

CONTROL OF ECTOPARASITES

BACKGROUND

In the rearing of animals, such as companion animals and livestock, ectoparasites cause enormous losses, including economic losses, particularly because many ectoparasites can act as disease vectors.

The control of animal ectoparasites is an ongoing challenge. For example, numerous strains of ticks have developed resistance to a wide range of pesticides such as arsenic, hexachlorohexane, camphechlor, DDT, pyrethrines, carbamates and organophosphorous compounds despite the fact that these compounds have varied modes of action and several distinct primary sites of attack in the ectoparasite. It is therefore generally accepted that it is highly desirable to develop and commercialize additional active agents with new modes of action for ectoparasite control.

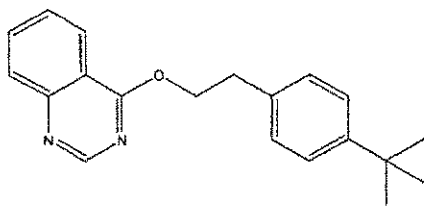
Compounds harboring a quinazoline, pyrazole or pyrimidine core are well known for their fungicidal, insecticidal and miticidal use in the crop chemistry applications (e.g., U.S. Patent No. 5,411,963). However several reports have indicated that fenazaquin and tebufenpyrad have limited spectrum of activity against insect pests as well as relatively low toxicity to beneficial mite species under normal use (*Pest Manag Sci* 2005 61(2):103-10).

SUMMARY

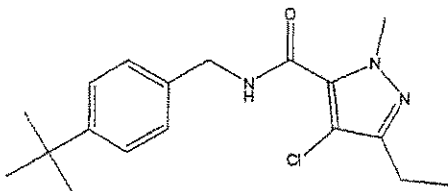
Described herein are methods for preventing and/or repressing ectoparasites of animals. The methods include the application to the animal of an effective amount of a composition that includes one or more of: 4-*tert*-butylphenethyl quinazolin-4-yl ether (fenazaquin), 4-chloro-5-ethyl-2-methyl-*N*-[(4-*tert*-butylphenyl)methyl]pyrazole-3-carboxamide (tebufenpyrad), 5-chloro-*N*-[2-[4-(2-ethoxyethyl)-2,3-dimethylphenoxy]ethyl]-6-ethyl-4-pyrimidinamine (pyrimidifen), and 4-chloro-3-ethyl-1-methyl-*N*-[4-(*p*-tolylloxy)benzyl]pyrazole-5-carboxamide (tolfenpyrad). Fenazaquin, tebufenpyrad, pyrimidifen, and tolfenpyrad are thought to affect metabolism by inhibiting the mitochondrial electron transport chain by binding with Complex I at co-enzyme Q₀ and represent a novel mode of action for ectoparasite control in animal health.

The unexpected anti-tick and anti-flea properties of certain mitochondrial electron transport inhibitors are of considerable significance since there are relatively few agricultural pesticides that can be effectively be used against ectoparasites of animals.

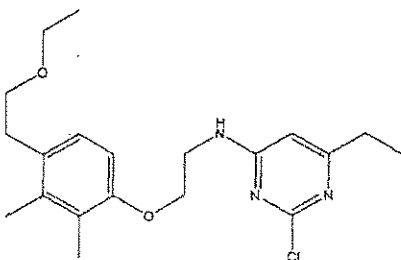
Compositions and processes for controlling ectoparasites of animals are described herein. The methods entail the use of compositions that include: 4-*tert*-butylphenethyl quinazolin-4-yl ether (Formula I), 4-chloro-5-ethyl-2-methyl-*N*-[(4-*tert*-butylphenyl)methyl]pyrazole-3-carboxamide (Formula II), 5-chloro-*N*-[2-[4-(2-ethoxyethyl)-2,3-dimethylphenoxy]ethyl]-6-ethyl-4-pyrimidinamine (Formula III) and 4-chloro-3-ethyl-1-methyl-*N*-[4-(*p*-tolylloxy)benzyl]pyrazole-5-carboxamide disclosed as formula IV, to control ticks, mites, fleas, flies, and lice that infest animals.



