasing year after year.

Furthermore, *D. stramonium*, *L. camara* and *R. communis* are poisonous and represent a threat in a location where severe droughts frequently force domestic animals to browse among small trees and shrubs.

On the contrary, *T. minuta* and *O. suave* are very well known by the people as plants naturally growing in fields surrounding the villages, without bringing problems to the livestock.

As far as *A. calidophila* is concerned, it could be a viable alternative to the above-mentioned two species as a source of repellent extracts, but it is not really widespread in the environment, being concentrated only in some areas. Moreover, its cultivation needs particular care and this may be difficult for nomadic people mainly used to deal with livestock rather than cultivation.

With regard to the toxicity bioassays, *C. aurea* is the plant giving by far the best results. In fact, even if the mortality recorded was not very high, the movement of all the surviving ticks in the bioassays with acetone extracts at a concentration of 20% and 10% was drastically affected, so that they were considered as non-viable. The same symptom was also recorded for 85% of the ticks in the bioassay with acetone extract at a concentration of 5%.

As regards the other species, *C. macrostachys*, *C. megalocarpus*, *E. candelabrum*, *E. tirucalli*, *C. quadrangularis*, *L. camara*, *S. rhynchocarpa* and *A. calidophila* only showed good toxicity with acetone extracts at 20%; for the rest, only *S. incanum* caused the death of at least half of the ticks in the toxicity bioassay with acetone extract at 10%.

An additional important result concerning *C. aurea* is that even a 10% water extract affected the tick movements, making it very useful for people without access to solvents such as hexane or acetone. Furthermore, *C. aurea* can easily grow in dry climates and in overgrazed areas, both conditions being very common in southern Ethiopia. Its cultivation is also easy and does not require special skills; moreover, its ectoparasiticidal properties are well known by the Borana people, who use it for treating humans and cattle.

As far as further studies that could be undertaken are concerned, the following points may be considered.

In the first place, the active compounds of the more effective plant species should be isolated and characterized.

Secondly, some field studies using *T. minuta*, *O. suave* and *C. aurea* extracts, either separately or as mixtures, should be programmed. The following aspects should be investigated: extractants used, concentrations, quantities, frequency of applications, stability of the extracts, toxicity for mammals and for the environment. Practical details such as the opportunity for procurement and the cost of the extractants, as well as the possibility to replace them with petrol, soap solutions or simple water, should also be carefully evaluated.

Finally, several aspects regarding the potential of cultivating, managing, extracting and distributing extracts of the most promising species, should be considered.

The accomplishment of these tasks would require close collaboration between all the stakeholders: public administrators, veterinary and agriculture services, customary authorities, traditional healers, local communities, Community Animal Health Workers, development agents and stock-owners. After a source of funding for such a project has been identified, information and coordination meetings of all stakeholders would be required to make the results obtained in this study available to rural people, in order to improve their quality of life.

5 ANNEXES

The results of the repellency bioassays are detailed in Tables 4 to 21.

The four replications for each plant and concentration are shown in the first column, indicated by an R (= Replication). The time of recording, *i.e.* every 30 minutes, is reported in the second column. Then, the number of ticks present on the platform (P) or on the two rods (Test and Control) is shown, with a specification regarding the position of the ticks (T = Filter paper on the top of the rod; M = Middle part of the rod, not covered by filter paper; B = Filter paper on the bottom of the rod).

5.1 TABLE 4 - Repellency indexes of *Acacia seyal*, *Adenium somalense* and *Aloe parvidens*

Acacia seyal var. seyal (hexane 10%)									
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	4	1	0	0	3	1	1
	60'	2	0	3	0	4	0	1
	90'	1	0	3	0	5	0	1
	120'	2	1	1	0	5	0	1
2	30'	4	1	0	0	1	0	4
	60'	4	2	0	0	1	0	3
	90'	3	2	0	1	1	0	3
	120'	0	3	0	1	2	0	4
3	30'	1	3	1	1	1	1	2
	60'	1	4	0	1	1	0	3
	90'	1	4	0	1	1	0	3
	120'	1	4	0	1	1	0	3
4	30'	4	2	0	0	3	0	1
	60'	3	2	0	0	3	0	2
	90'	2	3	0	0	5	0	0
	120'	1	4	0	0	5	0	0
Tot.	120'	4	12	1	2	13	0	8
				15			21	
Repellency Index : 17								

Acacia seyal var. seyal (acetone 10%)									
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	5	1	1	0	2	0	1
	60'	4	1	1	1	2	0	1
	90'	2	3	0	1	3	0	1
	120'	2	3	0	1	3	0	1
2	30'	4	1	0	0	1	0	4
	60'	4	1	0	1	1	0	3
	90'	3	2	0	1	1	0	3
	120'	2	2	0	1	2	0	3
3	30'	2	3	0	1	1	1	2
	60'	1	4	0	1	1	0	3
	90'	1	4	0	1	1	0	3
	120'	1	4	0	1	1	0	3
4	30'	4	3	0	1	0	1	1
	60'	3	3	0	2	2	0	0
	90'	2	4	0	0	4	0	0
	120'	1	4	0	0	5	0	0
Tot.	120'	6	13	0	3	11	0	7
				16			18	
Repellency Index : 6								

Adenium somalense (hexane 10%)									
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	1	4	1	0	1	1	2
	60'	1	5	0	0	3	0	1
	90'	0	5	0	0	4	0	1
	120'	0	5	0	0	4	0	1
2	30'	3	1	1	1	3	0	1
	60'	2	2	0	1	4	0	1
	90'	2	2	0	1	4	0	1
	120'	2	2	0	1	4	0	1
3	30'	4	1	0	1	3	0	1
	60'	3	2	0	0	3	1	1
	90'	3	2	0	0	4	0	1
	120'	3	2	0	0	4	0	1
4	30'	1	0	1	1	5	0	2
	60'	0	3	0	0	5	1	1
	90'	0	3	0	0	6	0	1
	120'	0	3	0	0	6	0	1
Tot.	120'	5	12	0	1	18	0	4
				13			22	
Repellency Index : 26								

Adenium somalense (acetone 10%)									
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	2	2	1	1	1	0	3
	60'	2	3	0	1	3	0	1
	90'	2	4	0	0	3	0	1
	120'	2	4	0	0	3	0	1
2	30'	3	2	0	1	2	0	2
	60'	2	2	0	1	5	0	0
	90'	2	2	0	1	5	0	0
	120'	1	3	0	0	6	0	0
3	30'	5	2	0	1	0	2	0
	60'	4	2	0	1	3	0	0
	90'	4	2	0	1	3	0	0
	120'	4	2	0	1	3	0	0
4	30'	3	1	1	0	2	0	3
	60'	1	1	2	0	5	0	1
	90'	1	3	0	0	5	0	1
	120'	1	3	0	0	5	0	1
Tot.	120'	8	12	0	1	17	0	2
				13			19	
Repellency Index : 19								

Aloe parvidens (hexane 10%)									
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	6	0	0	0	2	0	2
	60'	3	2	0	0	4	0	1
	90'	2	2	1	0	3	0	2
	120'	2	2	1	0	3	0	2
2	30'	3	0	0	0	6	0	1
	60'	3	0	0	0	6	0	1
	90'	0	1	0	0	9	0	0
	120'	0	1	0	0	9	0	0
3	30'	7	0	0	0	2	1	0
	60'	6	1	0	0	3	0	0
	90'	3	3	0	0	4	0	0
	120'	3	3	0	0	4	0	0
4	30'	4	1	0	0	3	0	2
	60'	4	1	0	0	4	0	1
	90'	1	2	0	0	6	0	1
	120'	1	2	0	0	6	0	1
Tot.	120'	6	8	1	0	22	0	3
				9			25	
Repellency Index : 47								

Aloe parvidens (acetone 10%)									
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	3	2	0	3	2	0	0
	60'	2	2	1	2	2	0	1
	90'	2	2	1	2	2	0	1
	120'	2	3	0	2	2	0	1
2	30'	5	0	0	3	2	0	0
	60'	4	1	0	2	3	0	0
	90'	4	1	0	2	3	0	0
	120'	3	2	0	2	3	0	0
3	30'	6	0	1	0	2	1	0
	60'	4	1	0	0	3	1	1
	90'	2	3	0	0	5	0	0
	120'	2	3	0	0	5	0	0
4	30'	3	1	0	0	3	0	3
	60'	1	2	0	0	4	1	2
	90'	1	2	0	0	6	0	1
	120'	1	2	0	0	6	0	1
Tot.	120'	8	10	0	4	16	0	2
				14			18	
Repellency Index : 12								

R = Replication; P = Platform; T = Top; M = Middle; B = Bottom (see additional explanations in the text)

5.2 TABLE 5 - Repellency indexes of *Aloe calidophila*

Aloe calidophila (hexane 10%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	3	0	0	0	3	0	4
	60'	4	0	0	0	2	1	3
	90'	3	0	1	0	4	0	2
	120'	3	1	0	0	4	0	2
2	30'	5	0	0	0	5	0	0
	60'	5	0	1	0	4	0	0
	90'	3	1	0	0	6	0	0
	120'	3	1	0	0	6	0	0
3	30'	10	0	0	0	0	0	0
	60'	10	0	0	0	0	0	0
	90'	9	0	0	0	1	0	0
	120'	8	0	0	0	1	0	1
4	30'	8	0	0	0	1	0	1
	60'	7	0	0	0	1	0	2
	90'	3	0	0	0	3	0	4
	120'	3	0	0	0	3	0	4
Tot.	120'	17	2	0	0	14	0	7
				2			21	
Repellency Index : 83								

Aloe calidophila (acetone 10%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	8	1	0	0	0	0	1
	60'	7	1	0	0	2	0	0
	90'	4	3	0	0	3	0	0
	120'	4	3	0	0	3	0	0
2	30'	6	2	0	0	1	1	0
	60'	3	2	0	1	2	0	2
	90'	1	2	0	1	4	0	2
	120'	0	2	0	1	4	0	3
3	30'	6	0	1	0	2	0	1
	60'	6	1	0	0	3	0	0
	90'	6	1	0	0	3	0	0
	120'	6	1	0	0	3	0	0
4	30'	9	0	0	0	1	0	0
	60'	6	2	0	0	2	0	0
	90'	5	3	0	0	2	0	0
	120'	5	3	0	0	2	0	0
Tot.	120'	15	9	0	1	12	0	3
				10			15	
Repellency Index : 20								

Aloe calidophila (hexane 5%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	3	0	0	0	3	0	4
	60'	4	0	0	0	2	1	3
	90'	3	0	1	0	4	0	2
	120'	3	1	0	0	4	0	2
2	30'	5	0	0	0	5	0	0
	60'	5	0	1	0	4	0	0
	90'	3	1	0	0	6	0	0
	120'	3	1	0	0	6	0	0
3	30'	5	1	0	0	1	0	3
	60'	5	1	0	0	1	1	2
	90'	3	1	0	0	4	0	2
	120'	3	1	0	0	4	0	2
4	30'	8	0	0	0	1	0	1
	60'	7	0	0	0	1	0	2
	90'	3	0	0	0	3	0	4
	120'	3	0	0	0	3	0	4
Tot.	120'	12	3	0	0	17	0	8
				3			25	
Repellency Index : 79								

