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Perspectives for the use of plant extracts to control the cattle tick *Rhipicephalus* (*Boophilus*) *microplus*

Perspectivas para o uso de extratos de plantas para o controle do carrapato de bovinos *Rhipicephalus* (*Boophilus*) *microplus*

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Abstract

The evolution of resistance of *Rhipicephalus* (*Boophilus*) *microplus* to synthetic acaricides has given rise to the need for new scientific investigations on alternative ways to control this tick. In this regard, various studies on plants have been developed in an attempt to find extracts with acaricidal properties. Evaluations on plant extracts for controlling *R.* (*B.*) *microplus* have grown intensely over the last decade. There are many advantages from using plant extracts: for example, they can be used in organic cattle farming or even replace synthetic acaricides and they are associated with lower environmental and food contamination, slower development of resistance and lower toxicity to animals and humans. *In vitro* studies on plant extracts have shown promising results, but most of these extracts have not been tested on animals to validate their use. Difficulties in preparing proper formulations, differences in the chemical composition of plants of the same species due to extrinsic and intrinsic factors and sparse information on active acaricide compounds are hindrances that need to be addressed in order to enable progress within this scientific field.

Keywords: Phytotherapy, cattle tick, *Rhipicephalus* (*Boophilus*) *microplus*, *in vitro* bioassays, *in vivo* bioassays.

Resumo

A evolução da resistência do *Rhipicephalus* (*Boophilus*) *microplus* aos acaricidas sintéticos tem impulsionado novas investigações científicas sobre métodos alternativos para controlar este carrapato. Considerando isso, vários estudos com plantas têm sido desenvolvidos numa tentativa de encontrar extratos com propriedades acaricidas. Avalições de extratos de plantas para o controle de *R.* (*B.*) *microplus* tem sido intensificadas nesta última década. Existem muitas vantagens com o uso de extratos de plantas no controle deste carrapato, como: eles podem ser utilizados na produção orgânica de bovinos, ou mesmo substituir os acaricidas sintéticos, além do mais, estão associados com baixa contaminação ambiental e dos alimentos, desenvolvimento mais lento de resistência e baixa toxicidade para animais e seres humanos. Estudos *in vitro* de extratos de plantas têm apresentado resultados promissores, mas a maioria destes extratos não têm sido testada em animais para validar estes resultados. Dificuldades para preparar formulações apropriadas, diferenças na composição química de plantas de uma mesma espécie devido a fatores intrínsecos e extrínsecos e informações esparsas.sobre os princípios ativos são entraves que precisam ser solucionados visando o desenvolvimento deste campo de pesquisa.

Palavras-chave: Fitoterapia, carrapato de bovinos, *Rhipicephalus* (*Boophilus*) *microplus*, testes *in vitro*, testes *in vivo*.

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Introduction

From an economic point of view, *Rhipicephalus* (*Boophilus*) *microplus* (Canestrini 1887) (Acari, Ixodidae) is the main tick in the Neotropical region and one of the most important in the world (WALKER et al., 2003; MARTINS et al., 2006; JONSSON; PIPER, 2007). The principal control method involves the use of synthetic acaricides. However, the development and selection of resistant strains of *R.* (*B.*) *microplus* in different parts of the world has made several chemical agents ineffective (FAO, 2004). Moreover, environmental pollution and contamination of meat and milk are associated with this kind of control (SONENSHINE, 1993).

Research on plants for use in tick control has been developed in an attempt to find extracts with acaricidal properties that can be used in association with or even as replacements for synthetic compounds. One advantage from the use of those compounds is that resistance develops slowly because there is usually a mixture of different active agents with different mechanisms of action (BALANDRIN et al., 1985; CHAGAS et al. 2003; OLIVO et al., 2009). Plant based formulations enable expansion of organic agriculture or may even be used as an auxiliary in conventional production systems (VIEIRA; CAVALCANTE, 1999; OLIVO et al., 2009).