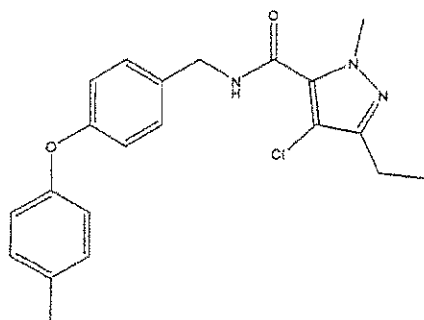
Formula I



Formula II



Formula III



Formula IV

The compounds in Formula I, Formula II, Formula III and Formula IV are suitable for controlling arthropods which attack agricultural livestock such as, for example, cattle, sheep, goats, horses, pigs, donkeys, camels, buffaloes, rabbits, chickens, turkeys, ducks, geese, other domestic animals such as, for example, dogs, cats, caged birds, aquarium fish and so-called experimental animals such as, for example, hamsters, guinea pigs, rats and mice. By controlling these arthropods, cases of death and reductions in productivity (for meat, milk, wool, hides, eggs, and the like) can be lessened, so that more economical and simpler animal husbandry is possible.

Described herein is a method for treating non-human subject, the method comprising administering to the subject a composition comprising the compound of Formula I or a salt thereof.

Described herein is a method for treating non-human subject, the method comprising administering to the subject a composition comprising the compound of Formula II or a salt thereof.

Described herein is method for treating non-human subject, the method comprising administering to the subject a composition comprising the compound of Formula III or a salt thereof.

Described herein is a method for treating non-human subject, the method comprising administering to the subject a composition comprising the compound of Formula II or a salt thereof.

In various embodiments of the methods described herein: the non-human subject is a mammal; the non-human subject is a bird; the administration comprises topical administration, the administration comprises parenteral (e.g., oral) administration; and the non-human subject is infested with an ectoparasite or is at risk of infestation with an ectoparasite. In various embodiments: the ectoparasite is an arthropod; ectoparasite is selected from the families Ixodidae, Argasidae, Psoroptidae, Sarcoptidae, Muscidae, Trichodectidae or Pulicidae; the ectoparasite is selected from *Boophilus* spp, *Rhipicephalus* spp, *Dermacentor* spp, *Hyalomma* spp, *Amblyomma* spp, *Otobius* spp, *Ornithodoros* spp, *Damalinia* spp, *Stomoxys* spp, *Bovicola* spp or *Ctenocephalides* spp.

In various embodiments of the methods described herein: the composition is a solid; the composition is a liquid or gel; the administration comprising applying a liquid composition comprising the compound to the non-human subject; the administration comprising applying a solid composition comprising the compound to the non-human subject; the administration comprises spraying, dipping, or spotting the onto the non-human subject; the compound is present in the liquid composition at 0.01 to 50.0% by weight; the compound is present in the liquid composition at 0.02 to 10.0% by weight; the non-human subject is selected from: cattle, sheep, goats, pigs, dogs, cats and horses; the topical administration comprises fitting the non-human subject with a solid article comprising the composition (e.g., a tag, a collar, a collar tag, an ear tag, a tail tag, a limb band or a halter); the solid article comprises a polymeric material.

Described herein is a pharmaceutical composition comprising the compound of Formula I or a salt thereof in a unit dosage form.

Described herein is a pharmaceutical composition comprising the compound of Formula II or a salt thereof in a unit dosage form.

Described herein is a pharmaceutical composition comprising the compound of Formula III or a salt thereof in a unit dosage form.

Described herein is a pharmaceutical composition comprising the compound of Formula IV or a salt thereof in a unit dosage form.

Described herein is a composition comprising the compound of Formula I or a salt thereof, wherein the composition is suitable for topical administration to a non-human subject.

Described herein is a composition comprising the compound of Formula I or a salt thereof, wherein the composition is suitable for topical administration to a non-human subject.

