



## Review

# Agricultural entomology in the state of Acre, Brazil: a historical overview and future challenges

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**Abstract.** Family-based agriculture is predominant in the state of Acre, Brazil. Although it has less economic impact in relation to large-scale plantations, it is also subject to biological imbalances, such as pest attacks, generating economic losses for producers. Phytosanitary knowledge is still incipient in this Brazilian state and it becomes an obstacle to production, often resulting in mistaken management decisions. In this context, this work aimed to present a history of two decades of research in the area of Agricultural Entomology, especially in the areas of integrated management and biological pest control of the most relevant crops grown in Acre state. In this review, 58 scientific papers related to Agricultural Entomology were presented, 23 on surveys and/or new insect records and/or new insect associations with host plants, 17 on insect control using plant extracts from the Amazon region, 13 on integrated pest management and five on bioecology, action levels and/or population dynamics of insect pests in the state of Acre. Through this review, it is observed that basic researches in the area of Agricultural Entomology (surveys, new species record, bioecological or dynamic population studies) have been carried out in this area of the Amazon. Despite a remarkable advance in scientific studies related to integrated pest management in the state in the past ten years, still there is a need to concentrate efforts on research aimed at prospecting and using Amazonian biodiversity (fauna and flora), which subsidize applied programs for integrated pest management of the main crops grown in the state of Acre.

**Keywords:** Agricultural pests; Biological Control; Integrated pest management; Phytosanitary; Western Amazon.

Brazil is among the largest agricultural producing countries, occupying the third place in the ranking of the largest food exporters, with optimistic future forecasts according to the National Supply Company (CONAB 2018). On the other hand, the country is also one of the main consumers of pesticides in the world, becoming evident one of the major barriers to agricultural production: the problem caused by the attack of pests that drastically reduce production (SANTOS & BERNARDES 2018).

Livestock farming production systems have a predominant participation in the economy of the primary sector of Acre state and they are also the activities with the greatest social and environmental impact on the state's countryside (VALENTIM & ANDRADE 2003; AMARAL *et al.* 2006). The other agricultural activities developed in the state are mainly family-based, with cassava and banana as the main crops produced in this Amazon region. The agricultural areas are used to plant annual food crops (rice, corn, beans, cassava etc) and perennial crops (banana, coffee, pineapple, orange, papaya, tangerine, passion fruit, açai palm, in addition to other species) (ANDRADE NETO *et al.* 2011a; 2011b).

The crops commonly planted in the state host a great diversity of insects of economic importance, presenting at least one species of key pest related to their cultivation. When planted in monocultures they suffer from the biological imbalance existing in this production system (FAZOLIN *et al.* 2012a). The negative interference of insect pests in plantations may

cause considerable financial losses. It is estimated that the attacks caused by these insects result in economic losses of billions of Brazilian reais annually for the economy (RANGEL 2015).

The lack of technologies that improve productivity and technical information are some of the problems faced by family farmers in the state of Acre (ANDRADE NETO *et al.* 2011b; NOGUEIRA *et al.* 2013). Research institutions such as the Brazilian Agricultural and Research Corporation (Embrapa) and universities, through postgraduate programs, are the main sources of knowledge generation and responsible for the transfer of technology to producers in the state.

In this context, this work aimed to present the 'state of the art' regarding Agricultural Entomology researches carried out in the state of Acre in the last two decades. To this end, the publications listed in the Lattes Curriculum of all the entomologists (professionals and students) who work or have worked in this area of research in the state were consulted. The databases consulted were: Capes journals portal, Scielo platform and Ainfo journals portal - Embrapa's documents and digital collection management system. Book chapters, articles and scientific notes published in indexed journals, research bulletins, circulars and technical communications, documents from the Embrapa's series, as well as expanded abstracts were consulted. The research focused particularly on studies related to integrated management and biological pest control of the main agricultural crops in this state.