Aloe calidophila (hexane 1%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	4	4	0	0	1	1	0
	60'	4	4	0	0	2	0	0
	90'	4	4	0	0	2	0	0
	120'	4	4	0	0	2	0	0
2	30'	4	1	1	0	2	0	2
	60'	4	2	0	0	2	0	2
	90'	3	2	0	0	3	0	2
	120'	3	2	0	0	3	0	2
3	30'	7	0	0	0	1	0	2
	60'	7	0	0	0	1	0	2
	90'	3	1	0	0	5	0	1
	120'	2	2	0	0	5	0	1
4	30'	6	0	0	0	0	0	4
	60'	6	0	0	0	0	0	4
	90'	6	0	0	0	1	0	3
	120'	5	0	0	0	4	0	1
Tot.	120'	14	8	0	0	14	0	4
				8			18	
Repellency Index : 38								

R = Replication; P = Platform; T = Top; M = Middle; B = Bottom (see additional explanations in the text)

5.3 TABLE 6 - Repellency indexes of *Azadirachta indica, Boscia angustifolia* and *Calotropis procera*

Azadirachta indica (hexane 10%)									
R	TIME	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	2	4	0	0	2	0	2	
	60'	2	4	0	0	2	0	2	
	90'	2	4	0	0	2	0	2	
	120'	2	4	0	0	2	0	2	
2	30'	3	7	0	0	0	0	0	
	60'	3	7	0	0	0	0	0	
	90'	3	7	0	0	0	0	0	
	120'	2	8	0	0	0	0	0	
3	30'	6	0	0	0	1	0	3	
	60'	6	0	0	0	1	0	3	
	90'	6	0	0	0	1	0	3	
	120'	3	1	0	1	2	0	3	
4	30'	5	1	0	0	3	0	1	
	60'	1	3	0	0	5	0	1	
	90'	1	3	0	0	5	0	1	
	120'	1	3	0	0	5	0	1	
Tot.	120'	8	16	0	1	9	0	6	
				17			15		
Repellency Index : - 6									

Azadirachta indica (acetone 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	2	2	0	1	3	0	2	
	60'	2	3	0	0	3	1	1	
	90'	2	3	0	0	4	0	1	
	120'	2	3	0	0	4	0	1	
2	30'	5	0	1	2	0	0	2	
	60'	2	3	0	0	2	0	3	
	90'	2	3	0	0	2	0	3	
	120'	2	3	0	0	2	0	3	
3	30'	5	1	0	2	0	0	2	
	60'	5	1	0	2	1	0	1	
	90'	5	2	0	1	1	0	1	
	120'	5	2	0	1	1	0	1	
4	30'	5	1	0	1	1	1	1	
	60'	4	3	0	0	2	0	1	
	90'	4	3	0	0	2	0	1	
	120'	4	3	0	0	2	0	1	
Tot.	120'	13	11	0	1	9	0	6	
				12			15		
Repellency Index : 11									

Boscia angustifolia (hexane 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	7	1	0	0	0	0	2	
	60'	3	4	0	0	1	0	2	
	90'	3	4	0	0	1	0	2	
	120'	3	4	0	0	1	0	2	
2	30'	5	4	0	0	0	0	1	
	60'	1	7	0	0	1	0	1	
	90'	1	7	0	0	1	0	1	
	120'	1	7	0	0	1	0	1	
3	30'	3	1	1	0	3	0	2	
	60'	2	4	0	0	3	1	0	
	90'	2	4	0	0	3	1	0	
	120'	1	4	0	0	5	0	0	
4	30'	1	0	0	0	4	0	5	
	60'	2	0	0	0	5	0	3	
	90'	2	0	0	0	5	0	3	
	120'	1	1	0	0	6	0	2	
Tot.	120'	6	16	0	0	13	0	5	
				16			18		
Repellency Index : 6									

Boscia angustifolia (acetone 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	4	1	2	1	1	0	1	
	60'	4	3	0	1	1	0	1	
	90'	3	3	0	1	2	0	1	
	120'	3	3	0	1	2	0	1	
2	30'	5	2	0	0	3	0	0	
	60'	3	3	0	0	3	0	1	
	90'	3	3	0	0	3	0	1	
	120'	2	4	0	0	3	0	1	
3	30'	5	0	1	1	3	0	0	
	60'	5	1	0	1	3	0	0	
	90'	3	3	0	1	3	0	0	
	120'	3	3	0	1	3	0	0	
4	30'	5	1	0	1	1	0	2	
	60'	1	2	0	1	4	0	2	
	90'	1	2	0	1	4	0	2	
	120'	1	2	0	1	4	0	2	
Tot.	120'	9	12	0	3	12	0	4	
				15			16		
Repellency Index : 3									

Calotropis procera (hexane 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	5	4	0	0	0	1	0	
	60'	3	6	0	0	0	0	1	
	90'	1	8	0	0	0	0	1	
	120'	1	8	0	0	0	0	1	
2	30'	3	6	0	0	1	0	0	
	60'	0	9	0	0	1	0	0	
	90'	0	9	0	0	1	0	0	
	120'	0	9	0	0	1	0	0	
3	30'	1	4	0	0	5	0	0	
	60'	1	5	0	0	4	0	0	
	90'	1	5	0	0	4	0	0	
	120'	1	5	0	0	4	0	0	
4	30'	5	0	0	0	4	0	1	
	60'	1	1	0	0	5	0	3	
	90'	1	0	0	0	5	0	4	
	120'	1	0	0	0	5	0	4	
Tot.	120'	3	22	0	0	10	0	5	
				22			15		
Repellency Index : - 19									

Calotropis procera (acetone 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	5	4	0	0	0	1	0	
	60'	3	6	0	0	1	0	0	
	90'	2	5	0	0	3	0	0	
	120'	1	5	0	0	4	0	0	
2	30'	4	2	0	1	1	1	1	
	60'	2	3	0	1	2	1	1	
	90'	2	3	0	2	2	0	1	
	120'	1	4	0	2	2	0	1	
3	30'	5	1	0	1	1	0	2	
	60'	3	2	1	1	3	0	0	
	90'	3	3	0	1	3	0	0	
	120'	3	3	0	1	3	0	0	
4	30'	4	4	0	0	1	0	1	
	60'	2	4	0	1	2	0	1	
	90'	1	5	0	1	2	0	1	
	120'	1	5	0	1	2	0	1	
Tot.	120'	6	17	0	4	11	0	2	
				21			13		
Repellency Index : - 24									

R = Replication; P = Platform; T = Top; M = Middle; B = Bottom (see additional explanations in the text)

5.4 TABLE 7 - Repellency indexes of *Calpurnia aurea, Cordia africana* and *Euphorbia candelabrum*

Calpurnia aurea (hexane 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	0	5	0	0	3	0	2	
	60'	0	4	1	0	3	0	2	
	90'	0	4	1	0	3	0	2	
	120'	0	4	1	0	3	0	2	
2	30'	4	3	0	0	2	0	1	
	60'	3	3	0	0	3	0	1	
	90'	2	4	0	0	3	0	1	
	120'	2	4	0	0	3	0	1	
3	30'	3	3	0	0	2	0	2	
	60'	3	3	0	0	2	0	2	
	90'	3	3	0	0	2	0	2	
	120'	3	3	0	0	2	0	2	
4	30'	1	6	1	0	1	0	1	
	60'	1	7	0	0	1	0	1	
	90'	1	7	0	0	1	0	1	
	120'	1	7	0	0	1	0	1	
Tot.	120'	6	18	1	0	9	0	6	
				19			15		
Repellency Index : - 12									

Calpurnia aurea (acetone 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	5	4	0	0	0	0	1	
	60'	5	4	0	0	1	0	0	
	90'	3	5	0	0	2	0	0	
	120'	2	5	0	0	3	0	0	
2	30'	4	3	0	1	2	0	0	
	60'	2	5	0	1	2	0	0	
	90'	1	5	0	1	3	0	0	
	120'	1	5	0	1	3	0	0	
3	30'	2	2	0	2	2	0	2	
	60'	1	4	1	0	2	0	2	
	90'	1	4	1	0	2	0	2	
	120'	1	4	1	0	2	0	2	
4	30'	5	3	1	0	1	0	0	
	60'	3	4	0	0	2	0	1	
	90'	3	4	0	0	2	0	1	
	120'	3	4	0	0	2	0	1	
Tot.	120'	7	18	1	1	10	0	3	
				20			13		
Repellency Index : - 21									

Cordia africana (hexane 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	5	2	0	1	1	0	1	
	60'	2	2	0	2	3	0	1	
	90'	2	2	0	2	3	0	1	
	120'	2	2	0	2	3	0	1	
2	30'	6	1	1	0	1	0	1	
	60'	5	2	0	0	2	0	1	
	90'	5	2	0	0	2	0	1	
	120'	3	3	0	0	2	0	2	
3	30'	5	1	1	1	2	0	0	
	60'	4	1	0	1	3	1	0	
	90'	2	2	0	1	4	1	0	
	120'	1	2	0	1	5	1	0	
4	30'	4	1	0	0	3	1	1	
	60'	4	1	0	0	3	0	2	
	90'	2	1	0	0	5	0	2	
	120'	2	1	0	0	5	0	2	
Tot.	120'	8	8	0	3	15	1	5	
				11			21		
Repellency Index : 31									

Cordia africana (acetone 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	5	1	1	1	1	0	1	
	60'	4	2	0	1	2	0	1	
	90'	3	2	0	1	3	0	1	
	120'	3	2	0	1	3	0	1	
2	30'	5	1	0	1	2	0	1	
	60'	2	2	0	0	3	1	2	
	90'	2	3	0	0	3	1	1	
	120'	2	3	0	0	4	0	1	
3	30'	4	2	1	1	1	0	1	
	60'	3	2	0	2	2	1	0	
	90'	3	2	0	2	2	1	0	
	120'	3	2	0	2	3	0	0	
4	30'	6	1	0	0	3	0	0	
	60'	4	3	0	0	3	0	0	
	90'	4	3	0	0	3	0	0	
	120'	4	3	0	0	3	0	0	
Tot.	120'	12	10	0	3	13	0	2	
				13			15		
Repellency Index : 7									

Euphorbia candelabrum (hexane 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	8	0	0	0	2	0	0	
	60'	6	0	0	0	2	0	2	
	90'	2	1	0	2	2	1	2	
	120'	1	1	0	2	5	0	1	
2	30'	8	0	0	0	2	0	0	
	60'	7	0	0	0	2	0	1	
	90'	6	1	0	0	2	0	1	
	120'	6	2	0	0	1	0	1	
3	30'	8	0	0	0	0	1	1	
	60'	6	0	0	0	3	0	1	
	90'	5	0	0	1	2	0	2	
	120'	5	1	0	0	2	1	1	
4	30'	5	0	0	1	2	1	1	
	60'	4	0	0	1	4	0	1	
	90'	3	0	1	1	4	0	1	
	120'	2	1	0	0	5	0	2	
Tot.	120'	14	5	0	2	13	1	5	
				7			19		
Repellency Index : 46									

Euphorbia candelabrum (acetone 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	5	2	0	1	2	0	0	
	60'	4	3	0	0	2	0	1	
	90'	4	3	0	0	2	1	0	
	120'	4	3	0	0	3	0	0	
2	30'	6	1	1	0	0	0	2	
	60'	5	2	0	0	2	0	1	
	90'	5	2	0	0	2	0	1	
	120'	5	2	0	0	2	0	1	
3	30'	6	1	0	1	2	0	0	
	60'	5	1	0	0	3	0	1	
	90'	4	1	0	1	2	0	2	
	120'	4	2	0	0	2	1	1	
4	30'	5	3	0	0	2	0	0	
	60'	4	3	0	0	2	0	1	
	90'	3	3	0	1	2	0	1	
	120'	2	3	0	1	2	0	2	
Tot.	120'	15	10	0	1	9	1	4	
				11			14		
Repellency Index : 12									