Described herein is a composition comprising the compound of Formula II or a salt thereof, wherein the composition is suitable for topical administration to a non-human subject.

Described herein is a composition comprising the compound of Formula III or a salt thereof, wherein the composition is suitable for topical administration to a non-human subject.

Described herein is a composition comprising the compound of Formula IV or a salt thereof, wherein the composition is suitable for topical administration to a non-human subject.

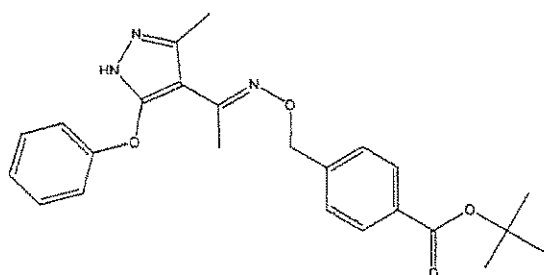
In various embodiment the composition is a powder.

The details of one or more embodiments of the invention are set forth in the accompanying description below. Other features, objects, and advantages of the invention will be apparent from the description and from the claims.

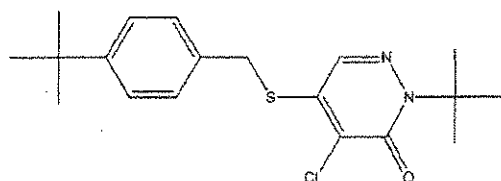
DETAILED DESCRIPTION

Several compounds having activity as mitochondrial complex I inhibitors were commercialized in the 1990s for the purpose of protecting crops and other plants from predation by plant pests such as spider mites (e.g., two spotted spider mite) or rust mites (e.g., apple rust mite). These

compounds include fenazaquin (4-*tert*-butylphenethyl quinazolin-4-yl ether; Formula I), tebufenpyrad (4-chloro-5-ethyl-2-methyl-*N*-[(4-*tert*-butylphenyl)methyl]pyrazole-3-carboxamide; Formula II), pyrimidifen (5-chloro-*N*-[2-[4-(2-ethoxyethyl)-2,3-dimethylphenoxy]ethyl]-6-ethyl-4-pyrimidinamine), tolfenpyrad (4-chloro-3-ethyl-1-methyl-*N*-[4-(*p*-tolylloxy)benzyl]pyrazole-5-carboxamide; Formula IV), fenpyroximate (tert-butyl 4-[[[(1,3-dimethyl-5-phenoxy-pyrazol-4-yl)methylideneamino]oxymethyl]benzoate) and pyridaben (4-chloro-2-*tert*-butyl-5-[(4-*tert*-butylphenyl)methylsulfanyl]pyridazin-3-one).



Formula V (fenpyroximate)



Formula VI (pyridaben)

Despite acting at a conserved site (coenzyme Q₀ of Complex I) and interfering with an essential process (mitochondrial electron transport) these pesticides nonetheless show surprising and unpredictable species selectivity. Although used primarily as acaricides against plant parasitic mites, these compounds generally demonstrate minimal impact on predatory mites and many beneficial insects under field conditions (*Pest Manag Sci* 2005 61(2):103-10).

A specific example of the large species dependent differences in potency of complex I inhibitors is seen for fenazaquin in a study by Hackler *et al.* Fenazaquin is highly active against cotton aphids (LC₅₀ of 2.6 ppm) and against mosquito larvae (LC₅₀ of 0.725 ppm) but has low potency against the cabbage looper (LC₅₀ 188 ppm) and greater than 400 ppm activity against both

southern corn rootworm and tobacco budworm (Hackler et al. 1998 Development of broad-spectrum insecticide activity from a miticide. In: *Synthesis and Chemistry of Agrochemicals V* (Baker et al., eds), American Chemical Society, Washington DC, pp. 147-156). These species sensitivity differences could be due to intrinsic activity differences (i.e., active site changes), metabolism differences and/or penetration differences. For example, fenazaquin is extensively metabolized by the tobacco bud worm, which may explain the poor efficacy against this species. Additionally fenazaquin is degraded more extensively by rat liver microsomes than by trout liver microsomes which may partially explain the higher toxicity of the compound to fish than to mammals. At present, these species-dependent differences in the interactions of the compounds with the active sites, or metabolism or penetration differences are impossible to predict a priori.