### Pasture pests (*Brachiaria* spp.)

Considered the main pasture pests, they attack pastures in high humidity season causing severe damages that vary for each grass species. In the state of Acre there is evidence of the occurrence of the species *Deois flavopicta* Stål, *Deois incompleta* Walker, *Notozulia entreriana* Berg and *Mahanarva tristis* Fabricius (Hemiptera: Cercopidae). Particular attention should be paid to the attack by *M. tristis*, a species that causes the highest level of injury to pastures in the state (FAZOLIN *et al.* 2009a; FAZOLIN *et al.* 2016a).

Avant-garde studies were carried out in the past century, evaluating the resistance of grasses to the attack of leafhoppers (FAZOLIN & KOURI 1984) and the use of fire as a controlling agent for these insects (FAZOLIN & KOURI 1985). FAZOLIN *et al.* (2009a) carried out work on population dynamics of leafhoppers in pastures of *Brachiaria humidicola* (Rendle) (Poaceae) and survey of insects associated with Tanner-Grass, Tangola and African Star Grass, respectively. These authors evaluated the consortium of different cultivars of *Brachiaria* as a mechanism to control leafhoppers.

In addition to typical grasshoppers, other pests of lesser relevance are reported for grasses in Acre state. FAZOLIN *et al.* (2009a), recorded the attack of grass bug, *Blissus antillus* Leonard (Hemiptera: Lygaeidae) and *Spodoptera frugiperda* J. E. Smith (Lepidoptera: Noctuidae). However, these attacks are reported as sporadic and there are no other studies and reports.

### Peanut pests (*Arachis* spp.)

In the state of Acre there are two important pest species associated with forage peanuts, *Arachis pintoi* Krapov & Gregory (Fabaceae), the carmine spider mite: *Tetranychus ogmophallos* Ferreira & Flechtmann (Acari: Tetranychidae) and the lace bug: *Gargaphia paula* Drake & Ruhoff (Hemiptera: Tingidae) (GUIDOTI *et al.* 2004; FAZOLIN *et al.* 2015a)

SANTOS (2016) e SILVA *et al.* (2018) conducted works observing the population dynamics of *T. ogmophallos* and *G. Paula* in two forage peanut plots without application of phytosanitary products. It was observed that the population peaks of *T. ogmophallos*, in pure and hybrid accessions of *A. pintoi*, occurred in the months of August to November under the edaphoclimatic conditions of the state of Acre. SANTOS & MOURA (2017a) carried out a survey of insects associated with edible peanuts, *Arachis hypogaea* L. (Fabaceae), reporting the occurrence of 26 different insect species associated with peanuts, belonging to three orders, with wide dominance of coleopterans. Among these, *Disonycha brasiliensis* Costa Lima and *Cerotoma arcuata tingomariana* Bechyné (Coleoptera: Chrysomelidae) were reported as the first records of association with peanuts plants in Brazil, as well as potential pests to culture in the state.

### Coffee pests (*Coffea canephora* Pierre ex Froehner)

FAZOLIN *et al.* (2012a) reported the presence of coffee borer *Hypothenemus hampei* Ferrari (Coleoptera: Curculionidae) and the leaf miner, *Leucoptera coffeella* Guérin-Ménéville (Lepidoptera: Lyonetiidae) in Acre state.

Studies on coffee pests in the state are scarce, with only two published works, a record of coffee borer infestation and management guidelines for *Coffea canephora* Pierre ex Froehner (Rubiaceae), commonly known as Conilon coffee, made by FAZOLIN *et al.* (2000a).

MARTINS *et al.* (2019) assessed the diversity and abundance of chrysopids (Neuroptera: Chrysopidae) in irrigated and non-irrigated experimental planting of Conilon coffee, indicating

*Ceraeochrysa cubana* Hagen (Neuroptera: Chrysopidae) as a promising species to be used in biological pest control programs in the state of Acre.