R = Replication; P = Platform; T = Top; M = Middle; B = Bottom (see additional explanations in the text)

5.5 TABLE 8 - Repellency indexes of *Cissus quadrangularis*

Cissus quadrangularis (hexane 10%)								
R	*Time*	P	TEST			CONTROL		
			T	M	B	T	M	B
1	*30'*	3	1	0	0	2	0	4
	60'	4	1	0	0	2	0	3
	90'	4	1	0	0	2	0	3
	120'	2	1	0	0	2	0	5
2	*30'*	7	0	0	0	1	0	2
	60'	5	0	0	0	2	1	2
	90'	5	0	0	0	3	0	2
	120'	2	0	0	0	3	0	5
3	*30'*	6	1	0	0	3	0	0
	60'	5	1	0	0	4	0	0
	90'	5	1	0	0	4	0	0
	120'	3	2	0	0	5	0	0
4	*30'*	5	0	0	0	4	0	1
	60'	4	0	0	0	5	0	1
	90'	2	0	0	0	5	0	3
	120'	2	0	0	0	5	0	3
Tot.	*120'*	9	3	0	0	15	0	13
				3			28	
Repellency Index : 81								

Cissus quadrangularis (acetone 10%)								
R	*Time*	P	TEST			CONTROL		
			T	M	B	T	M	B
1	*30'*	4	1	0	0	3	0	2
	60'	3	1	0	1	3	0	2
	90'	3	1	0	1	3	0	2
	120'	3	1	0	1	3	0	2
2	*30'*	5	2	0	1	1	0	1
	60'	5	2	0	1	2	0	0
	90'	4	3	0	0	3	0	0
	120'	4	3	0	0	3	0	0
3	*30'*	3	2	0	2	2	0	1
	60'	3	3	0	1	3	0	0
	90'	3	3	0	1	3	0	0
	120'	3	3	0	1	3	0	0
4	*30'*	4	2	0	0	3	0	1
	60'	3	2	0	0	4	0	1
	90'	2	3	0	0	4	0	1
	120'	2	3	0	0	4	0	1
Tot.	*120'*	12	10	0	2	13	0	3
				12			16	
Repellency Index : 14								

Cissus quadrangularis (hexane 5%)								
R	*Time*	P	TEST			CONTROL		
			T	M	B	T	M	B
1	*30'*	10	0	0	0	0	0	0
	60'	9	0	0	0	0	0	1
	90'	7	0	1	0	0	0	2
	120'	5	2	1	0	0	0	2
2	*30'*	9	1	0	0	0	0	0
	60'	8	1	0	0	0	0	1
	90'	6	1	0	0	2	0	1
	120'	4	3	0	0	2	0	1
3	*30'*	6	1	0	0	1	0	2
	60'	6	1	0	0	1	0	2
	90'	5	1	0	0	1	0	3
	120'	4	1	0	0	1	0	4
4	*30'*	5	2	0	0	2	1	0
	60'	5	2	0	0	2	1	0
	90'	4	2	0	0	3	1	0
	120'	3	2	0	0	4	1	0
Tot.	*120'*	16	8	1	0	7	1	7
				9			15	
Repellency Index : 25								

Cissus quadrangularis (hexane 1%)								
R	*Time*	P	TEST			CONTROL		
			T	M	B	T	M	B
1	*30'*	4	3	0	0	2	0	1
	60'	3	3	0	0	3	0	1
	90'	2	3	0	0	3	0	2
	120'	2	3	0	0	3	0	2
2	*30'*	6	2	0	0	0	0	2
	60'	4	3	0	0	1	0	2
	90'	2	4	0	0	1	0	3
	120'	2	4	0	0	1	0	3
3	*30'*	5	3	0	0	1	0	1
	60'	4	3	0	0	1	0	2
	90'	3	3	0	1	1	0	2
	120'	4	3	0	0	1	0	2
4	*30'*	8	2	0	0	0	0	0
	60'	7	3	0	0	0	0	0
	90'	7	3	0	0	0	0	0
	120'	6	4	0	0	0	0	0
Tot.	*120'*	14	14	0	0	5	0	7
				14			12	
Repellency Index : - 8								

R = Replication; P = Platform; T = Top; M = Middle; B = Bottom (see additional explanations in the text)

5.6 TABLE 9 - Repellency indexes of *Commiphora erythraea*

Commiphora erythraea (hexane 10%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	4	1	0	0	1	1	3
	60'	2	1	0	0	6	0	1
	90'	1	1	0	0	7	0	1
	120'	1	1	0	0	7	0	1
2	30'	5	1	0	0	1	0	3
	60'	3	1	0	0	3	0	3
	90'	3	1	0	0	3	0	3
	120'	3	1	0	0	3	0	3
3	30'	6	0	1	0	1	1	1
	60'	3	0	0	0	2	0	5
	90'	2	1	0	0	4	0	3
	120'	2	1	0	0	4	0	3
4	30'	4	0	0	0	3	0	3
	60'	3	0	0	1	3	0	3
	90'	3	0	0	1	5	0	1
	120'	3	0	0	1	5	0	1
Tot.	120'	9	3	0	1	19	0	8
				4			27	
Repellency Index : 74								

Commiphora erythraea (acetone 10%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	5	1	0	1	0	1	2
	60'	4	2	0	1	1	0	2
	90'	3	2	0	1	2	0	2
	120'	3	2	0	1	2	0	2
2	30'	4	0	0	1	1	2	2
	60'	4	1	0	0	1	1	3
	90'	4	1	0	0	2	0	3
	120'	3	1	0	0	2	0	4
3	30'	3	0	2	2	3	0	0
	60'	3	4	0	0	3	0	0
	90'	2	4	0	0	3	0	1
	120'	2	4	0	0	3	0	1
4	30'	6	2	0	1	1	0	0
	60'	5	2	0	1	1	0	1
	90'	3	3	0	1	3	0	0
	120'	3	3	0	1	3	0	0
Tot.	120'	11	10	0	2	10	0	7
				12			17	
Repellency Index : 17								

Commiphora erythraea (hexane 5%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	4	1	0	2	3	0	0
	60'	3	2	0	1	4	0	0
	90'	3	2	0	1	4	0	0
	120'	3	2	0	1	4	0	0
2	30'	4	2	0	0	1	0	3
	60'	1	2	0	0	3	0	4
	90'	1	2	0	0	4	0	3
	120'	1	2	0	0	4	0	3
3	30'	5	1	0	1	1	0	2
	60'	4	1	0	1	2	0	2
	90'	3	1	0	1	3	0	2
	120'	3	1	0	1	3	0	2
4	30'	3	0	1	0	2	0	4
	60'	2	0	1	1	2	0	4
	90'	2	2	0	1	4	0	1
	120'	2	2	0	1	4	0	1
Tot.	120'	9	7	0	3	15	0	6
				10			21	
Repellency Index : 35								

Commiphora erythraea (hexane 1%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	3	2	0	1	1	0	3
	60'	1	3	0	1	3	0	2
	90'	1	4	0	1	3	0	1
	120'	1	4	0	1	3	0	1
2	30'	2	1	1	1	1	1	3
	60'	2	3	0	0	3	0	2
	90'	2	3	0	0	3	0	2
	120'	2	3	0	0	3	0	2
3	30'	3	1	0	1	1	2	2
	60'	2	1	0	1	2	2	2
	90'	2	1	0	1	4	0	2
	120'	2	1	0	1	4	0	2
4	30'	4	0	1	0	1	1	3
	60'	4	0	1	1	1	0	3
	90'	3	2	0	1	4	0	0
	120'	3	2	0	1	4	0	0
Tot.	120'	8	10	0	3	14	0	5
				13			19	
Repellency Index : 19								

R = Replication; P = Platform; T = Top; M = Middle; B = Bottom (see additional explanations in the text)

5.7 TABLE 10 - Repellency indexes of *Croton macrostachys*

Croton macrostachys (hexane 10%)								
R	Time	p	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	6	0	1	0	1	0	2
	60'	4	2	0	0	1	0	3
	90'	4	2	0	0	2	0	2
	120'	6	1	1	0	1	0	1
2	30'	5	2	0	0	3	0	0
	60'	6	0	0	0	4	0	0
	90'	5	0	0	0	5	0	0
	120'	4	0	0	0	6	0	0
3	30'	8	1	0	0	1	0	0
	60'	6	0	2	0	1	0	1
	90'	6	1	0	0	2	0	1
	120'	5	0	1	0	3	0	1
4	30'	5	1	0	0	1	0	3
	60'	7	1	0	0	1	0	1
	90'	4	1	1	0	1	1	2
	120'	2	0	1	0	6	0	1
Tot.	120'	17	1	3	0	16	0	3
				4			19	
Repellency Index : 65								

Croton macrostachys (acetone 10%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	8	1	0	1	0	0	0
	60'	5	2	0	1	1	0	1
	90'	5	2	0	1	2	0	0
	120'	5	2	0	1	2	0	0
2	30'	6	2	0	0	2	0	0
	60'	5	2	0	0	3	0	0
	90'	4	3	0	0	3	0	0
	120'	4	3	0	0	3	0	0
3	30'	5	2	0	1	1	0	1
	60'	3	3	0	0	3	0	1
	90'	2	3	0	1	3	0	1
	120'	2	3	0	1	3	0	1
4	30'	4	1	0	1	2	0	2
	60'	1	2	0	3	3	0	1
	90'	1	2	0	3	3	0	1
	120'	1	2	0	3	3	0	1
Tot.	120'	12	10	0	5	11	0	2
				15			13	
Repellency Index : - 7								

Croton macrostachys (hexane 5%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	5	0	0	0	3	0	2
	60'	3	2	0	0	4	0	1
	90'	2	2	1	0	3	0	2
	120'	2	2	1	0	3	0	2
2	30'	3	0	0	0	6	0	1
	60'	3	0	0	0	6	0	1
	90'	0	1	0	0	9	0	0
	120'	0	1	0	0	9	0	0
3	30'	4	1	0	0	3	0	2
	60'	4	1	0	0	4	0	1
	90'	1	2	0	0	6	0	1
	120'	1	2	0	0	6	0	1
4	30'	5	2	0	0	2	1	0
	60'	5	2	0	0	3	0	0
	90'	2	3	0	1	4	0	0
	120'	2	3	0	1	4	0	0
Tot.	120'	5	8	1	1	22	0	3
				10			25	
Repellency Index : 43								

Croton macrostachys (hexane 1%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	9	0	0	0	1	0	0
	60'	7	1	0	0	2	0	0
	90'	6	2	0	0	2	0	0
	120'	4	2	0	0	4	0	0
2	30'	7	2	0	0	1	0	0
	60'	4	3	0	1	2	0	0
	90'	3	3	0	1	2	0	1
	120'	3	3	0	1	2	0	1
3	30'	8	1	0	1	0	0	0
	60'	5	2	1	1	0	0	1
	90'	4	3	0	1	2	0	0
	120'	4	3	0	1	2	0	0
4	30'	8	1	0	0	1	0	0
	60'	6	2	0	0	1	0	1
	90'	4	2	1	0	2	0	1
	120'	4	3	0	0	2	0	1
Tot.	120'	15	11	0	2	10	0	2
				13			12	
Repellency Index : - 4								