Surprisingly we have found that fenazquin (4-*tert*-butylphenethyl quinazolin-4-yl ether) and certain other mitochondrial complex I inhibitors are active on fleas and ticks, two distantly related groups of arthropods that are both commercially important ectoparasites in animal husbandry.

The compounds 4-*tert*-butylphenethyl quinazolin-4-yl ether, 4-chloro-5-ethyl-2-methyl-N-[(4-*tert*-butylphenyl)methyl]pyrazole-3-carboxamide, 5-chloro-N-[2-[4-(2-ethoxyethyl)-2,3-dimethylphenoxy]ethyl]-6-ethyl-4-pyrimidinamine, and 4-chloro-3-ethyl-1-methyl-N-[4-(*p*-tolylloxy)benzyl]pyrazole-5-carboxamide are contemplated to be active against animal parasites (ectoparasites) such as hard ticks, soft ticks, mange mites, harvest mites, lice, hair lice, bird lice and fleas. These parasites include the ectoparasites of the order *Acari* of the family Ixodidae, e.g., the cattle ticks such as *Boophilus* spp, e.g. *Boophilus microplus*, *Boophilus decoloratus* and *Boophilus annulatus*; *Rhipicephalus* spp such as *Rhipicephalus sanguineus*, *Rhipicephalus appendiculatus*, *Rhipicephalus pulchellus* and *Rhipicephalus evertsi*; *Hyalomma* spp such as *Hyalomma truncatum*, *Hyalomma rufipes*, *Hyalomma detritum*, *Hyalomma marginatum*, *Hyalomma dromedarii* and *Hyalomma anatolicum excavatum*; *Dermacentor* species such as *Dermacentor variabilis* and *Dermacentor andersoni*; *Amblyomma* spp such as *Amblyomma variegatum*, *Amblyomma herbraeum*, *Amblyomma pomposum*, *Amblyomma americanum*, *Amblyomma cayennense*, *Amblyomma maculatum*, *Amblyomma gemma* and *Amblyomma lepidium*; of the family *Argasidae*, e.g., *Otobius* spp such as *Otobius megnini* and *Ornithodoros*

spp such as *Ornithodoros savignyi*, *Ornithodoros lahorensis* and *Ornithodoros tholozani*; of the family *Psoroptidae*, e.g., *Psoroptes ovis* and *Psoroptes equi*; and of the family *Sarcoptidae* e.g. *Sarcoptes bovis* or *Sarcoptes scabiei*; ectoparasites of the order *Diptera*, which includes biting and sucking flies; ectoparasites of the order *Phthiraptera*, which includes sucking and chewing lice; and ectoparasites of the order *Siphonaptera*, including but not limited to the cat flea (*Ctenocephalides felis*) and the dog flea (*Ctenocephalides canis*).

The active compounds can be enterally administered in the form of, for example, tablets, capsules, potions, drenches, granules, pastes, boluses, the feed-through method, suppositories. The compounds can be parenterally administered such as, for example, by injections (intramuscularly, subcutaneously, intravenously, intraperitoneally and the like). The compounds can also be administered as implants, by nasal administration, by dermal administration in the form of, for example, immersing or dipping, spraying, pouring-on, spotting-on, washing, dusting, and with the aid of active-compound-comprising molded articles such as collars, ear tags, tail tags, limb bands, halters, marking devices and the like.

The active compound content of the use forms prepared from the commercially available formulations can vary within wide limits. The active compound concentration of the use forms can be from 0.0000001 to 95% by weight of active compound, preferably between 0.0001 and 10% by weight.

When used for cattle, poultry, domestic animals and the like, the active compound combinations can be applied as formulations (for example powders, emulsions, flowables) comprising the active compounds in an amount of 1 to 80% by weight, either directly or after 100- to 10,000-fold dilution, or they may be used as a chemical dip.