### Fruit pests in general

THOMAZINI *et al.* (2003) made the first records of fruit flies of the genus *Anastrepha* (Diptera: Tephritidae) for the Acre state, in samples in the municipality of Rio Branco.

Until 2010 the species of fruit flies reported in the state of Acre were: *Anastrepha coronilli* Carrejo & González, *Anastrepha distincta* Greene, *Anastrepha leptozona* Hendel, *Anastrepha obliqua* Macquart, *Anastrepha striata* Schiner and *Anastrepha tumida* Stone (THOMAZINI *et al.* 2003; PEREIRA *et al.* 2010). Later, ADAIME *et al.* (2017) and AZEVEDO *et al.* (2018) reported the first records of species *Ceratitidis capitata* (Wiedemann) and *Anastrepha serpentina* (Wiedemann) (Diptera: Tephritidae) for the state, respectively.

Currently, eight species of Tephritidae (seven species of *Anastrepha*, besides *C. capitata*) and two of Lonchaeidae are reported for the state (ADAIME *et al.* 2016; AZEVEDO *et al.* 2018). In addition to these species, VASCONCELOS *et al.* (2017) also mentioned the first record of *Zaprionus indianus* Gupta (Diptera: Drosophilidae), known as fig-fly, a frugivorous species of less economic importance in the state. With regard to the natural enemies of these pests, THOMAZINI & ALBUQUERQUE (2009), made the first records of parasitoids of *Anastrepha* in the Acre state, being *Opius bellus* Gahan, *Doryctobracon areolatus* Szépligeti and *Utetes anastrephae* Viereck (Hymenoptera: Braconidae) associated with *A. obliqua* in taperebá fruits, in the municipality of Bujari and *D. areolatus* associated with *A. obliqua* in guava fruits, in the municipality of Rio Branco. Posteriorly, AZEVEDO *et al.* (2018) described the first occurrence of the parasitoid *Asobara anastrephae* (Muesebeck) in fruits of *Spondias mombin* L. (Anacardiaceae), infested by *A. obliqua* collected in the municipality of Rio Branco.

### Açaí palm pests (*Euterpe oleracea* Mart.)

The first record of the occurrence of leafhopper, *Aetalion reticulatum* (L.) (Hemiptera: Aethalionidae), associated with açai tree clump plants, *Euterpe oleracea* Mart. (Arecaceae) in Acre state, was carried out by SANTOS *et al.* (2015). Then, ANDRADE NETO *et al.* (2016) reported the first infestation of the caterpillar *Herminodes* sp. (Lepidoptera: Noctuidae) attacking a commercial plantation of *E. oleracea* in the municipality of Bujari.

SANTOS & COSTA (2019), increased knowledge about the natural enemies of leafhoppers in the State, reporting the first occurrence of *Pterygogramma marquesi* Brèthes (Hymenoptera: Trichogrammatidae) in *A. reticulatum* eggs. The authors report that this egg parasitoid has the potential to be used in an applied biological control program to this pest in the state, requiring studies related to rearing the species in the laboratory.

### Banana pests (*Musa* spp.)

The banana root weevil *Cosmopolites sordidus* Germar (Coleoptera: Curculionidae) is considered one of the main banana pests in the state of Acre, with wide distribution in the state. FAZOLIN *et al.* (1990, 2000b) carried out pioneering work on the integrated management of this pest, evaluating the effect of three insecticides on its control and the attractiveness of homemade traps made with the pseudostem. FAZOLIN & SANTOS (2017), describe technical instructions with step by step containing the main methods for the control of the banana root weevil.

FAZOLIN *et al.* (2012a), reported the giant borer *Telchin licus* Drury (Lepidoptera: Castniidae) occurring in banana plants in Acre state. Subsequently, FAZOLIN & SANTOS (2017), point out the giant borer as the main pest of cultivar D'Angola (long banana) in the state of Acre, causing severe damage to infested crops. Research related to the control of the giant borer is strongly necessary, given the damage that this species causes in the cultivation and the economic importance of this culture for the state of Acre.