The use of phytotherapy in the field of veterinary sciences has been an incremental process. Nevertheless, it needs to be emphasized that investigations on the use of plant extracts to control ticks, especially *R.* (*B.*) *microplus*, have become intensified over the last decade, both in Brazil and in other countries. Even though a large number of investigations have proven the acaricide activity of certain plant extracts in the laboratory, follow-up studies are needed with the aim of validating this control strategy.

In this review, the main plants that could be used to control *R.* (*B.*) *microplus*, both *in vitro* and *in vivo*, and the barriers faced in developing this alternative tick control strategy, will be discussed.

In Vitro Tests

Around the world, extracts from approximately 55 plant species belonging to 26 families have already been evaluated against *R.* (*B.*) *microplus*. In some species, active compounds with insecticide and/or acaricide activity have been identified, but only a few substances have so far been proven to be active against *R.* (*B.*) *microplus* (Table 1). Brazil is a tropical country, with continental dimensions and the highest biodiversity on the planet. Studies on the efficacy of native or naturalized plants against *R.* (*B.*) *microplus* have been rapidly expanding in this country, and the main results observed will be shown here.

The two species of Meliaceae most investigated against *R.* (*B.*) *microplus* are *Melia azedarach* and *Azadirachta indica* (neem). Preliminary investigations on *M. azedarach* showed that the oily hexanic extract obtained from ripe fruits affected reproduction on engorged females (BORGES et al., 1994). More recently, studying some ripe fruit extracts, Borges et al. (2003) observed a higher larval mortality in chloroformic extracts (100%) and hexanic extracts (98%) than in ethanolic extracts (50%), at concentration after 0.25%. Similarly, hexanic and chloroformic extracts produced a greater inhibition on females reproductive efficiency (100 and 91.5%, respectively) than did ethanolic extracts (46%). Sousa et al. (2008) showed that extracts from green fruits were 1.5 times more efficient than extracts from ripe fruits. However, lower efficiency was obtained by Vivan (2005). Aqueous and hexanic extracts obtained from leaves and fruits and tested at 0.025 to 0.2% concentration inhibited reproductive efficiency by 1.1 to 47.54%.

Low interference with reproductive efficiency (32%) was obtained by Costa et al. (2008) using a hydroalcoholic leaf extract from *A. indica* at 20% concentration. In two studies conducted by Broglio-Micheletti et al. (2009, 2010), extracts and commercial products based on *A. indica* were tested. Hexanic extracts from seeds and ethanolic extracts from leaves at a concentration of 2% had efficacy of 38.4 and 2.3%, respectively, on females reproduction (BROGLIO-MICHELETTI et al., 2009). The efficiency of commercial formulations of hexanic and alcoholic extracts from seeds at a concentration of 2% has been found to range from 17 to 73%, with higher efficiency from hexanic extracts (BROGLIO-MICHELETTI et al., 2010).

Various species of the genus *Cymbopogon* (Poaceae) have also been tested against *R.* (*B.*) *microplus*. The essential oil of *Cymbopogon winterianus* Jowitt was tested against larvae and engorged females. Total inhibition of eclosion was observed at a concentration of 7.14% and of egg conversion at 10%. All the larvae died at concentrations between 5.5 and 7.14%. The principal components of the essential oil, i.e. citronellal, geraniol and citronellol, were tested against females, and the best results were observed for the first two components. However, activity remained inferior to obtained from the entire essential oil (MARTINS, 2006). The essential oil of *Cymbopogon nardus* caused 79% inhibition of reproduction at a concentration of 1% (OLIVO et al., 2008). On the other hand, Costa et al. (2008) observed that this plant had low efficacy (17%) against females using a hydroalcoholic extract from leaves at a concentration of 20%. Alcoholic leaf extract of *Cymbopogon citratus* at a concentration of 2% had efficacy of 18.35% against engorged females (BROGLIO-MICHELETTI et al., 2009)