The compounds of formula I, II, III and IV are applied to the ectoparasites of the order Acari, in free base form or in agriculturally acceptable acid addition salt form, e.g., as hydrochloride or acetate, by topical treatment of the animals, e.g., by dusting, by dipping or by spray treatments with dilute aqueous form. The compounds of formula I, II, III and IV are preferably used in free base form. The degree of dilution may vary although preferably a concentration in the range of

0.01 to 50.0%, particularly of 0.02 to 10%, by weight of the active agent is employed. The treatment is preferably repeated at intervals of between 7 to 21 days.

The active agent can be conveniently formulated as a dust, dust concentrate, wettable powder, emulsifiable concentrate or as a solution, with conventional solid or liquid adjuvants.

Particularly preferred compositions of the invention are liquid concentrates, especially those containing preferably 3.0 to 50% by weight of active agent, to be diluted with water before use. Such liquid concentrate preferably includes an emulsifying agent such as a polyglycolether derived from a high molecular weight alcohol, mercaptan or alkyl phenol with an alkylene oxide as well as a diluent such as a liquid aromatic hydrocarbon or mineral oil.

Suitable solid carriers are for example ammonium salts and ground natural minerals such as kaolins, clays, talc, chalk, quartz, attapulgite, montmorillonite or diatomaceous earth, and ground synthetic materials such as highly-disperse silica, alumina and silicates; suitable solid carriers for granules are: for example crushed and fractionated natural rocks such as calcite, marble, pumice, sepiolite and dolomite, or else synthetic granules of inorganic and organic meals, and granules of organic material such as sawdust, coconut shells, maize cobs and tobacco stalks; suitable emulsifiers and/or foam formers are: for example nonionic and anionic emulsifiers such as polyoxyethylene fatty acid esters, polyoxyethylene fatty alcohol ethers, for example alkylaryl polyglycol ethers, alkylsulphonates, alkyl sulphates, arylsulphonates, or else protein hydrolysates; suitable dispersants are: for example lignin-sulphite waste liquors and methylcellulose.

Carboxymethylcellulose and natural and synthetic polymers in the form of powders, granules or latices, such as gum arabic, polyvinyl alcohol and polyvinyl acetate, or else natural phospholipids such as cephalins and lecithins and synthetic phospholipids can be used in the formulations. Other additives can be mineral and vegetable oils. It is possible to use colorants such as inorganic pigments, for example iron oxide, titanium oxide and Prussian Blue, and organic colorants such as alizarin colorants, azo colorants and metal phthalocyanine colorants, and trace nutrients such as salts of iron, manganese, boron, copper, cobalt, molybdenum and zinc.

The formulations generally comprise between 0.1 and 95% by weight of active compound, preferably between 0.5 and 90%.

The action of the compounds in Formula I, II, III and IV against animal ectoparasites can be seen from the examples which follow. The examples are to be construed as merely illustrative, and not limitative of the remainder of the disclosure in any way whatsoever. All of the publications cited herein are hereby incorporated by reference in their entirety.

EXAMPLE 1: Activity against *A. americanum* larvae in a dip survival assay.

Using a previously-described protocol that can effectively predict compound potency against adult ticks in the field (White, WH. et al., An *in vitro* larval immersion microassay for identifying and characterizing candidate acaricides. J Med Entomol. 2004 Nov;41(6):1034-42), test compounds from a dimethyl sulfoxide (DMSO) stock or 2% DMSO alone were dispensed into a round-bottom 96-well plate and mixed with aqueous buffer containing 1% ethanol and 0.2% Triton X100. The final DMSO concentration does not exceed 2%. Larval-stage lone star ticks (*Amblyomma americanum*) were dispensed into the wells containing test compounds and submerged for 30 minutes. The ticks were subsequently dispensed into a tissue biopsy bag, which is allowed to dry for 1 hour. After drying, the bags were incubated at 25° with 95% humidity for 24 hours and the number of live and dead larvae were counted. The results of this study are presented in Table 1.