R = Replication; P = Platform; T = Top; M = Middle; B = Bottom (see additional explanations in the text)

5.8 TABLE 11 - Repellency indexes of *Croton megalocarpus*

Croton megalocarpus (hexane 10%)								
R	*Time*	P	TEST			CONTROL		
			T	M	B	T	M	B
1	*30'*	8	0	0	0	2	0	0
	60'	6	0	0	0	3	0	1
	90'	6	0	0	0	3	0	1
	120'	3	0	0	0	3	0	4
2	*30'*	5	0	0	0	3	0	2
	60'	3	0	0	0	4	0	3
	90'	3	0	0	0	4	0	3
	120'	3	0	0	0	5	0	2
3	*30'*	7	0	0	0	1	0	2
	60'	5	0	0	0	1	0	4
	90'	3	0	0	0	1	0	6
	120'	2	0	0	0	2	0	6
4	*30'*	8	0	0	0	2	0	0
	60'	4	1	0	0	2	0	3
	90'	4	1	0	0	2	0	3
	120'	4	1	0	0	2	0	3
Tot.	*120'*	12	1	0	0	12	0	15
				1			**27**	
Repellency Index : 93								

Croton megalocarpus (acetone 10%)								
R	*Time*	P	TEST			CONTROL		
			T	M	B	T	M	B
1	*30'*	7	2	0	0	1	0	0
	60'	4	4	0	0	2	0	0
	90'	4	4	0	0	2	0	0
	120'	3	4	0	0	3	0	0
2	*30'*	5	2	0	1	1	0	1
	60'	3	3	0	2	1	0	1
	90'	3	3	0	2	1	0	1
	120'	3	3	0	2	1	0	1
3	*30'*	7	1	0	1	1	0	0
	60'	5	2	0	0	1	0	2
	90'	3	4	0	0	2	0	1
	120'	2	4	0	0	3	0	1
4	*30'*	8	1	0	0	1	0	0
	60'	4	3	0	0	3	0	0
	90'	4	3	0	0	3	0	0
	120'	4	3	0	0	3	0	0
Tot.	*120'*	12	14	0	2	10	0	2
				16			**12**	
Repellency Index : - 14								

Croton megalocarpus (hexane 5%)								
R	*Time*	P	TEST			CONTROL		
			T	M	B	T	M	B
1	*30'*	3	0	0	0	5	0	2
	60'	3	0	0	0	5	0	2
	90'	3	0	0	0	5	0	2
	120'	3	0	0	0	5	0	2
2	*30'*	6	0	0	0	4	0	0
	60'	5	0	0	0	4	0	1
	90'	4	1	0	0	4	0	1
	120'	4	1	0	0	4	0	1
3	*30'*	6	0	0	1	3	0	0
	60'	5	0	1	0	4	0	0
	90'	3	2	0	0	4	0	1
	120'	3	2	0	0	4	0	1
4	*30'*	5	0	0	0	4	0	1
	60'	4	0	0	0	5	0	1
	90'	4	0	0	0	5	0	1
	120'	4	0	0	0	5	0	1
Tot.	*120'*	14	3	0	0	18	0	5
				3			**23**	
Repellency Index : 77								

Croton megalocarpus (hexane 1%)								
R	*Time*	P	TEST			CONTROL		
			T	M	B	T	M	B
1	*30'*	6	2	1	0	1	0	0
	60'	3	3	0	0	4	0	0
	90'	3	3	0	0	4	0	0
	120'	3	3	0	0	4	0	0
2	*30'*	7	1	0	0	0	0	2
	60'	5	1	0	0	1	1	2
	90'	4	1	0	0	3	0	2
	120'	4	1	0	0	3	0	2
3	*30'*	4	2	0	1	1	1	1
	60'	4	3	0	0	2	1	0
	90'	4	3	0	0	3	0	0
	120'	4	3	0	0	3	0	0
4	*30'*	4	1	0	1	2	2	0
	60'	3	1	1	1	3	1	0
	90'	3	3	0	0	4	0	0
	120'	3	3	0	0	4	0	0
Tot.	*120'*	14	10	0	0	14	0	2
				10			**16**	
Repellency Index : 23								

R = Replication; P = Platform; T = Top; M = Middle; B = Bottom (see additional explanations in the text)

5.9 TABLE 12 - Repellency indexes of *Datura stramonium*

Datura stramonium (hexane 10%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	9	0	0	0	1	0	0
	60'	8	0	0	0	2	0	0
	90'	7	0	0	0	1	0	2
	120'	4	1	0	0	5	0	0
2	30'	6	0	0	0	4	0	0
	60'	3	0	0	0	5	0	2
	90'	2	0	0	0	6	0	2
	120'	1	0	0	0	6	0	3
3	30'	9	0	0	0	1	0	0
	60'	5	1	0	0	3	0	1
	90'	4	1	0	0	3	0	2
	120'	3	1	0	0	4	0	2
4	30'	8	0	0	0	2	0	0
	60'	6	0	0	0	3	0	1
	90'	4	0	0	0	4	0	2
	120'	4	1	0	0	4	0	1
Tot.	120'	12	3	0	0	19	0	6
				3			25	
Repellency Index : 79								

Datura stramonium (acetone 10%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	6	0	0	0	1	0	3
	60'	5	1	1	0	1	0	2
	90'	5	2	0	0	1	0	2
	120'	4	1	1	0	1	0	3
2	30'	7	0	0	0	3	0	0
	60'	5	1	0	0	4	0	0
	90'	4	2	0	0	4	0	0
	120'	4	2	0	0	4	0	0
3	30'	8	0	0	0	2	0	0
	60'	7	1	0	1	1	0	0
	90'	7	1	0	1	1	0	0
	120'	6	2	0	1	1	0	0
4	30'	2	3	0	0	2	0	3
	60'	2	1	1	0	2	0	4
	90'	1	3	0	0	2	0	4
	120'	2	2	0	0	2	0	4
Tot.	120'	16	7	1	1	8	0	7
				9			15	
Repellency Index : 25								

Datura stramonium (hexane 5%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	4	0	1	0	2	1	2
	60'	4	1	1	0	3	0	1
	90'	3	0	1	1	4	0	1
	120'	3	0	1	1	4	0	1
2	30'	4	3	0	1	1	1	0
	60'	4	3	0	0	3	0	0
	90'	4	3	0	0	3	0	0
	120'	4	2	0	0	3	0	1
3	30'	7	1	0	0	1	0	1
	60'	3	4	0	0	2	0	1
	90'	3	3	1	0	2	0	1
	120'	2	3	1	0	3	0	1
4	30'	8	0	0	0	2	0	0
	60'	4	1	1	0	3	0	1
	90'	5	2	0	0	3	0	0
	120'	5	1	0	0	4	0	0
Tot.	120'	14	6	2	1	14	0	3
				9			17	
Repellency Index : 31								

Datura stramonium (acetone 5%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	4	0	1	0	4	0	1
	60'	4	0	1	0	4	0	1
	90'	1	1	2	0	5	0	1
	120'	2	2	0	0	5	0	1
2	30'	2	4	0	0	4	0	0
	60'	1	5	0	0	4	0	0
	90'	0	6	0	0	4	0	0
	120'	0	6	0	0	4	0	0
3	30'	9	0	0	0	1	0	0
	60'	8	1	0	0	1	0	0
	90'	4	2	0	0	2	0	2
	120'	3	2	0	0	2	0	3
4	30'	5	2	0	0	3	0	0
	60'	5	2	0	0	3	0	0
	90'	1	2	0	0	5	0	2
	120'	0	3	0	0	5	0	2
Tot.	120'	5	13	0	0	16	0	6
				13			22	
Repellency Index : 26								

Datura stramonium (hexane 1%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	4	0	2	0	3	1	0
	60'	2	2	1	0	5	0	0
	90'	3	2	0	0	5	0	0
	120'	2	2	0	0	6	0	0
2	30'	1	5	0	0	3	0	1
	60'	1	4	1	0	3	0	1
	90'	2	3	0	0	4	0	1
	120'	1	4	0	0	3	0	2
3	30'	7	2	0	0	0	0	1
	60'	5	1	0	0	2	0	2
	90'	4	1	1	0	2	0	2
	120'	4	2	0	0	2	0	2
4	30'	5	2	0	0	3	0	0
	60'	4	2	0	0	3	0	1
	90'	0	5	0	0	3	0	2
	120'	0	5	0	0	3	0	2
Tot.	120'	7	13	0	0	14	0	6
				13			20	
Repellency Index : 21								

Datura stramonium (acetone 1%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	7	2	0	0	0	0	1
	60'	5	4	0	0	0	0	1
	90'	5	5	0	0	0	0	0
	120'	4	4	0	0	0	0	2
2	30'	4	2	0	2	1	0	1
	60'	4	4	0	0	2	0	0
	90'	4	3	0	0	2	0	1
	120'	4	3	0	0	2	0	1
3	30'	3	0	0	1	0	0	6
	60'	2	0	0	1	1	0	6
	90'	2	0	0	1	2	0	5
	120'	0	1	0	1	2	0	6
4	30'	7	1	0	1	0	0	1
	60'	3	3	0	0	0	0	4
	90'	3	3	0	0	0	0	4
	120'	3	3	0	0	0	0	4
Tot.	120'	11	11	0	1	4	0	13
				12			17	
Repellency Index : 17								

R = Replication; P = Platform; T = Top; M = Middle; B = Bottom (see additional explanations in the text)

5.10 TABLE 13 - Repellency indexes of *Euphorbia tirucalli*, *Ficus sycomorus* and *Ficus thonningii*

Euphorbia tirucalli (hexane 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	8	1	0	0	1	0	0	
	60'	7	1	0	0	2	0	0	
	90'	6	2	0	0	2	0	0	
	120'	6	2	0	0	2	0	0	
2	30'	5	0	0	1	3	0	1	
	60'	5	0	0	1	3	0	1	
	90'	3	0	0	1	4	0	2	
	120'	3	0	0	1	4	0	2	
3	30'	4	1	0	1	4	0	0	
	60'	1	1	0	2	6	0	0	
	90'	1	1	0	2	6	0	0	
	120'	0	1	0	2	7	0	0	
4	30'	10	0	0	0	0	0	0	
	60'	6	1	0	0	3	0	0	
	90'	4	2	0	0	4	0	0	
	120'	2	2	0	0	6	0	0	
Tot.	120'	11	5	0	3	19	0	2	
				8			21		
Repellency Index : 45									

Euphorbia tirucalli (acetone 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	6	2	0	1	0	0	1	
	60'	4	3	0	1	2	0	0	
	90'	3	3	0	1	3	0	0	
	120'	3	3	0	1	3	0	0	
2	30'	7	1	0	0	2	0	0	
	60'	5	1	1	0	3	0	0	
	90'	2	2	1	1	3	0	1	
	120'	0	2	1	1	4	0	2	
3	30'	5	2	0	0	3	0	0	
	60'	4	1	0	1	4	0	0	
	90'	4	1	0	1	4	0	0	
	120'	4	1	0	1	4	0	0	
4	30'	7	2	0	0	1	0	0	
	60'	5	2	0	0	3	0	0	
	90'	4	3	0	0	3	0	0	
	120'	4	3	0	0	3	0	0	
Tot.	120'	11	9	1	3	14	0	2	
				13			16		
Repellency Index : 10									