The essential oils of *Eucalyptus citriodora* and *Eucalyptus staigeriana* Myrtaceae killed 100% of the larvae at a concentration of 10%, while *Eucalyptus globulus* had the same efficacy but at twice the concentration. Against engorged females, the maximum efficacy was observed at a concentration of 25% for *E. citriodora*, 10% for *E. globulus* and 15% for *E. staigeriana*. When the essential oils were formulated as concentrate emulsions, the effect was strengthened (CHAGAS et al., 2002). The hydroalcoholic extract of leaves of *Eucalyptus* sp had efficacy of 96% against engorged females at a concentration of 10% (COSTA et al., 2008). From the same family, Broglio-Micheletti et al. (2009) tested the alcoholic extract of flowers of *Syzygium malaccensis* at a concentration of 2% and observed that the rate of interference with the engorged females reproduction was 59%.

The essential oil from leaves of *Hesperozygis ringens* (Lamiaceae) was tested at 0.625 to 50 $\mu L.mL^{-1}$ concentration (≈ 0.0625 to 5%) inhibiting oviposition by 11.5 to 76.4% with 95% inhibition of larval hatchability at the highest concentration. Those concentrations were all lethal for 100% of larvae. Pulegone was the main compound isolated from the essential oil (RIBEIRO et al., 2010). In addition, tests on this family were carried out using the essential oil from leaves

Table 1. Natural products tested against *Rhipicephalus* (*Boophilus*) *microplus* and active compounds with acaricidal or insecticidal activity.

