Fire Ant

Subjects: Zoology

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Red imported fire ants, Solenopsis invicta Buren (hereafter, fire ants), are a significant threat to public health and a danger to livestock, pets and wildlife due to their venomous stings. Fire ants are also a significant agricultural pest because they can damage many crops. As one of the worst invasive species, fire ants, which are originally from South America, have been introduced into many countries and regions and have become an important global pest.

Red imported fire ant | active ingredient | bait | mound treatment | repellant | fumigant | natural products

1. Alternatives to Synthetic Chemical Insecticides for Use in Fire Ant Bait

1.1. Naturally Occurring Compounds Used in Current Fire Ant Baits

Abamectin and spinosad are the only two bait AIs that are not synthetic insecticides. Abamectin and spinosad are fermentation products of bacteria *Streptomyces avermitilis* and *Saccharopolyspora spinosa* respectively [1]. Abamectin is a mixture of avermectins containing primarily avermectin B1a and avermectin B1b and spinosad a mixture of spinosyn A and spinosyn D. Currently there are five commercial fire ant bait products based on these natural compounds (Table 1). Antixx® Fire Ant Bait is the only bait that has been certified for use in organic production by the Organic Materials Review Institute (OMRI)(Eugene, OR, USA)[2].

Table 1. Fire ant bait products that use Abamectin or Spinosad as active ingredients.

Product Name	AI and Concentration	Company
Clinch	abamectin (0.011%)	Syngenta Crop Protection. LLC, Greensboro, NC, USA
Ferti-lome Come and Get It Fire Ant Killer	spinosad (0.015%)	Voluntary Purchasing Group, Bonham, TX, USA

Payback Fire Ant Bait	spinosad (0.015%)	Southern Agricultural Insecticides, Inc. (Palmetto, FL; Hendersonville, NC; Boone, NC, USA
Antixx® Fire Ant Bait	spinosad (0.015%)	W. Neudorff GmbH KG, Emmerthal, Germany

In addition to organic AIs, boron based inorganic compounds have been tested as fire ant bait AIs, particularly borax and boric acid. These two compounds have a long history of use for controlling ants and their toxicity has been investigated in many ant species, such as Florida carpenter ants, *Camponotus floridanus* (Buckley) [3], Argentine ants, *Linepithema humile* (Mayr) [4][5], *Dolichoderus thoracicus* (Smith), a widespread ant species in Asia [6], and fire ants [7]. Boron compound-based ant bait products are commercially available for controlling many ant species, particularly indoor pest ants. Although fire ants are generally considered an outdoor pest, they occasionally migrate into homes for shelter and food, to escape outdoor harsh conditions, such as extreme heat, drought, or flooding. The boric acid/sucrose water bait has successfully eliminated large laboratory fire ant colonies [8] and there are numerous recipes of boron compound-based homemade fire ant control products found on the internet. However, sufficient scientific data that support their efficacy for controlling fire ants in the field is lacking.

1.2. Naturally Occurring Compounds that are Recently Evaluated as Potential Fire Ant Bait Active Ingredients

Effort has been made in searching for naturally occurring compounds as fire ant bait AIs. Five compounds isolated from the root powder of *Periploca sepium* Bunge (Asclepiadaceae), including four pregnane glycosides and one oligasaccharide, possess oral toxicity against fire ants. Among these five compounds, the periplocoside x, a pregnane glycoside, showed the greatest toxicity [9] where it induced a severe, time-dependent cytotoxicity in the midgut epithelial cells of fire ants[10].

Several common natural compounds have been found to be toxic to fire ants by ingestion. It was found that intake of glutamic acid monosodium salt hydrate, glycine, L-alanine, succinic acid, succinic acid disodium, inosinate 5'-monophosphate disodium salt hydrate, or guanosine 5′-monophosphate disodium salt caused mortality of fire ants. Glycine and guanosine 5′-monophosphate disodium salt exhibited the strongest toxicities, causing 100% mortality in workers after 84 h. LC_{50} values were 0.004 g/mL and 0.02 g/mL for guanosine 5′-monophosphate disodium salt and glycine, respectively [11]. It was found that intake of various sweeteners such as erythritol, aspartame, or saccharin caused significant mortality in fire ants [12]. The mortality of the workers could reach above 80% after 72 h feeding on 0.1 or 0.2 g/mL erythritol. The mortality of males, females, and larvae could reach close to 100% after 9 d feeding at high concentrations. The effect of erythritol was found to be dose-dependent for workers, males, females, and larvae. Transfer of erythritol among the fire ant colonies was also observed. Toxicity of aspartame was not observed on other ants, such as black garden ants, *Lasius niger* [13], indicating a possible species selectivity of its toxicity toward ants. The toxicity of erythritol was well documented for many other insect species,

such as fruit fly [14], termites [15], house fly and stable fly [16][17], pear psylla [18]. mosquitoes [19], and pavement ant, *Tetramorium immigrans* Santschi [20].

Due to their slow-acting property and low mammalian toxicity, these compounds may be potentially useful as AIs or additives in fire ant baits. However, before these compounds are used in the control of fire ants, it is necessary to have a better understanding on their modes of action. It is also worthy to further conduct structure-activity relationship analyses for these compounds, which may lead to more promising molecules.

2. Fire Ant Repellants

2.1. Naturally Occurring Organic Compounds/Materials that Have Been Evaluated as Fire Ant Repellants

The repellency of many naturally occurring compounds/materials has been tested against fire ants, including defensive compounds from other ants [21][22], plant raw materials [23][24], plant essential oils and their individual components[25][26][27][28][29][30][31][32][33][34].

Many plant essential oils exhibit repellency against fire ants, such as ylang ylang oil (Du et al. unpublished data), nootka oil [35], mint oil [26], and essential oils of Salvia sclarea L., Capsicum annuum L., Mentha canadensis L., Mentha longifolia (L.) Huds., Cedrus deodara (Roxb.) G.Don, Pinus spp. [36], Eucalyptus globulus Labill, Artemisia carvifolia Buch.-Ham. ex Roxb [37], Cymbopogon nardus (L.) Rendle, Cinnamomum cassia (L.) J.Pres, and Ilex purpurea Hassk [93]. A Chinese essential oil product also show repellency against fire ants [38][31]. There are about 17,500 higher plant species that produce essential oils [39], but only small fraction of essential oils has been tested on fire ants, indicating that plant essential oils may be a rich source of new fire ant repellants.

Fire ant repellants are usually compounds with low molecular weight, so they are very volatile. The application of those compounds under field conditions may require improved delivery technologies in order to achieve a sustained efficacy. Recently, nanoparticle encapsulation technique has been used to formulate essential oils for pest insect control [40]. A nanoformulation of essential oil of Pogostemon cablin (Blanco) Benth for controlling leaf-cutting ants, Atta opaciceps (Borgmeier), Atta sexdens (Linnaeus), Atta sexdens rubropilosa Forel has been reported [41].

One noteworthy factor is that some compounds/materials showed opposite biological effects based on concentrations. Ylang ylang oil exhibited repellency against fire ants at high concentrations, but attractancy at low concentration (Du et al. unpublished data). Similar phenomenon was observed for individual compounds, such as eucalyptol [42], prenyl acetate and pentyl acetate (Du et al. unpublished data). In the field, after the concentration of a repellant decreases with time, it may become an attractant, entirely opposite to its intended effect. Such materials and compounds may not be suitable to be used as fire ant repellants.

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