Ficus sycomorus (hexane 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	5	4	0	0	1	0	0	
	60'	4	4	0	0	1	0	1	
	90'	4	4	0	0	1	0	1	
	120'	2	5	0	0	2	0	1	
2	30'	2	4	1	0	3	0	0	
	60'	2	5	0	0	3	0	0	
	90'	2	5	0	0	3	0	0	
	120'	1	6	0	0	3	0	0	
3	30'	7	3	0	0	0	0	0	
	60'	6	4	0	0	0	0	0	
	90'	6	4	0	0	0	0	0	
	120'	6	4	0	0	0	0	0	
4	30'	5	1	0	1	1	1	1	
	60'	1	3	0	0	4	0	2	
	90'	1	3	0	0	4	0	2	
	120'	0	3	0	0	4	0	3	
Tot.	120'	9	18	0	0	9	0	4	
				18			13		
Repellency Index : - 16									

Ficus sycomorus (acetone 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	6	1	2	1	0	0	0	
	60'	4	3	0	1	1	0	1	
	90'	3	4	0	1	1	0	1	
	120'	2	4	0	1	2	0	1	
2	30'	4	2	1	1	2	0	0	
	60'	4	3	0	1	2	0	0	
	90'	0	5	0	1	2	0	2	
	120'	0	5	0	1	2	0	2	
3	30'	6	1	0	2	1	0	0	
	60'	5	1	0	2	2	0	0	
	90'	2	4	0	2	2	0	0	
	120'	2	4	0	2	2	0	0	
4	30'	4	2	0	1	1	1	1	
	60'	1	3	0	1	3	1	1	
	90'	0	4	0	1	3	1	1	
	120'	0	4	0	1	3	1	1	
Tot.	120'	4	17	0	5	9	1	4	
				22			14		
Repellency Index : - 22									

Ficus thonningii (hexane 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	7	1	0	0	1	0	1	
	60'	7	1	0	0	2	0	0	
	90'	7	1	0	0	2	0	0	
	120'	5	2	0	0	3	0	0	
2	30'	4	2	0	0	0	0	4	
	60'	5	0	1	0	0	0	4	
	90'	5	1	0	0	0	0	4	
	120'	5	1	0	0	0	0	4	
3	30'	4	1	1	0	2	0	2	
	60'	3	2	1	0	3	0	1	
	90'	3	2	1	0	3	0	1	
	120'	4	2	0	0	3	0	1	
4	30'	7	1	0	0	1	0	1	
	60'	7	1	0	0	1	0	1	
	90'	5	1	0	0	3	0	1	
	120'	5	1	0	0	3	0	1	
Tot.	120'	19	6	0	0	9	0	6	
				6			15		
Repellency Index : 43									

Ficus thonningii (acetone 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	5	2	0	0	2	0	1	
	60'	5	2	0	0	2	0	1	
	90'	3	2	0	0	3	0	2	
	120'	3	2	0	0	3	0	2	
2	30'	7	0	1	0	1	0	1	
	60'	6	1	0	0	1	0	2	
	90'	5	2	0	0	1	0	2	
	120'	5	2	0	0	1	0	2	
3	30'	3	3	0	1	1	0	2	
	60'	2	3	0	2	2	0	1	
	90'	3	3	0	2	2	0	0	
	120'	3	3	0	2	2	0	0	
4	30'	6	0	1	0	1	0	2	
	60'	4	0	1	1	3	0	1	
	90'	4	0	1	1	3	0	1	
	120'	4	0	1	1	3	0	1	
Tot.	120'	15	7	1	3	9	0	5	
				11			14		
Repellency Index : 12									

R = Replication; P = Platform; T = Top; M = Middle; B = Bottom (see additional explanations in the text)

5.11 TABLE 14 - Repellency indexes of *Lantana camara*

Lantana camara (hexane 10%)									
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	6	0	0	0	3	0	1
	60'	4	0	0	0	5	0	1
	90'	4	0	0	0	5	0	1
	120'	4	0	0	0	5	0	1
2	30'	8	0	0	0	2	0	0
	60'	6	0	0	0	3	1	0
	90'	4	0	0	0	5	0	1
	120'	4	0	0	0	6	0	0
3	30'	6	1	0	0	1	0	2
	60'	5	1	0	0	1	0	3
	90'	4	1	0	0	2	0	3
	120'	3	1	0	0	3	0	3
4	30'	5	0	0	0	4	0	1
	60'	4	0	0	0	6	0	0
	90'	3	0	0	0	6	0	1
	120'	3	0	0	0	7	0	0
Tot.	120'	14	1	0	0	21	0	4
				1			25	
Repellency Index : 92								

Lantana camara (acetone 10%)									
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	4	1	0	0	4	1	0
	60'	2	1	0	0	7	0	0
	90'	2	0	1	0	7	0	0
	120'	1	1	0	0	7	0	1
2	30'	6	0	1	0	2	1	0
	60'	6	1	0	0	3	0	0
	90'	5	1	0	0	4	0	0
	120'	4	1	0	0	5	0	0
3	30'	5	0	0	0	4	1	0
	60'	5	0	0	0	5	0	0
	90'	5	0	0	0	5	0	0
	120'	5	0	0	0	5	0	0
4	30'	4	2	0	0	2	0	2
	60'	3	2	0	1	3	0	1
	90'	3	2	1	0	3	0	1
	120'	3	2	1	0	3	0	1
Tot.	120'	13	4	1	0	20	0	2
				5			22	
Repellency Index : 63								

Lantana camara (hexane 5%)									
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	7	0	0	0	3	0	0
	60'	5	0	0	0	5	0	0
	90'	5	0	0	0	5	0	0
	120'	4	1	0	0	5	0	0
2	30'	6	0	0	0	4	0	0
	60'	4	1	0	1	4	0	0
	90'	3	1	0	2	4	0	0
	120'	2	1	0	3	4	0	0
3	30'	5	0	0	0	2	0	3
	60'	3	1	0	0	3	0	3
	90'	3	1	0	0	3	0	3
	120'	2	1	0	0	4	0	3
4	30'	5	0	0	0	3	1	1
	60'	3	0	0	0	5	0	2
	90'	2	0	0	0	5	0	3
	120'	2	0	0	0	5	0	3
Tot.	120'	10	3	0	3	18	0	6
				6			24	
Repellency Index : 60								

Lantana camara (acetone 5%)									
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	7	3	0	0	0	0	0
	60'	4	4	0	0	1	0	1
	90'	4	4	0	0	2	0	0
	120'	4	4	0	0	2	0	0
2	30'	4	0	0	0	2	0	4
	60'	4	0	0	0	2	0	4
	90'	4	0	0	0	3	0	3
	120'	3	0	0	0	3	0	4
3	30'	6	0	2	0	2	0	0
	60'	3	3	0	0	3	0	1
	90'	2	3	0	0	4	0	1
	120'	2	3	0	0	4	0	1
4	30'	7	1	0	0	2	0	0
	60'	6	1	0	0	3	0	0
	90'	5	1	0	0	4	0	0
	120'	3	2	0	0	5	0	0
Tot.	120'	12	9	0	0	14	0	5
				9			19	
Repellency Index : 36								

Lantana camara (hexane 1%)									
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	7	2	0	0	1	0	0
	60'	4	3	0	0	1	0	2
	90'	4	3	0	0	1	0	2
	120'	4	3	0	0	1	0	2
2	30'	6	1	0	0	3	0	0
	60'	5	1	0	0	3	0	1
	90'	3	0	0	0	5	0	2
	120'	2	1	0	0	5	0	2
3	30'	4	4	0	0	1	0	1
	60'	2	5	0	0	1	0	2
	90'	2	5	0	0	1	0	2
	120'	1	5	0	0	1	0	3
4	30'	6	2	0	0	1	0	1
	60'	4	2	0	0	1	0	3
	90'	1	2	1	0	2	0	4
	120'	0	4	0	0	3	0	3
Tot.	120'	7	13	0	0	10	0	10
				13			20	
Repellency Index : 21								

Lantana camara (acetone 1%)									
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	4	2	1	1	0	0	2
	60'	5	2	1	0	0	0	2
	90'	5	3	0	0	0	0	2
	120'	4	4	0	0	0	0	2
2	30'	8	1	0	0	1	0	0
	60'	8	1	0	0	1	0	0
	90'	7	1	0	0	2	0	0
	120'	4	3	0	1	2	0	0
3	30'	8	0	0	0	2	0	0
	60'	6	0	0	1	2	0	1
	90'	5	0	0	1	2	0	2
	120'	3	0	0	1	3	0	3
4	30'	7	0	0	0	2	0	1
	60'	5	0	0	0	4	0	1
	90'	4	0	0	1	4	0	1
	120'	3	1	0	1	3	0	2
Tot.	120'	14	8	0	3	8	0	7
				11			15	
Repellency Index : 15								

R = Replication; P = Platform; T = Top; M = Middle; B = Bottom (see additional explanations in the text)

5.12 TABLE 15 - Repellency indexes of *Maerua triphylla*

Maerua triphylla (hexane 10%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	4	0	0	0	4	0	2
	60'	2	0	0	0	6	0	2
	90'	2	0	0	0	6	0	2
	120'	2	0	0	0	6	0	2
2	30'	2	2	1	0	4	0	1
	60'	1	3	1	0	3	1	1
	90'	1	3	1	0	4	0	1
	120'	1	3	1	0	4	0	1
3	30'	3	0	0	0	6	0	1
	60'	3	0	0	0	6	0	1
	90'	3	0	0	0	6	0	1
	120'	3	0	0	0	6	0	1
4	30'	8	1	1	0	0	0	0
	60'	6	1	0	0	1	0	2
	90'	5	1	0	0	1	0	3
	120'	5	1	0	0	1	0	3
Tot.	120'	11	4	1	0	17	0	7
				5			24	
Repellency Index : 66								

Maerua triphylla (acetone 10%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	7	0	0	0	2	0	1
	60'	6	0	0	0	3	0	1
	90'	5	1	0	0	3	0	1
	120'	5	1	0	0	3	0	1
2	30'	4	1	0	0	4	0	1
	60'	3	1	0	0	5	0	1
	90'	2	0	0	0	7	0	1
	120'	2	0	0	0	7	0	1
3	30'	5	1	0	0	3	0	1
	60'	3	3	0	0	3	0	1
	90'	4	2	0	0	2	1	1
	120'	4	2	0	0	2	1	1
4	30'	3	0	0	0	0	0	7
	60'	3	0	0	0	0	0	7
	90'	1	0	0	0	4	0	5
	120'	1	0	0	0	4	0	5
Tot.	120'	12	3	0	0	16	1	8
				3			25	
Reppellency Index : 79								

Maerua triphylla (hexane 5%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	5	2	0	0	0	0	3
	60'	4	1	0	0	2	0	3
	90'	4	0	0	0	3	0	3
	120'	4	0	0	0	3	0	3
2	30'	0	2	0	1	7	0	0
	60'	0	2	0	1	7	0	0
	90'	0	2	0	1	7	0	0
	120'	0	2	0	1	7	0	0
3	30'	3	2	0	2	3	0	0
	60'	2	2	0	2	4	0	0
	90'	0	3	0	2	5	0	0
	120'	0	3	0	2	5	0	0
4	30'	4	3	1	0	2	0	0
	60'	1	6	0	0	3	0	0
	90'	0	7	0	0	3	0	0
	120'	0	7	0	0	3	0	0
Tot.	120'	4	12	0	3	18	0	3
				15			21	
Repellency Index : 17								