Family	Plant tested against *R. microplus* (Reference)	Natural products with acaricidal or insecticidal activity
Asteraceae	*Calea serrata* Less. (RIBEIRO et al., 2008a)	
Acanthaceae	*Rhinacanthus nasutus* (L.) Kurz (KAMARAJ et al., 2010)	
Amaranthaceae	*Achyranthes aspera* L. (ZAHIR et al., 2009)	
Anacardiaceae	*Mangifera indica* L. (SRIVASTAVA et al., 2008)	
Annonaceae	*Annona squamosa* L. (MAGADUM et al., 2009; CHUNGSAMARNYART et al., 1990, 1991a)	Squamocin (KAWAZU et al., 1989) Acetogenins (HOPP et al., 1998) Annotemoyin-1 (PARVIN et al., 2003)
	Annona muricata L. (CHUNGSAMARNYART et al., 1991b; BROGLIO-MICHELETTI et al., 2009)	Goniothalamicin (ALKOFAHI et al., 1987) Gigantetrocin A, annomontacin, bullatalicin (ALALI et al., 1998) Squamocin (GUADAÑO et al., 2000)
Caesalpiniaceae	*Cassia auriculata* L. (KAMARAJ et al., 2010)	
Clusicaceae	*Hypericum polyanthemum* Klotzsch (RIBEIRO et al., 2007)	
Combretaceae	*Terminalia chebula* Retz. (KAMARAJ et al., 2010)	
Ebenaceae	*Diospyros anisandra* S. F. Blake (ROSADO-AGUILAR et al., 2008)	
Euphorbiaceae	*Ricinus communis* L. (ZAHIR et al., 2009)	
Lamiaceae	*Hyptis verticillata* Jacq. (FACEY et al., 2005)	Cadina-4,10(15)-dien-3-one (PORTER et al., 1995)
	Cunila spicata Benth., *Cunila microcephala* Benth, *Cunila angustifolia* Benth (APEL et al., 2009)	α-pinene, β-pinene, sabinene, menthofuran and 1,8-cineole (APEL et al., 2009*)
	Anisomeles malabarica (L.) R. Br. (ZAHIR et al., 2009)	
	Hesperozygis ringens Benth. (RIBEIRO et al., 2010)	
Lauraceae	*Cinnamomum zeylanicum* Blume (ÁLVAREZ et al., 2008)	
Leguminosae	*Dahlstedtia pentaphylla* (Taub) Burk. (PEREIRA; FAMADAS, 2004)	
	Tamarindus indicus L. (CHUNGSAMARNYART; JANSAWAN, 2001, MAGADUM et al. 2009)	Oxalic, malic, succinic, citric and tartaric acids (CHUNGSAMARNYART; JANSAWAN, 2001*)
	Copaifera reticulata Ducke (FERNANDES; FREITAS, 2007)	
Liliaceae	*Allium sativum* L. (MAGADUM et al., 2009)	Lectins (BANDYOPADHYAY et al., 2001)
	Gloriosa superba L. (ZAHIR et al., 2009)	
Meliaceae	*Azadirachta indica* A. Juss. (WILLIAMS, 1993; VALENTE et al., 2007; SRIVASTAVA et al., 2008; COSTA et al., 2008; MAGADUM et al. 2009; BROGLIO-MICHELETTI et al., 2009, 2010)	Azadirachtin (BUTTERWORTH; MORGAN, 1971) Salanin (MEISNER et al., 1981) Nimbin, nimbinin (SIDDIQUI et al., 1988) Meliatetraolenone, odoratone (SIDDIQUI et al., 2003)
	Melia azedarach L. (BORGES et al., 1994, 2003; VIVAN, 2005; SOUSA et al., 2008).	Azedarachol (NAKATANI et al., 1985) Trichilins, azedarachins (NAKATANI et al., 1995) Meliacarpins (BOHNENSTENGEL et al., 1999) Azadirachtin (MORGAN; THORNTON, 1973)
Myrtaceae	*Psidium guajava* L. (ZAHIR et al., 2009)	
	Pimenta dioica (L.) Merr. (BROWN et al., 1998)	Eugenol, methyleugenol (BROWN et al., 1998*)
	Eucalyptus globulus Labill. (CHAGAS et al., 2002; MAGADUM et al., 2009)	Terpenoids, δ-phenothrin, pyrethrum (YANG et al., 2004)
	Eucalyptus staigeriana F. Muell., *Eucalyptus citriodora* Hook. (CHAGAS et al., 2002)	
	Syzygium malaccensis (L.) Merr. & Perry (BROGLIO-MICHELETTI et al., 2009)	
Moraceae	*Artocarpus altilis* Park. (WILLIAMS, 1993)	
Piperaceae	*Piper aduncum* L. (SILVA et al., 2009)	Dill apiol (BERNARD et al., 1995; SILVA et al., 2009*)
	Piper mikanianum (Kunth) Steud., *Piper xylosteoides* (Kunth) Steud., *Piper amalago* L. (FERRAZ et al., 2010)	Phenylpropanoids, monoterpene and sesquiterpene hydrocarbons (FERRAZ et al., 2010)*
	Piper nigrum L. (ÁLVAREZ et al., 2008)	Piperine, pellitorine, pipercide (MIYAKADO et al., 1979)

*tested against *R.* (*B.*) *microplus*.

Table 1. Continued...