KOCHEMBORGER *et al.* (2016), made the first report of the occurrence of *Metamasius hemipterus* (L.) (Coleoptera: Curculionidae) in banana crops in Acre state, a species that is not known to cause economic damage to the banana crop, but when at a high population level it can cause damage to the culture.

### Cassava pests (*Manihot* spp.)

FAZOLIN & ESTRELA (2016) described the main cassava pests for the Amazon region, recording only the occurrence of mandarová, *Erinnyis ello* (L.) (Lepidoptera: Sphingidae) for the Acre state. Due to the successive outbreaks in the state, the mandarová gained special attention making it necessary that measures were adopted for its control.

FAZOLIN *et al.* (2007a) describes various methods of controlling mandarová within integrated pest management, together with examples of experiences of controlling this pest in the Juruá's Valley. FAZOLIN *et al.* (2007b) present seven steps to control this species, in addition to conducting evaluations of the efficiency of the use of *Baculovirus erinnyis* (Baculoviridae), reaching mortality of 96% of the caterpillars, demonstrating a high effectiveness in combating this pest. SIHLER *et al.* (2016) presented the characterization of a *Baculovirus* isolate that occurs in natural populations of *E. ello* in the municipality of Cruzeiro do Sul, a viable, safe and economical alternative for the control of mandarová.

With regard to natural enemies, SANTOS *et al.* (2017c) verified the first occurrence of the endoparasitoid *Brachymeria annulata* Fabricius (Hymenoptera: Chalcididae) in pre-pupae of *E. ello*, in the municipality of Epitaciolândia, in infestation of this species in rubber trees cultivation.

SANTOS *et al.* (2019a) increased knowledge about the geographic distribution of two species of lace bugs associated with cassava cultivation in the state of Acre, reporting the first record of occurrence of *Vatiga manihotae* Drake, *Vatiga illudens* Drake and *Gargaphia opima* Drake (Hemiptera: Tingidae) in the Kaxinawá indigenous land of Nova Olinda, municipality of Feijó, the latter being, the first record for Brazil.

### Corn pests (*Zea mays* L.)

The works in the field of Agricultural Entomology, published in the state of Acre on the culture of corn, refer to the management and control of Lepidoptera and Coleoptera associated with the crop. In the state, the presence of the following pests is reported: fall armyworm, *S. frugiperda*, corn weevil, *Sitophilus zeamais* Motsch (Coleoptera: Curculionidae) and maize cob borer, *Helicoverpa zea* Boddie (Lepidoptera: Noctuidae) (FAZOLIN *et al.* 2012a).

The works carried out in the state aiming at the management of corn weevil refer to the use of alternative methods to conventional chemical control, with evaluation of the insecticidal potential and toxic effect found in several plants found in the Amazon region (ESTRELA *et al.* 2006; FAZOLIN *et al.* 2007c; FAZOLIN *et al.* 2009b; FAZOLIN *et al.* 2010; FAZOLIN *et al.* 2012b; SANTOS *et al.* 2019b).

Regarding the control of the fall armyworm, the studies are divided between studies with the essential oil of monkey's pepper, *Piper aduncum* L. (Piperaceae) (botanical insecticide), chemical insecticides and studies of synergistic effects between the two. Aiming to provide options for the management of *S. frugiperda* resistance to chemical insecticides, FAZOLIN *et al.* (2015b, 2016b, 2016c, 2017a) evaluated the combination of the essential oil of *P. aduncum* with 15 conventional chemical active ingredients. ALMEIDA *et al.* (2017) analyzed the efficiency of six active ingredients mixed with copaiba oil-resin. SANTOS *et al.* (2015, 2016b, 2016c) observed the insecticidal potential of pure oils from 11 plant species in the control of the caterpillar, indicating the efficiency of Copaiba (*Copaifera* sp., Fabaceae), Babassu (*Orbignya phalerata* Mart., Arecaceae) and Crapwood (*Carapa guianensis* Aubl., Meliaceae).