**Table 1: Number of live/total tick larvae
24 hours after treatment**

Treatment: Concentration				
	2%			
DMSO	43/45			
Formula I	0.05%	0.01%	0.001%	
	0/48	0/51	23/80	

Formula II	0.05%	0.01%	0.001%
	0/69	0/77	38/85

Formula III	0.05%	0.01%	0.001%
	0/55	0/62	24/57

Formula IV	0.05%	0.01%	0.001%
	0/76	0/79	58/114

EXAMPLE 2: Activity against *C. felis* ova.

Evaluation of test compounds against flea ova is a commonly-used assay for the determination of commercial efficacy against these insect parasites (McTier TL *et al.*, Evaluation of the effects of selamectin against adult and immature stages of fleas (*Ctenocephalides felis felis*) on dogs and cats. Vet Parasitol. 2000 Aug 23;91(3-4):201-12; Dryden M *et al.*, Efficacy of a topically applied formulation of metaflumizone on cats against the adult cat flea, flea egg production and hatch, and adult flea emergence. Vet Parasitol. 2007 Dec 15;150(3):263-7). Compounds were dissolved in acetone and 100 μ l of each solution was placed in 5ml glass vials and allowed to air dry.

Forty ova from cat flea (*Ctenocephalides felis*) that were less than 48 hours old as well as flea dirt (primarily adult flea fecal material and host dander) were placed in the vials. Vials were covered with paper towels to allow air exchange and incubated at 25° with 90% humidity for 5 days, and the number of larvae were counted. . The results of this study are presented in Table 2:

Table 2: Number of flea larvae emerging (percent of total eggs) from 40 ova after 5 days.

Treatment: Amount per vial	
Acetone	8 (20%)

Formula I	1mg	100 μ g	10 μ g
-----------	-----	-------------	------------

1 (2.5%)	1 (2.5%)	4 (10%)
----------	----------	---------

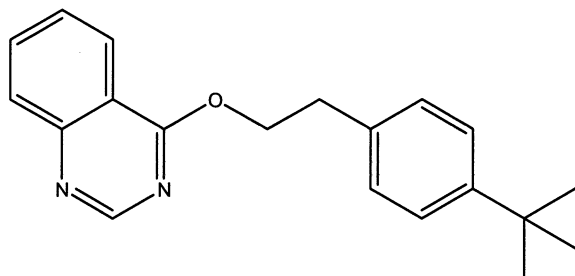
Formula II	1mg	100µg	10µg
	1 (2.5%)	1 (2.5%)	7 (17.5%)

Formula III	1mg	100µg	10µg
	1 (2.5%)	0 (0%)	1 (2.5%)

Formula IV	1mg	100µg	10µg
	0 (0%)	0 (0%)	6 (15%)

CLAIMS:

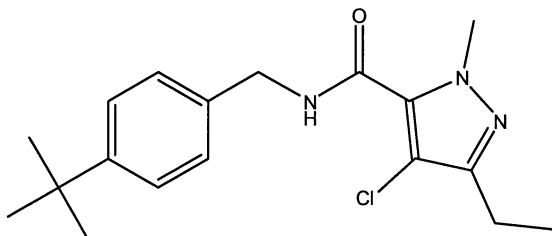
1. A use of a compound of Formula I or a salt thereof



(I)

in preparation of a pharmaceutical composition for prevention or treatment of an ectoparasite infestation in a non-human mammal.

2. A use of a compound of Formula II or a salt thereof

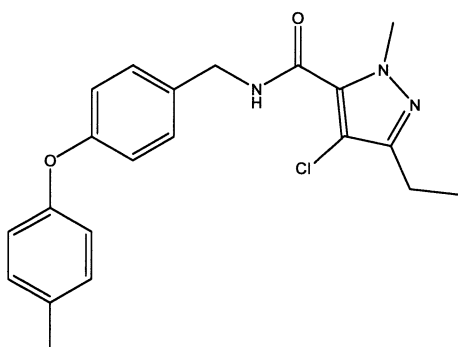


(II)

in preparation of a pharmaceutical composition for prevention or treatment of an ectoparasite infestation in a non-human mammal.