Family	Plant tested against *R. microplus* (Reference)	Natural products with acaricidal or insecticidal activity
Phytolaccaceae	*Petiveria alliacea* L. (ROSADO-AGUILAR et al., 2010)	Dibenzyl trisulfide (JOHNSON et al., 1997)
Poaceae	*Melinis minutiflora* P. Beauv. (HERNÁNDEZ et al., 1989; PRATES et al., 1993)	1,8-cineole, citronellol, α and β pinene, linalool, isopinocamphone and camphor (PRATES et al., 1998*)
	Cymbopogon winterianus Jowitt (SRIVASTAVA et al., 1988; MARTINS, 2006; MARTINS; GONZALEZ, 2007)	Citronellal, geraniol, citronellol (MARTINS, 2006*)
	Cymbopogon citratus (D.C.) Stapf (CHUNGSAMARNYART; JIWAJINDA, 1992; HEIMERDINGER et al., 2006; BROGLIO-MICHELETTI et al., 2009)	
	Cymbopogon nardus (L.) Rendle (CHUNGSAMARNYART; JIWAJINDA, 1992; OLIVO et al., 2008; COSTA et al., 2008)	
Rosaceae	*Prunus persica* L. Bastsch (SRIVASTAVA et al., 2008)	
Rutaceae	*Citrus maxima* Merr., *Citrus reticulata* Blanco., *Citrus suncris* L., *Citrus sinensis* L., *Citrus hystrix* DC (CHUNGSAMARNYART; JANSAWAN, 1996)	d (+)-limonene (CHUNGSAMARNYART; JANSAWAN, 1996*)
	Citrus leminum (Risso.) (MAGADUM et al., 2009)	
Sapindaceae	*Magonia pubescens* A.St. Hil. (FERNANDES et al., 2008)	
Solanaceae	*Solanum trilobatum* L. (ZAHIR et al., 2009)	
	Withania somnifera (L.) Dunal (MAGADUM et al., 2009)	
	Nicotiana tabacum L. (MAGADUM et al., 2009; OLIVO et al., 2009)	
	Solanum torvum Sw. (KAMARAJ et al., 2010)	
	Withania somnifera Dun. (MAGADUM et al., 2009)	
Verbenaceae	*Vitex negundo* L. (KAMARAJ et al., 2010)	
Winteraceae	*Drimys brasiliensis* Miers (RIBEIRO et al., 2008b)	Sesquiterpenoids, cyclocolorenone, bicyclogermacrene and alpha-gurjunene (RIBEIRO et al., 2008b).

*tested against *R.* (*B.*) *microplus*.

of five *Cunila* species at concentrations of 2.5, 5 and 10 µL.mL^{-1} (≈ 0.25, 0.5 and 1%). *C. angustifolia* and *C. incana* caused 100% mortality of larvae at the lowest concentration and *C. spicata* at a concentration of 5 µL.mL^{-1}. *C. incisa* and *C. microcephala* had insignificant action against larvae. The main compounds found in these plants were α-pinene, β-pinene, sabinene, menthofuran and 1,8-cineole (APEL et al., 2009).

Pereira and Famadas (2004) evaluated the action of the ethanolic root extract of *Dahlstedtia pentaphylla* (Leguminosae) against two strains of tick: one acaricide-sensitive Mozo strain, and one from the field. The plant was less efficient against the field strain. The efficiency was close to 100% at a concentration of 20%: LC_{50} 1:34.94 mL (≈ 2.86%) against engorged females and 1:231.337 mL (≈ 0.43%) against larvae. The LC_{50} and LC_{99} of the oleoresinous extract of *Copaifera reticulata* (Leguminosae) against larvae were 1.579 ppm (≈ 0.16%) and 3.491 ppm (≈ 0.35%), respectively (FERNANDES; FREITAS, 2007).

Hexanic, ethyl acetate and ethanolic extracts from leaves of *Piper aduncum* (Piperaceae) were tested against engorged females in increasing, double concentrations from 5 to 100 mg.mL^{-1} (≈ 0.5 to 10%). For all extracts, even at the highest concentration, the reproductive control was no higher than 62%. Larvae mortality was evaluated at concentrations of 1 to 20 mg.mL^{-1} (≈ 0.1 to 2%), and was found to be 70.42, 40.5 and 17.2% in the hexanic, ethanolic and ethyl acetate extracts, respectively, at the highest concentration. Hydrodistillation of the hexanic extract produced 6.8% essential oil, 94.84% consisting on the sesquiterpene dill apiol, which caused 100% larval mortality at 0.1 mg.mL^{-1} (≈ 0.01%) (SILVA et al., 2009). The essential oil of *Piper mikanianum* (LC_{50} 2.33 µL.mL^{-1}; ≈ 0.233%) was more active against larvae than that of *Piper xylosteoides* (LC_{50} 6.15 µL.mL^{-1}; ≈ 0.615%), while the oil of *Piper amalago* was inactive. The main compounds were phenylpropanoids, monoterpenes and sesquiterpene hydrocarbons (FERRAZ et al., 2010).