Maerua triphylla (acetone 5%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	1	6	0	0	3	0	0
	60'	0	7	0	0	3	0	0
	90'	0	7	0	0	3	0	0
	120'	0	7	0	0	3	0	0
2	30'	2	0	0	1	4	0	3
	60'	2	1	0	0	4	0	3
	90'	1	2	0	0	4	0	3
	120'	1	2	0	0	4	0	3
3	30'	3	1	0	0	4	0	2
	60'	3	1	0	0	4	0	2
	90'	3	1	0	0	4	0	2
	120'	3	1	0	0	4	0	2
4	30'	3	4	0	0	2	0	1
	60'	3	4	0	0	2	0	1
	90'	4	3	0	0	3	0	0
	120'	4	3	0	0	3	0	0
Tot.	120'	8	13	0	0	14	0	5
				13			19	
Repellency Index : 19								

Maerua triphylla (hexane 1%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	4	3	0	0	3	0	0
	60'	1	4	0	0	5	0	0
	90'	1	4	0	0	5	0	0
	120'	0	5	0	0	5	0	0
2	30'	4	2	0	0	4	0	0
	60'	4	2	0	0	4	0	0
	90'	1	4	0	0	5	0	0
	120'	0	5	0	0	5	0	0
3	30'	5	2	1	0	2	0	0
	60'	2	4	0	0	4	0	0
	90'	2	4	0	0	4	0	0
	120'	1	5	0	0	4	0	0
4	30'	3	4	1	0	0	0	2
	60'	4	4	0	0	0	0	2
	90'	1	6	0	0	1	0	2
	120'	1	6	0	0	2	0	1
Tot.	120'	2	21	0	0	16	0	1
				21			17	
Repellency Index : - 11								

Maerua triphylla (acetone 1%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	4	5	0	0	0	0	1
	60'	3	5	0	0	0	0	2
	90'	2	5	0	1	0	0	2
	120'	2	5	0	1	0	0	2
2	30'	6	3	0	0	0	0	1
	60'	6	3	0	0	0	0	1
	90'	5	3	0	1	0	0	1
	120'	5	3	0	1	0	0	1
3	30'	5	2	0	0	0	0	3
	60'	5	2	0	0	1	0	2
	90'	4	3	0	0	1	0	2
	120'	4	3	0	0	1	0	2
4	30'	4	0	0	0	0	0	6
	60'	3	0	0	0	0	0	7
	90'	2	1	0	0	0	0	7
	120'	2	1	0	0	0	0	7
Tot.	120'	13	12	0	2	1	0	12
				14			13	
Repellency Index : - 4								

R = Replication; P = Platform; T = Top; M = Middle; B = Bottom (see additional explanations in the text)

5.13 TABLE 16 - Repellency indexes of *Ocimum suave*

Ocimum suave (hexane 10%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	7	0	0	0	1	0	2
	60'	4	0	1	0	2	0	3
	90'	1	1	2	0	3	0	3
	120'	1	1	2	0	3	0	3
2	30'	7	0	0	0	1	1	1
	60'	7	0	0	0	1	0	2
	90'	7	0	0	0	1	0	2
	120'	6	0	0	0	1	0	3
3	30'	3	0	0	0	2	0	5
	60'	3	0	0	0	3	0	4
	90'	2	0	0	0	4	0	4
	120'	1	0	0	0	5	0	4
4	30'	8	0	0	0	0	0	2
	60'	6	0	0	0	1	0	3
	90'	6	0	0	0	1	0	3
	120'	6	0	0	0	1	1	2
Tot.	120'	14	1	2	0	10	1	12
				3			23	
Repellency Index : 77								

Ocimum suave (acetone 10%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	4	1	1	0	3	0	1
	60'	1	4	0	0	3	0	2
	90'	3	2	0	0	3	0	2
	120'	3	3	0	0	2	0	2
2	30'	5	0	0	0	1	0	4
	60'	4	0	0	0	1	0	5
	90'	3	0	0	1	1	0	5
	120'	3	0	0	0	1	0	6
3	30'	8	0	0	0	2	0	0
	60'	8	0	0	0	2	0	0
	90'	6	1	0	0	2	0	1
	120'	6	1	0	0	2	0	1
4	30'	8	0	0	0	2	0	0
	60'	8	0	0	0	1	0	1
	90'	6	0	0	0	2	0	2
	120'	7	0	0	0	1	0	2
Tot.	120'	19	4	0	0	6	0	11
				4			17	
Repellency Index : 62								

Ocimum suave (hexane 5%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	6	0	2	0	1	1	0
	60'	5	1	2	0	2	0	0
	90'	4	0	4	0	2	0	0
	120'	4	0	4	0	2	0	0
2	30'	5	0	0	0	4	0	1
	60'	5	0	0	0	4	0	1
	90'	5	0	0	0	4	0	1
	120'	5	0	0	0	4	0	1
3	30'	3	0	0	0	5	0	2
	60'	4	0	0	0	4	0	2
	90'	2	0	0	0	4	0	4
	120'	2	0	0	0	4	0	4
4	30'	2	1	0	0	6	0	1
	60'	2	1	0	0	6	0	1
	90'	1	1	0	0	7	0	1
	120'	1	1	0	0	7	0	1
Tot.	120'	12	1	4	0	17	0	6
				5			23	
Repellency Index : 64								

Ocimum suave (acetone 5%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	5	1	2	0	0	0	2
	60'	2	4	0	0	0	0	4
	90'	2	3	1	0	0	0	4
	120'	2	4	0	0	0	0	4
2	30'	2	1	1	0	0	0	6
	60'	1	2	0	0	0	0	7
	90'	0	3	0	0	0	0	7
	120'	0	3	0	0	0	0	7
3	30'	4	3	0	0	1	0	2
	60'	4	3	0	0	2	0	1
	90'	3	3	0	0	2	0	2
	120'	3	3	0	0	2	0	2
4	30'	4	0	1	0	3	0	2
	60'	4	1	0	0	3	0	2
	90'	4	1	0	0	4	0	1
	120'	3	1	0	0	4	0	2
Tot.	120'	8	11	0	0	6	0	15
				11			21	
Repellency Index : 31								

Ocimum suave (hexane 1%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	5	2	0	1	1	0	1
	60'	6	3	0	0	0	1	0
	90'	5	2	2	0	1	0	0
	120'	4	1	4	1	0	0	0
2	30'	7	1	0	0	1	1	0
	60'	5	1	1	0	2	0	1
	90'	5	3	0	0	1	0	1
	120'	7	1	0	0	1	0	1
3	30'	5	0	0	0	2	2	1
	60'	3	1	0	0	4	1	1
	90'	4	0	0	0	6	0	0
	120'	1	1	0	0	7	0	1
4	30'	8	0	0	0	0	0	2
	60'	4	3	0	0	1	0	2
	90'	2	2	0	0	4	0	2
	120'	1	2	0	0	5	0	2
Tot.	120'	13	5	4	1	13	0	4
				10			17	
Repellency Index : 26								

Ocimum suave (acetone 1%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	5	0	0	0	2	0	3
	60'	1	2	0	1	3	0	3
	90'	0	2	0	1	3	0	4
	120'	0	3	0	0	3	0	4
2	30'	1	6	0	0	1	0	2
	60'	1	6	0	0	2	0	1
	90'	0	7	0	0	2	0	1
	120'	0	7	0	0	2	0	1
3	30'	5	0	0	0	3	0	2
	60'	5	0	0	0	3	0	2
	90'	4	1	0	0	3	0	2
	120'	2	1	0	0	4	0	3
4	30'	3	0	0	0	5	0	2
	60'	4	0	0	0	5	0	1
	90'	3	1	0	0	5	0	1
	120'	2	1	0	0	5	0	2
Tot.	120'	4	12	0	0	14	0	10
				12			24	
Repellency Index : 33								

R = Replication; P = Platform; T = Top; M = Middle; B = Bottom (see additional explanations in the text)

5.14 TABLE 17 - Repellency indexes of *Ricinus communis* (green variety)

R. communis - green var. (hexane 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	4	0	0	0	5	0	1	
	60'	1	1	0	0	5	0	3	
	90'	0	2	0	0	5	0	3	
	120'	0	2	0	0	5	0	3	
2	30'	1	0	0	0	8	0	1	
	60'	1	0	0	0	9	0	0	
	90'	1	0	0	0	9	0	0	
	120'	0	1	0	0	9	0	0	
3	30'	4	0	0	0	5	0	1	
	60'	1	1	0	0	7	0	1	
	90'	1	1	0	0	7	0	1	
	120'	1	1	0	0	7	0	1	
4	30'	4	1	0	0	5	0	0	
	60'	1	1	0	0	8	0	0	
	90'	1	1	0	0	8	0	0	
	120'	1	1	0	0	8	0	0	
Tot.	120'	2	5	0	0	29	0	4	
				5			33		
Repellency Index : 74									

R. communis - green var. (acetone 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	6	1	0	0	1	0	2	
	60'	3	2	0	0	3	0	2	
	90'	3	2	0	0	3	0	2	
	120'	2	2	0	0	3	0	3	
2	30'	5	0	0	0	1	0	4	
	60'	3	0	0	0	2	0	5	
	90'	2	1	0	0	2	0	5	
	120'	2	1	0	0	2	0	5	
3	30'	1	1	0	0	4	0	4	
	60'	1	0	0	0	4	0	5	
	90'	1	0	0	0	4	0	5	
	120'	0	0	1	0	4	0	5	
4	30'	5	0	0	0	1	0	4	
	60'	3	0	1	0	2	0	4	
	90'	3	0	0	0	5	0	2	
	120'	3	0	0	0	6	0	1	
Tot.	120'	7	3	1	0	15	0	14	
				4			29		
Repellency Index : 76									

R. communis - green var. (hexane 5%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	2	1	0	0	4	0	3	
	60'	2	1	0	0	4	0	3	
	90'	2	1	0	0	4	0	3	
	120'	2	1	0	0	4	0	3	
2	30'	1	2	0	0	4	0	3	
	60'	1	2	0	0	4	0	3	
	90'	1	1	0	0	4	0	4	
	120'	1	1	0	0	4	0	4	
3	30'	4	0	1	2	3	0	0	
	60'	5	2	0	0	3	0	0	
	90'	5	2	0	0	3	0	0	
	120'	5	2	0	0	3	0	0	
4	30'	4	4	0	0	1	1	0	
	60'	3	5	0	0	2	0	0	
	90'	3	5	0	0	2	0	0	
	120'	3	5	0	0	2	0	0	
Tot.	120'	11	9	0	0	13	0	7	
				9			20		
Repellency Index : 38									