3. A use of 5-chloro-*N*-[2-[4-(2-ethoxyethyl)-2,3-dimethylphenoxy]ethyl]-6-ethyl-4-pyrimidinamine or a salt thereof in preparation of a pharmaceutical composition for prevention or treatment of an ectoparasite infestation in a non-human mammal.

4. A use of a compound of Formula IV or a salt thereof



(IV)

in preparation of a pharmaceutical composition for prevention or treatment of an ectoparasite infestation in a non-human mammal.

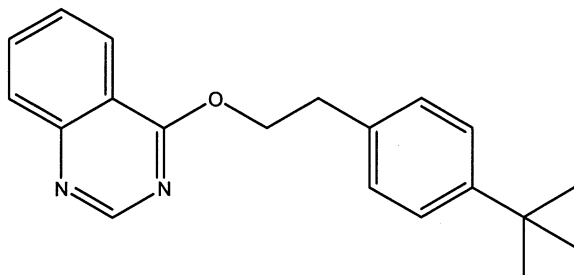
5. The use according to any one of claims 1 to 4, wherein the pharmaceutical composition is to be administered topically.
6. The use according to any one of claims 1 to 4, wherein the pharmaceutical composition is to be administered parenterally.
7. The use according to any one of claims 1 to 6, wherein the non-human mammal is infested with the ectoparasite.
8. The use according to any one of claims 1 to 6, wherein the non-human mammal is at risk of infestation with the ectoparasite.
9. The use according to any one of claims 1 to 8, wherein the ectoparasite is an arthropod.
10. The use according to any one of claims 1 to 8, wherein the ectoparasite is from the family *Ixodidae*, *Argasidae*, *Psoroptidae*, *Sarcoptidae*, *Muscidae*, *Trichodectidae* or *Pulicidae*.
11. The use according to any one of claims 1 to 8, wherein the ectoparasite is selected from the group consisting of *Boophilus spp*, *Rhipicephalus spp*, *Dermacentor spp*, *Hyalomma*

spp, *Amblyomma spp*, *Otobius spp*, *Ornithodoros spp*, *Damalinia spp*, *Stomoxys spp*, *Bovicola spp* and *Ctenocephalides spp*.

12. The use according to any one of claims 1 to 8, wherein the ectoparasite is a flea, tick or fly.
13. The use according to any one of claims 1 to 8, wherein the ectoparasite is a flea.
14. The use according to any one of claims 1 to 8, wherein the ectoparasite is a tick.
15. The use according to any one of claims 1 to 14, wherein the composition is a solid.
16. The use according to any one of claims 1 to 14, wherein the composition is a liquid or gel.
17. The use according to claim 16, wherein the liquid or gel is for spraying, dipping, or spotting onto the non-human mammal.
18. The use according to claim 16 or 17, wherein the compound is present in the liquid composition at 0.01 to 50.0% by weight.
19. The use according to claim 16 or 17, wherein the compound is present in the liquid composition at 0.02 to 10.0% by weight.
20. The use according to any one of claims 1 to 19, wherein a solid article comprises the composition.
21. The use according to claim 20, wherein the solid article is a collar, a collar tag, an ear tag, a tail tag, a limb band or a halter.
22. The use according to claim 20 or 21, wherein the solid article comprises a polymeric material.

23. The use according to any one of claims 1 to 22, wherein the non-human mammal is cattle, sheep, goats, pigs, dogs, cats or horses.

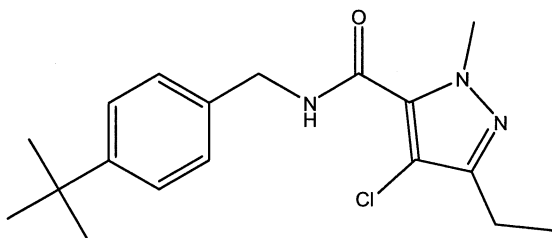
24. A pharmaceutical composition comprising a compound of Formula I or a salt thereof



(I)

and a pharmaceutically acceptable carrier or diluent in a unit dosage form.