Hexanic and methanolic extracts from stems and leaves of *Hypericum polyanthemum* (Clusiaceae) were tested at concentrations of 6.25 to 50 mg.mL^{-1} (≈ 0.625 to 5%). The effect against engorged females was low (19.2%) at the highest concentration of the hexanic extract, but on other hand, it killed all larvae in all concentrations (RIBEIRO et al., 2007). Similar effects were observed with the hexanic extracts of stems and leaves of *Calea serrata* (Asteraceae) at the same concentrations (RIBEIRO et al., 2008a).

The LC_{50} and LC_{99} of the ethanolic extracts of stems of *Magonia pubescens* (Sapindaceae) were 365 ppm (≈ 0.036%)

and 4,000 ppm (≈ 0.4%) against larvae (FERNANDES et al., 2008). Over 95% larvae mortality was obtained with the essential oil of *Drimys brasiliensis* (Winteraceae) at concentrations of 3.125 to 25 $\mu L.mL^{-1}$ (≈ 0.3125 to 2.5%). The oil was characterized by sesquiterpenoids, cyclocolorenone, bicyclogermacrene and alpha-gurjunene (RIBEIRO et al., 2008b). The ethanolic extract of seeds of *Annona muricata* L. (Annonaceae) at a concentration of 2% had 100% efficacy against engorged females (BROGLIO-MICHELETTI et al., 2009).

In Vivo Tests

Although a high number of plant extracts have been tested against *R.* (*B.*) *microplus* in laboratory tests, only some of them have also been evaluated on tick infested animals in order to validate the results obtained.

The essential oil of *C. winterianus* was evaluated in two treatments: one through application of the crude oil on the animal's back and the other through aspersion of a solution oil-alcohol (1:10). A significant difference in the number of females was observed between the treated groups, 22 to 28 days after treatment (5.3 to 14.4 and 2.8 to 11.3 in the crude oil and aspersion groups, respectively), and the control group (13.5 to 21.5) (MARTINS; GONZÁLEZ, 2007)

The hexanic extract of ripe fruits of *M. azedarach* at 0.25% was tested by Borges et al. (2005). Twenty-one days after the treatment, the average number of engorged females was significantly lower in the treated group (188) than in the control group (247), with efficacy ranging from –1.6 to 63.6% (average 27.3%). Recently, in an attempt to increase the efficacy of the hexanic extract of *M. azedarach*, Sousa et al. (2010) produced a concentrate emulsion of green fruits that was tested at concentrations of 0.25 and 0.5%. It was observed that the daily efficacy ranged from –46.7 to 82.6% in the treated group in the 0.25% group and from -16.6 to 89.0% in the 0.5% group. There was greater action against larvae and adults than against nymphs. The efficacy was greater than what was found by Borges et al. (2005), although the egg conversion and hatchability of the ticks did not differ between the two experiments. These *in vivo* results differed from laboratory test observations (BORGES et al., 1994, 2003, SOUSA et al., 2008), in which it had already been demonstrated that the fruit extracts of *M. azedarach* had higher efficacy against the females reproductive efficiency.

The efficacy of aqueous extracts from *A. indica* was compared with abamectin among artificially infested animals. One kilogram of leaves was mixed with 5 L of water and sprayed on the animals every week, for four weeks. Another group was treated once with abamectin. Similar tick counts were observed 15 and 30 days after treatment in the two groups: 62.5 and 7.71 in the neem group and 50.5 and 16.0 in the abamectin group, respectively (VALENTE et al., 2007). Srivastava et al. (2008) compared the ethanolic extract of neem seeds at a concentration of 8% with cypermethrin, on artificially infested animals. The mortality in the neem group was 70.5%, five days after the treatment and, in the cypermethrin group, 92.4%, three days after the treatment. Considering the reproductive efficiency of surviving ticks, the efficacy was 68.32 and 80.48% for the neem and cypermethrin groups, respectively. Similar results were observed by Magadum et al. (2009), also using neem seeds at the same concentration as Srivastava et al (2008).