### Bean pests [*Phaseolus vulgaris* L., *Vigna unguiculata* (L.) and *Canavalia ensiformis* L.]

Several basic studies were carried out involving insect pests of common bean in Acre state, these being the effect of population levels of *Cerotoma* sp. on the yield of *Vigna unguiculata* (L.) (cowpea bean) (FAZOLIN 1986), evaluation of cowpea seeds for the attack of *Callosobruchus analis* Fabricius (Coleoptera: Bruchidae) in different types of storage, description of damage and population dynamics of pests and enemies natural of cowpea (FAZOLIN & MESQUITA 1993), determination of the action level for the control of *Cerotoma tingomarianus* Bechyné (FAZOLIN 1986) and determination of the level of economic damage of that rootworm in *Phaseolus vulgaris* L. (FAZOLIN *et al.* 2001; FAZOLIN & ESTRELA 2004).

SANTOS *et al.* (2017b) reported the first occurrence of the lace bug, *Gargaphia lunulata* Mayr (Hemiptera: Tingidae), associated with the jack bean, *Canavalia ensiformis* L. (Fabaceae) in the Acre state, this plant being a new host for this species in Brazil.

The studies related to management are all directed to the control of the bean's rootworm (*C. tingomarianus*), using plant extracts as control alternatives. FAZOLIN *et al.* (1997, 2002) evaluated the insecticidal potential of several exotic or native plants in the Amazon region aiming to control this pest. FAZOLIN *et al.* (2005) and ALECIO *et al.* (2010) qualified the toxicity of the essential oil of *P. aduncum* e and the insecticidal action of the extract of *Derris amazonica* Killip (Fabaceae) in the management of rootworms in beans, respectively.

Complete information was published in the form of book chapters on the pest complexes associated with the cultivation and storage of beans in the Amazon (FAZOLIN *et al.* 2016c, 2016e), as well as information for carrying out alternative pest control in their cultivation and storage. (FAZOLIN *et al.* 2016f).

### Final Considerations

In this literature review, 66 scientific publications were listed, of which 58 are related to the area of Agricultural Entomology. Of these 58 studies, 23 refer to surveys or new insect records for the state of Acre, 17 on insect control using plants from the Amazon region, 13 adhering to integrated pest management [chemical control (chemical and/or botanical insecticides), biological (parasitoids and/or entomopathogens), resistance of plants to insects or alternative methods of control] and five on bioecology and population dynamics of insect pests in Acre state.

Many other entomological studies are reported for the state of Acre. However, this review covered works in the area of Agricultural Entomology, without including those published

in the form of simple abstracts. In addition, the scope of this work focused on the areas of biological management and control, of the pests of the crops of greatest economic relevance for the State.

In this review, it was found that most of the literature published in the area of Agricultural Entomology in the state of Acre is available in the form of simple abstracts, which limits its dissemination and practical use of information.

Although most research in the field of Agricultural Entomology is characterized as basic research, through this history, it has been observed that this research area has evolved in recent years, with research focused on integrated management, especially those focused on the use of plants in the Amazon region with potential insecticide. Although this scientific advance is notorious, there is still a need for research aimed at the prospection and use of local biodiversity (fauna and flora), which subsidize integrated management programs and applied biological control, concerning the main pests of Acre agriculture.

The Acre state is located in a region rich in biodiversity, bordering Peru and Bolivia. Thus, the possibility of entry of pests (including new ones) from neighboring countries is feasible. However, there is a great possibility of discovering new species of natural enemies (parasitoids, predators and entomopathogens), as well as plants with insecticidal activity, with great potential to be used in integrated pest management programs in this region of the Western Amazon.

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