R. communis - green var. (acetone 5%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	7	0	0	0	2	0	1	
	60'	7	0	0	0	2	0	1	
	90'	7	0	0	0	2	0	1	
	120'	6	1	0	0	2	0	1	
2	30'	3	0	1	0	3	1	2	
	60'	4	1	0	0	3	0	2	
	90'	0	2	0	0	3	0	5	
	120'	0	2	0	0	3	0	5	
3	30'	6	1	1	0	2	0	0	
	60'	3	3	1	0	3	0	0	
	90'	2	3	1	0	3	0	1	
	120'	2	3	1	0	3	0	1	
4	30'	6	1	0	0	1	0	2	
	60'	5	1	0	0	2	0	2	
	90'	4	1	0	0	2	0	3	
	120'	4	1	0	0	2	0	3	
Tot.	120'	12	7	1	0	10	0	10	
				8			20		
Repellency Index : 43									

R. communis - green var. (hexane 1%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	7	2	0	0	1	0	0	
	60'	4	5	0	0	1	0	0	
	90'	3	6	0	0	1	0	0	
	120'	2	6	0	0	1	0	1	
2	30'	5	0	0	1	3	0	1	
	60'	3	2	0	0	4	0	1	
	90'	3	2	0	0	4	0	1	
	120'	3	2	0	0	4	0	1	
3	30'	6	0	1	0	1	0	2	
	60'	2	3	0	0	1	0	4	
	90'	1	3	0	1	1	0	4	
	120'	1	3	0	1	1	0	4	
4	30'	5	1	0	1	2	0	1	
	60'	2	4	0	0	4	0	0	
	90'	1	4	0	0	5	0	0	
	120'	1	4	0	0	5	0	0	
Tot.	120'	7	15	0	1	11	0	6	
				16			17		
Repellency Index : 3									

R. communis - green var. (acetone 1%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	3	3	0	0	3	0	1	
	60'	1	3	0	0	5	0	1	
	90'	1	3	0	0	5	0	1	
	120'	1	3	0	0	5	0	1	
2	30'	7	1	0	2	0	0	0	
	60'	6	4	0	0	0	0	0	
	90'	4	5	0	0	1	0	0	
	120'	4	5	0	0	1	0	0	
3	30'	8	1	0	0	0	0	1	
	60'	7	1	0	0	0	0	2	
	90'	7	1	0	0	0	0	2	
	120'	7	1	0	0	0	0	2	
4	30'	7	0	1	0	0	1	1	
	60'	4	1	0	0	2	0	3	
	90'	3	2	0	0	2	0	3	
	120'	3	2	0	0	2	0	3	
Tot.	120'	15	11	0	0	8	0	6	
				11			14		
Repellency Index : 12									

R = Replication; P = Platform; T = Top; M = Middle; B = Bottom (see additional explanations in the text)

5.15 TABLE 18 - Repellency indexes of *Ricinus communis* (red variety)

R. communis - red var. (hexane 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	5	0	0	0	5	0	0	
	60'	5	0	0	0	5	0	0	
	90'	2	1	0	0	7	0	0	
	120'	2	1	0	0	7	0	0	
2	30'	6	0	1	0	2	0	1	
	60'	2	0	0	0	7	0	1	
	90'	1	1	0	0	7	0	1	
	120'	1	1	0	0	7	0	1	
3	30'	8	0	0	0	2	0	0	
	60'	4	2	0	0	4	0	0	
	90'	4	2	0	0	4	0	0	
	120'	4	2	0	0	4	0	0	
4	30'	7	0	0	0	1	1	1	
	60'	4	1	0	0	5	0	0	
	90'	1	1	0	0	7	0	1	
	120'	1	1	0	0	7	0	1	
Tot.	120'	8	5	0	0	25	0	2	
				5			27		
Repellency Index : 69									

R. communis - red var. (acetone 10%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	8	0	0	0	1	0	1	
	60'	5	0	0	0	2	0	3	
	90'	3	1	0	0	2	0	4	
	120'	3	1	0	0	2	0	4	
2	30'	5	1	0	0	2	0	2	
	60'	4	0	0	0	3	1	2	
	90'	3	0	0	0	4	0	3	
	120'	3	0	0	0	4	0	3	
3	30'	7	0	0	0	3	0	0	
	60'	7	0	0	0	3	0	0	
	90'	6	1	0	0	3	0	0	
	120'	4	1	0	0	4	0	1	
4	30'	6	0	0	0	2	0	2	
	60'	3	1	0	0	2	0	4	
	90'	3	1	0	0	2	0	4	
	120'	3	1	0	0	2	0	4	
Tot.	120'	13	3	0	0	12	0	12	
				3			24		
Repellency Index : 78									

R. communis - red var. (hexane 5%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	9	1	0	0	0	0	0	
	60'	5	4	0	0	1	0	0	
	90'	5	4	0	0	1	0	0	
	120'	4	4	0	0	2	0	0	
2	30'	5	1	0	0	4	0	0	
	60'	3	2	0	0	4	0	1	
	90'	3	2	0	0	4	0	1	
	120'	2	2	0	0	5	0	1	
3	30'	6	1	0	0	2	0	1	
	60'	5	1	0	0	2	0	2	
	90'	3	2	0	0	3	0	2	
	120'	2	3	0	0	3	0	2	
4	30'	6	2	0	0	1	1	0	
	60'	4	2	0	0	3	1	0	
	90'	2	2	0	0	6	0	0	
	120'	1	2	0	0	6	0	1	
Tot.	120'	9	11	0	0	16	0	4	
				11			20		
Repellency Index : 29									

R. communis - red var. (acetone 5%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	4	0	0	0	1	0	5	
	60'	2	1	0	0	1	0	6	
	90'	2	1	0	0	1	0	6	
	120'	2	1	0	0	1	0	6	
2	30'	8	1	0	0	0	0	1	
	60'	9	0	0	0	0	0	1	
	90'	9	0	0	0	0	0	1	
	120'	9	0	0	0	0	0	1	
3	30'	6	1	0	1	1	0	1	
	60'	5	2	0	0	1	0	2	
	90'	2	5	0	0	2	0	1	
	120'	2	5	0	0	2	0	1	
4	30'	7	0	0	0	1	0	2	
	60'	7	0	0	0	1	0	2	
	90'	7	0	0	0	2	0	1	
	120'	7	0	0	0	2	0	1	
Tot.	120'	20	6	0	0	5	0	9	
				6			14		
Repellency Index : 40									

R. communis - red var. (hexane 1%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	4	3	0	1	2	0	0	
	60'	0	6	0	1	2	0	1	
	90'	0	5	0	2	2	0	1	
	120'	1	3	0	2	3	0	1	
2	30'	5	3	1	0	1	0	0	
	60'	5	4	0	0	1	0	0	
	90'	3	3	1	2	1	0	0	
	120'	4	4	1	0	1	0	0	
3	30'	5	1	0	0	3	0	1	
	60'	4	2	0	0	3	0	1	
	90'	5	1	1	0	2	0	1	
	120'	2	3	0	0	4	0	1	
4	30'	7	0	0	1	1	0	1	
	60'	3	3	0	0	1	0	3	
	90'	3	2	0	1	1	0	3	
	120'	3	3	0	0	1	0	3	
Tot.	120'	10	13	1	2	9	0	5	
				16			14		
Repellency Index : - 7									

R. communis - red var. (acetone 1%)									
R	Time	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	30'	7	0	0	0	0	0	3	
	60'	4	1	0	0	1	0	4	
	90'	3	2	0	0	3	0	2	
	120'	4	2	0	0	3	0	1	
2	30'	8	2	0	0	0	0	0	
	60'	6	1	0	1	1	0	1	
	90'	6	1	0	1	1	0	1	
	120'	4	2	0	1	2	0	1	
3	30'	6	1	0	0	1	0	2	
	60'	4	1	0	0	1	0	4	
	90'	4	1	0	0	2	0	3	
	120'	4	1	0	0	2	0	3	
4	30'	9	0	0	0	0	0	1	
	60'	4	2	0	2	0	1	1	
	90'	1	2	0	2	2	1	2	
	120'	2	3	0	2	2	0	1	
Tot.	120'	14	8	0	3	9	0	6	
				11			15		
Repellency Index : 15									

R = Replication; P = Platform; T = Top; M = Middle; B = Bottom (see additional explanations in the text)

5.16 TABLE 19 - Repellency indexes of *Solanum incanum*, *Solanum somalense*, *Sterculia rhynchocarpa*

Solanum incanum (hexane 10%)									
R	*Time*	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	*30'*	3	1	0	0	6	0	0	
	60'	2	0	1	0	7	0	0	
	90'	0	1	0	0	9	0	0	
	120'	0	1	0	0	9	0	0	
2	*30'*	6	1	0	0	3	0	0	
	60'	5	1	0	0	2	0	2	
	90'	3	3	0	0	2	0	2	
	120'	3	3	0	0	2	0	2	
3	*30'*	5	1	1	0	3	0	0	
	60'	2	4	0	0	2	0	2	
	90'	1	5	0	0	2	0	2	
	120'	1	5	0	0	2	0	2	
4	*30'*	8	2	0	0	0	0	0	
	60'	6	2	0	0	2	0	0	
	90'	3	3	0	0	4	0	0	
	120'	3	3	0	0	4	0	0	
Tot.	*120'*	7	12	0	0	17	0	4	
				12			21		
Repellency Index : 27									

Solanum incanum (acetone 10%)									
R	*Time*	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	*30'*	6	2	0	0	2	0	0	
	60'	4	2	0	0	3	0	1	
	90'	4	2	0	0	3	0	1	
	120'	4	2	0	0	3	0	1	
2	*30'*	6	0	1	1	1	0	1	
	60'	4	1	1	1	2	0	1	
	90'	2	3	0	0	4	0	1	
	120'	2	3	0	0	4	0	1	
3	*30'*	6	1	1	1	0	0	1	
	60'	3	3	0	1	2	0	1	
	90'	3	3	0	1	2	0	1	
	120'	2	3	0	1	3	0	1	
4	*30'*	5	1	0	2	2	0	0	
	60'	2	2	0	1	4	1	0	
	90'	1	3	0	1	4	1	0	
	120'	1	3	0	1	4	1	0	
Tot.	*120'*	9	11	0	2	14	1	3	
				13			18		
Repellency Index : 16									

Solanum somalense (hexane 10%)									
R	*Time*	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	*30'*	3	1	0	0	6	0	0	
	60'	3	1	0	0	6	0	0	
	90'	3	1	0	0	6	0	0	
	120'	3	1	0	0	6	0	0	
2	*30'*	2	3	0	0	5	0	0	
	60'	0	3	0	0	7	0	0	
	90'	0	3	0	0	7	0	0	
	120'	0	3	0	0	7	0	0	
3	*30'*	5	2	1	0	1	1	0	
	60'	4	2	0	0	4	0	0	
	90'	3	2	0	0	5	0	0	
	120'	3	2	0	0	5	0	0	
4	*30'*	3	6	0	0	1	0	0	
	60'	2	6	0	0	2	0	0	
	90'	0	7	0	0	3	0	0	
	120'	0	7	0	0	3	0	0	
Tot.	*120'*	6	13	0	0	21	0	0	
				13			21		
Repellency Index : 24									

Solanum somalense (acetone 10%)									
R	*Time*	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	*30'*	7	1	0	0	2	0	0	
	60'	3	3	0	1	3	0	0	
	90'	2	3	0	1	4	0	0	
	120'	2	3	0	1	4	0	0	
2	*30'*	6	1	1	1	1	0	0	
	60'	4	2	0	1	3	0	0	
	90'	2	3	0	1	4	0	0	
	120'	1	3	0	2	4	0	0	
3	*30'*	4	1	1	0	3	1	0	
	60'	3	1	0	0	4	0	2	
	90'	1	3	0	0	4	0	2	
	120'	1	3	0	0	4	0	2	
4	*30'*	8	2	0	0	0	0	0	
	60'	5	2	0	0	3	0	0	
	90'	2	2	0	1	5	0	0	
	120'	2	2	0	1	5	0	0	
Tot.	*120'*	6	11	0	4	17	0	2	
				15			19		
Repellency Index : 12									