Pereira and Famadas (2006) tested the root extract of *D. pentaphylla* at concentrations of 1:10 and 1:20 mL, on artificially infested bovines. The highest efficacies were observed on the third and seventh days after treatment, reaching 76% in the group treated with the lowest concentration. The reproductive parameters of treated females were not affected by this extract.

Studies conducted by Olivo et al. (2009) evaluated the action of four increasing concentrations (1.25 to 5%) of an aqueous extract of *Nicotiana tabacum* on naturally infested animals. The efficacies ranged from 62% at a concentration of 5% in the first week up to 77.5%, 14 days after treatment, at the lowest concentration.

Difficulties Relating to the Use of Plant Extracts

The lost of efficiency of plant extracts when tested on the animals is undoubtedly a hindrance to development of alternative acaricides. This problem reflects the difficulty in controlling plant extracts, because of the high number of chemical compounds present (EVANS, 1996). It needs to be added that natural products show low persistence in the environment, because of degradation caused by daylight, temperature, pH and microbial action (MULLA; SU, 1999). However, if the complexity of components and multiple action modes may be a obstacle for using of plant extracts, on other hand the development of resistance is retarded (MULLA; SU, 1999; MAGADUM et al., 2009).

Differences relating to edaphoclimatic conditions and the cultivation and conservation of plant materials for extract production may imply oscillations of the results (HEIMERDINGER et al., 2006). Storage of *M. azedarach* fruits for five months at room temperature caused a decrease in their acaricide effect (SOUSA et al., 2008). Yakkundi et al. (1995) observed a 5% reduction in azadirachtin after one month of storage of *A. indica* seeds and 35% after four months. Likewise, Johnson et al. (1996) observed a decrease in azadirachtin and salanin after storage for six months.

Even though the synthesis of chemical compounds is determined by the genetic characteristics of the plant, edaphoclimatic factors also interfere with this factor (LAPA et al., 1999). Thus, the chemical composition of plant extracts varies according to the origin of the plant. Such indications were observed for *M. azedarach* as distinct compounds, when observed in fruits coming from different parts of the world (MORGAN; THORNTON, 1973; ARIAS; HIRSCHMANN, 1988; CABRAL et al., 1996). In unpublished results regarding action against *R.* (*B.*) *microplus* females in particular, Sousa observed varying efficacies when comparing *M. azedarach* extracts obtained from different regions of Goiás and Mato Grosso, Brazil. High efficacies ranging from 86.8 to 100% against reproductive efficiency were observed from five out of the eight extracts tested. Intermediate efficacy (41.8 and 51.2%) was obtained from two extracts and one extract had no effect.

Final Remarks

The use of plant extracts to control ticks, especially *R.* (*B.*) *microplus*, seems to be a viable alternative, given the enormous number of plants with activity against this tick that have already been found. However, difficulty in transposing the efficacy obtained from the laboratory to the field is one of the main obstacles to their use.

With the aim of surmounting this barrier, multidisciplinary efforts are clearly needed in order to find solutions. Formulations to protect the active compounds from environmental degradation and to enable fast penetration into the tick are necessary. There is the need to conduct pharmacokinetic investigations in order to ensure that standard extracts are used. Studies on soil, climate and cultivation, with the aim of achieving homogenous plants with regard to the presence of active compounds, are desirable. Moreover, toxicological studies to identify risks to human and animal health clearly cannot be neglected.

However, it needs to be borne in mind that the market for plant-based acaricidal products is extremely promising, especially if the high levels of synthetic acaricide consumption are considered. These alternative products for controlling cattle ticks not only would be usable for organic cattle farming but also would form an alternative for controlling resistant strains. Low contamination of food and the environment is also a worldwide desire. Thus, it is essential to invest in developing a pharmaceutical phytotherapy industry, with interdisciplinary approaches towards finding solutions for this important current topic.

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