25. A pharmaceutical composition comprising a compound of Formula II or a salt thereof

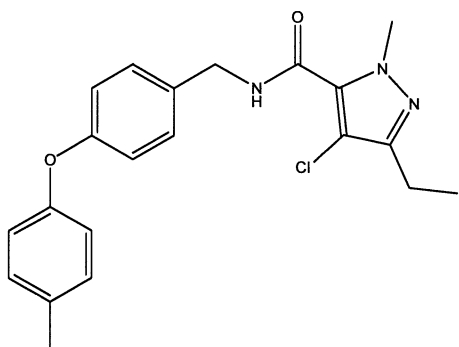


(II)

and a pharmaceutically acceptable carrier or diluent in a unit dosage form.

26. A pharmaceutical composition comprising 5-chloro-*N*-[2-[4-(2-ethoxyethyl)-2,3-dimethylphenoxy]ethyl]-6-ethyl-4-pyrimidinamine or a salt thereof
and a pharmaceutically acceptable carrier or diluent in a unit dosage form.

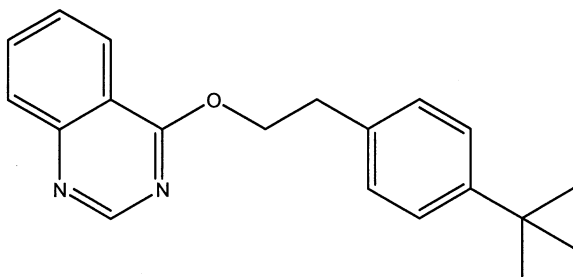
27. A pharmaceutical composition comprising a compound of Formula IV or a salt thereof



(IV)

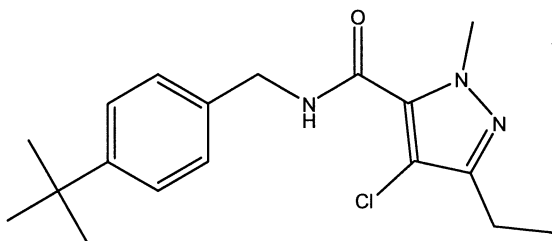
and a pharmaceutically acceptable carrier or diluent in a unit dosage form.

28. A composition comprising the compound of Formula I or a salt thereof and a pharmaceutically acceptable carrier or diluent, wherein the composition is suitable for topical administration to a non-human mammal



(I).

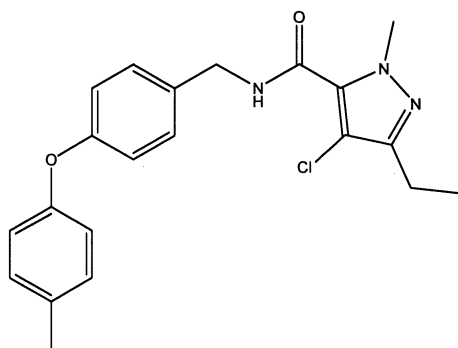
29. A composition comprising a compound of Formula II or a salt thereof and a pharmaceutically acceptable carrier or diluent, wherein the composition is suitable for topical administration to a non-human mammal



(II).

30. A composition comprising 5-chloro-*N*-[2-[4-(2-ethoxyethyl)-2,3-dimethylphenoxy]ethyl]-6-ethyl-4-pyrimidinamine and a pharmaceutically acceptable carrier or diluent, wherein the composition is suitable for topical administration to a non-human mammal.

31. A composition comprising a compound of Formula IV or a salt thereof and a pharmaceutically acceptable carrier or diluent, wherein the composition is suitable for topical administration to a non-human mammal



(IV).

32. The composition according to any one of claims 28 to 31, wherein the composition is a powder.