Sterculia rhynchocarpa (hexane 10%)									
R	*Time*	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	*30'*	6	1	0	1	0	2	0	
	60'	5	2	0	0	1	0	2	
	90'	3	2	0	0	3	0	2	
	120'	3	2	0	0	3	0	2	
2	*30'*	8	1	0	0	1	0	0	
	60'	7	2	0	0	1	0	0	
	90'	5	2	0	0	3	0	0	
	120'	5	2	0	0	3	0	0	
3	*30'*	5	1	0	0	2	1	1	
	60'	3	1	0	1	3	0	2	
	90'	2	2	0	1	3	0	2	
	120'	2	2	0	1	3	0	2	
4	*30'*	6	1	0	0	1	1	1	
	60'	5	1	0	0	3	1	0	
	90'	5	1	0	0	4	0	0	
	120'	5	1	0	0	4	0	0	
Tot.	*120'*	15	7	0	1	13	0	4	
				8			17		
Repellency Index : 36									

Sterculia rhynchocarpa (acetone 10%)									
R	*Time*	P	TEST			CONTROL			
			T	M	B	T	M	B	
1	*30'*	7	1	1	0	0	1	0	
	60'	7	1	0	1	1	0	0	
	90'	4	2	0	1	2	0	1	
	120'	4	2	0	1	2	0	1	
2	*30'*	6	0	0	1	2	0	1	
	60'	5	1	0	0	3	0	1	
	90'	5	1	0	0	3	0	1	
	120'	5	1	0	0	3	0	1	
3	*30'*	5	2	0	1	1	1	0	
	60'	3	3	0	0	2	1	1	
	90'	3	3	0	0	3	0	1	
	120'	3	3	0	0	3	0	1	
4	*30'*	7	1	0	0	2	0	0	
	60'	6	2	0	0	2	0	0	
	90'	3	2	0	0	3	0	2	
	120'	3	2	0	0	3	0	2	
Tot.	*120'*	15	8	0	1	11	0	5	
				9			16		
Repellency Index : 28									

R = Replication; P = Platform; T = Top; M = Middle; B = Bottom (see additional explanations in the text)

5.17 TABLE 20 - Repellency indexes of *Tagetes minuta*

Tagetes minuta (hexane 10%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	5	0	0	0	3	0	2
	60'	3	0	0	0	4	0	3
	90'	1	0	0	0	5	0	4
	120'	1	0	0	0	5	0	4
2	30'	2	0	0	0	6	0	2
	60'	1	0	0	0	6	0	3
	90'	1	0	0	0	6	0	3
	120'	1	0	0	0	6	0	3
3	30'	6	1	0	0	3	0	0
	60'	5	1	0	0	4	0	0
	90'	3	1	0	0	6	0	0
	120'	3	1	0	0	6	0	0
4	30'	5	1	0	0	2	0	2
	60'	5	1	0	0	2	0	2
	90'	2	2	0	0	3	0	3
	120'	1	2	0	0	3	0	4
Tot.	120'	6	3	0	0	20	0	11
				3			31	
Repellency Index : 82								

Tagetes minuta (acetone 10%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	5	1	1	0	3	0	0
	60'	5	2	0	0	3	0	0
	90'	3	2	0	0	5	0	0
	120'	3	2	0	0	5	0	0
2	30'	1	5	0	0	4	0	0
	60'	0	5	0	0	4	0	1
	90'	0	5	0	0	4	0	1
	120'	0	5	0	0	4	0	1
3	30'	6	0	1	0	1	0	2
	60'	5	0	1	0	1	0	3
	90'	3	0	1	0	3	0	3
	120'	3	0	1	0	3	0	3
4	30'	4	3	0	0	3	0	0
	60'	4	1	1	0	4	0	0
	90'	3	2	1	0	4	0	0
	120'	3	2	1	0	4	0	0
Tot.	120'	9	9	2	0	16	0	4
				11			20	
Repellency Index : 29								

Tagetes minuta (hexane 5%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	8	0	0	0	1	1	0
	60'	7	0	0	0	3	0	0
	90'	7	0	0	0	3	0	0
	120'	7	0	0	0	3	0	0
2	30'	8	0	0	0	1	0	1
	60'	6	1	0	0	1	0	2
	90'	6	1	0	0	1	0	2
	120'	3	1	0	0	2	1	3
3	30'	7	0	0	0	2	0	1
	60'	6	0	0	0	2	0	2
	90'	5	0	0	0	2	0	3
	120'	4	0	0	0	4	0	2
4	30'	5	1	0	0	3	0	1
	60'	2	2	0	0	3	0	3
	90'	2	2	0	0	3	0	3
	120'	1	2	0	0	3	0	4
Tot.	120'	15	3	0	0	12	1	9
				3			22	
Repellency Index : 76								

Tagetes minuta (acetone 5%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	4	3	0	0	3	0	0
	60'	4	3	0	0	3	0	0
	90'	3	4	0	0	3	0	0
	120'	3	4	0	0	3	0	0
2	30'	1	1	0	0	8	0	0
	60'	1	1	0	0	8	0	0
	90'	1	1	0	0	8	0	0
	120'	1	1	0	0	8	0	0
3	30'	1	5	0	0	2	0	2
	60'	1	5	0	0	2	0	2
	90'	0	5	0	0	3	0	2
	120'	0	5	0	0	3	0	2
4	30'	1	2	0	0	7	0	0
	60'	1	2	0	0	7	0	0
	90'	0	2	0	0	8	0	0
	120'	0	2	0	0	8	0	0
Tot.	120'	4	12	0	0	22	0	2
				12			24	
Repellency Index : 33								

Tagetes minuta (hexane 1%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	4	0	0	0	6	0	0
	60'	0	0	0	0	8	0	2
	90'	0	0	0	0	9	0	1
	120'	0	0	0	0	9	0	1
2	30'	2	1	0	0	7	0	0
	60'	2	1	0	0	7	0	0
	90'	2	1	0	0	7	0	0
	120'	2	1	0	0	7	0	0
3	30'	6	1	0	0	3	0	0
	60'	3	2	0	0	5	0	0
	90'	2	3	0	0	5	0	0
	120'	2	3	0	0	5	0	0
4	30'	6	2	0	0	2	0	0
	60'	3	2	1	0	4	0	0
	90'	1	3	1	0	5	0	0
	120'	1	4	0	0	5	0	0
Tot.	120'	5	8	0	0	26	0	1
				8			27	
Repellency Index : 54								

Tagetes minuta (acetone 1%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	3	1	0	0	6	0	0
	60'	2	1	0	0	6	0	1
	90'	2	1	0	0	6	0	1
	120'	1	2	0	0	6	0	1
2	30'	1	3	0	0	1	0	5
	60'	0	4	0	0	1	0	5
	90'	0	4	0	0	1	0	5
	120'	0	4	0	0	1	0	5
3	30'	2	5	0	0	3	0	0
	60'	2	5	0	0	3	0	0
	90'	2	5	0	0	3	0	0
	120'	2	4	0	1	3	0	0
4	30'	4	5	0	0	1	0	0
	60'	4	5	0	0	1	0	0
	90'	3	6	0	0	1	0	0
	120'	0	6	0	0	4	0	0
Tot.	120'	3	16	0	1	14	0	6
				17			20	
Repellency Index : 8								

R = Replication; P = Platform; T = Top; M = Middle; B = Bottom (see additional explanations in the text)

5.18 TABLE 21 - Repellency indexes of *Vernonia amygdalina*

Vernonia amygdalina (hexane 10%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	4	2	0	0	3	0	1
	60'	3	2	0	0	3	0	2
	90'	2	3	0	0	5	0	0
	120'	1	4	0	0	5	0	0
2	30'	4	1	0	0	3	1	1
	60'	2	0	3	0	4	0	1
	90'	1	0	3	0	5	0	1
	120'	2	1	1	0	5	0	1
3	30'	5	0	0	0	4	0	1
	60'	2	0	0	0	7	0	1
	90'	2	0	0	0	7	0	1
	120'	2	0	0	0	7	0	1
4	30'	5	0	1	0	3	0	1
	60'	4	0	1	0	4	0	1
	90'	0	1	1	0	7	1	0
	120'	0	1	1	0	6	1	1
Tot.	120'	5	6	2	0	23	1	3
				8			27	
Repellency Index : 54								

Vernonia amygdalina (acetone 10%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	5	1	0	1	2	0	1
	60'	4	3	0	0	3	0	0
	90'	4	3	0	0	3	0	0
	120'	4	3	0	0	3	0	0
2	30'	3	1	1	1	3	0	1
	60'	2	2	0	1	4	0	1
	90'	2	3	0	0	4	0	1
	120'	2	2	1	0	4	0	1
3	30'	5	0	0	0	4	0	1
	60'	3	3	0	0	3	0	1
	90'	3	3	0	0	3	0	1
	120'	2	3	0	0	4	0	1
4	30'	5	0	1	1	2	0	1
	60'	4	0	1	1	3	0	1
	90'	3	1	1	1	3	1	0
	120'	3	1	1	1	3	1	0
Tot.	120'	11	9	2	1	14	1	2
				12			17	
Repellency Index : 17								

Vernonia amygdalina (hexane 5%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	4	1	0	0	1	0	4
	60'	4	2	0	0	1	0	3
	90'	3	2	0	1	1	0	3
	120'	1	2	0	1	2	0	4
2	30'	3	2	0	1	1	0	3
	60'	2	2	0	1	2	0	3
	90'	2	2	0	1	2	0	3
	120'	2	2	0	1	2	0	3
3	30'	8	1	0	0	1	0	0
	60'	7	1	0	0	2	0	0
	90'	6	1	0	0	3	0	0
	120'	6	1	0	0	3	0	0
4	30'	8	0	0	0	1	0	1
	60'	5	0	0	0	3	0	2
	90'	4	0	0	1	3	0	2
	120'	2	2	0	1	3	0	2
Tot.	120'	11	7	0	3	10	0	9
				10			19	
Repellency Index : 31								

Vernonia amygdalina (hexane 1%)								
R	Time	P	TEST			CONTROL		
			T	M	B	T	M	B
1	30'	5	0	0	0	3	0	2
	60'	4	1	0	0	3	0	2
	90'	2	1	0	0	5	0	2
	120'	2	1	0	0	5	0	2
2	30'	5	4	0	0	1	0	0
	60'	3	4	0	0	3	0	0
	90'	3	4	0	0	3	0	0
	120'	3	4	0	0	3	0	0
3	30'	6	3	0	0	1	0	0
	60'	3	3	0	0	4	0	0
	90'	4	3	0	0	3	0	0
	120'	4	3	0	0	3	0	0
4	30'	4	2	0	0	0	1	3
	60'	2	3	0	0	1	0	4
	90'	2	3	0	0	1	0	4
	120'	2	3	0	0	1	0	4
Tot.	120'	11	11	0	0	12	0	6
				11			18	
Repellency Index : 24								

R = Replication; P = Platform; T = Top; M = Middle; B = Bottom (see additional explanations in the text)

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