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About the Insecticidal Activity of Anonaceae

Mini Review

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Abstract

Plants of the Annonaceae family biosynthesize secondary metabolites with insecticidal activity, especially against agricultural pests. This brief mini-review provides a concise overview of studies on the insecticidal activity of Annonaceae plants. It highlights the Annonaceae species and the insect species studied, as well as the most notable compounds.

Key words: Secondary Metabolites, Crop Pest, Insects, Acetogenins

Introduction

The Annonaceae family, which includes approximately 2,400 species [1], is recognized for its unique molecular characteristics and botanical traits, making it one of the oldest families of angiosperms. Members of the Annonaceae family produce a wide variety of secondary metabolites, with a notable emphasis on benzylisoquinoline alkaloids, which comprise around 1,000 different molecules [2]. Additionally, they biosynthesize nearly 400 polyketides [3] known as "Annonaceae acetogenins" (ACGs), which are unique metabolites exclusive to this family.

There are multiple reports on the insecticidal activity of extracts and isolated compounds from this family. This review aims to highlight the insecticidal potential of extracts and compounds, particularly ACGs on insect pests of crops.

Numerous studies have documented the insecticidal activity of extracts and isolated compounds from the Annonaceae family. This review aims to highlight the insecticidal potential of these extracts and compounds, particularly ACGs, against insect pests that affect crops.

Annonaceous Studied

In the Annonaceae family 32 species have been reported to possess insecticidal activity (Table 1). Among these, 20 belong to the *Annona* genus, with Annona squamosa and Annona muricata being the most extensively studied [7].

Table 1: Annonaceae with insecticidal activity on crop pest [4-6].

Annona** atemoya, A. bullata, A. cherimola, A. coriacea, A. cornifolia, A. crassiflora, A. dioica, A. emarginata, A. glabra, A. neosalicifolia, A. macroprophyllata, A. montana, A. mucosa, A. muricata, A. purpurea, A. rensoniana, A. reticulata, A. senegalensis, A. squamosa, A. sylvatica; Asimina angustifolia, As. triloba;* ***Cananga *odorata; Dennettia tripetala;* ***Disepalum*** *anomalum;* ***Duguetia*** *furfuracea, D. lanceolata;* ***Goniothalamus*** *giganteus;* ***Monodora*** *myristica;* ***Oxandra****. cf xylopioides;* ***Unonopsis*** *lindmanii;* ***Xylopia*** *aethiopica.*

Annonaceae Metabolites with Insecticidal Activity

Annonaceae acetogenins are the most researched molecules within this family and have shown the highest potency [8, 9]. In contrast, there have been fewer studies examining the toxic effects of phenols [10-12] and terpenes [10], which include essential oil extracts [13-15]. The diversity of these compounds enables extracts and isolated substances from different Annonaceae tissues to exhibit toxicity toward various insect species.

Studied Target Insects

Insect pests that are sensitive to molecules from the Annonaceae family are grouped into five orders (Table 2 & Figure 1). These insects are economically significant because they primarily attack a variety of plants, including horticultural crops, legumes, ornamental plants, fruit-bearing plants, and herbaceous plants. The most extensively studied pest is the corn earworm (*Spodoptera frugiperda*), especially during its larval stage [4]. This pest affects more than 80 cultivated species and has the potential to cause up to 100% loss in crops such as corn, rice, wheat, beans, sugar cane, and cotton [16].

Table 2: Insect pests of agricultural crops on which the activity of extracts or compounds of Annonaceae has been reported [4-6].

Crop pest	Common name
Coleoptera	
Acalymma vittatum	Striped cucumber beetle
Callosobruchus chinensis	Adzuki bean weevil, cowpea bruchid
Callosobruchus maculatus	Cowpea weevil, cowpea seed beetle.
Cylas formicarius	Sweetpotato weevil
Diabrotica undecimpunctata howardi	Spotted cucumber beetle
Epilachna varivestis	Mexican bean beetle
Henosepilachna vigintioctopunctata	28-spotted potato ladybird, Hadda beetle
Leptinotarsa decemlineata	Colorado potato beetle
Oncopeltus fasciatus	Large milkweed bug
Oryctes rhinoceros	Coconut rhinoceros beetle
Phaedon cochleariae	Mustard beetle, watercress beetle
Prostephanus truncatus	Larger grain borer
Sitophilus zeamais	Maize weevil, greater rice weevil
Sitophilus oryzae	Rice weevil
Tenebrio molitor	Yellow Mealworm beetle
Tibraca limbativentris	Rice stem bug
Tribolium castaneum	Red flour beetle
Trogoderma granarium	Cabinet beetle
Zabrotes subfasciatus	Mexican bean weevil
Diptera	
Anastrepha ludens	Mexican fruit fly
Ceratitis capitata	Mediterranean fruit fly
Drosophila melanogaster	Fruit fly
Drosophila suzukii	Spotted wing drosophila
Hemiptera	
Aphis gossypii	Cotton aphid, melon aphid
Aphis craccivora	Cowpea aphid, groundnut aphid, black legume aphid
Aphis glycines	Soybean aphid
Bactericera cockerelli	Potato psyllid
Bemisia tabaci	Silverleaf whitefly, cotton whitefly, sweetpotato whitefly
Dalbulus maidis	Corn leafhopper
Dichelops melacanthus	Green-belly stink bug
Dysdercus koenigii	Red cotton stainer bug
Euschistus heros	Brown stink bug
Myzus persicae	Green peach aphid, greenfly, peach-potato aphid
Nephotettix cincticeps	Rice green leafhopper
Nilaparvata lugens	Brown planthopper
Oncopeltus fasciatus	Large milkweed bug
Tibraca limbativentris	Rice stalk stinkbug
Hymenoptera	
Atta mexicana	Leaf cutter ant
Lepidoptera	
Anticarsia gemmatalis	Velvetbean caterpillar
Ascia monuste	Great southern white, cabbage caterpillar
Chrysodeixis includens	Soybean looper

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Crocidolomia binotalis	Cabbage cluster caterpillar
Crocidolomia pavonana	Croci, cabbage cluster caterpillar
Corcyra cephalonica	Rice moth
Helicoverpa armigera	Cotton bollworm, corn earworm
Leucinodes orbonalis	Eggplant fruit borer, fruit and shoot borer
Mamestra brassicae	Cabbage moth
Manduca sexta	Tobacco hornworm, hawk moth
Mythimna sequax	Wheat armyworm
Ostrinia nubilalis	European corn borer
Palpita forficifera	Olive moth
Plutella xylostella	Diamondback moth, cabbage moth
Spodoptera frugiperda	Fall armyworm
Spodoptera littoralis	African cotton leafworm, Egyptian cotton leafworm
Spodoptera litura	Tobacco cutworm, cotton leafworm
Pseudaletia sequax	Armyworm
Trichoplusia ni	Cabbage looper
Tuta absoluta	Tomato moth
Orthoptera	
Locusta migratoria	Migratory locust

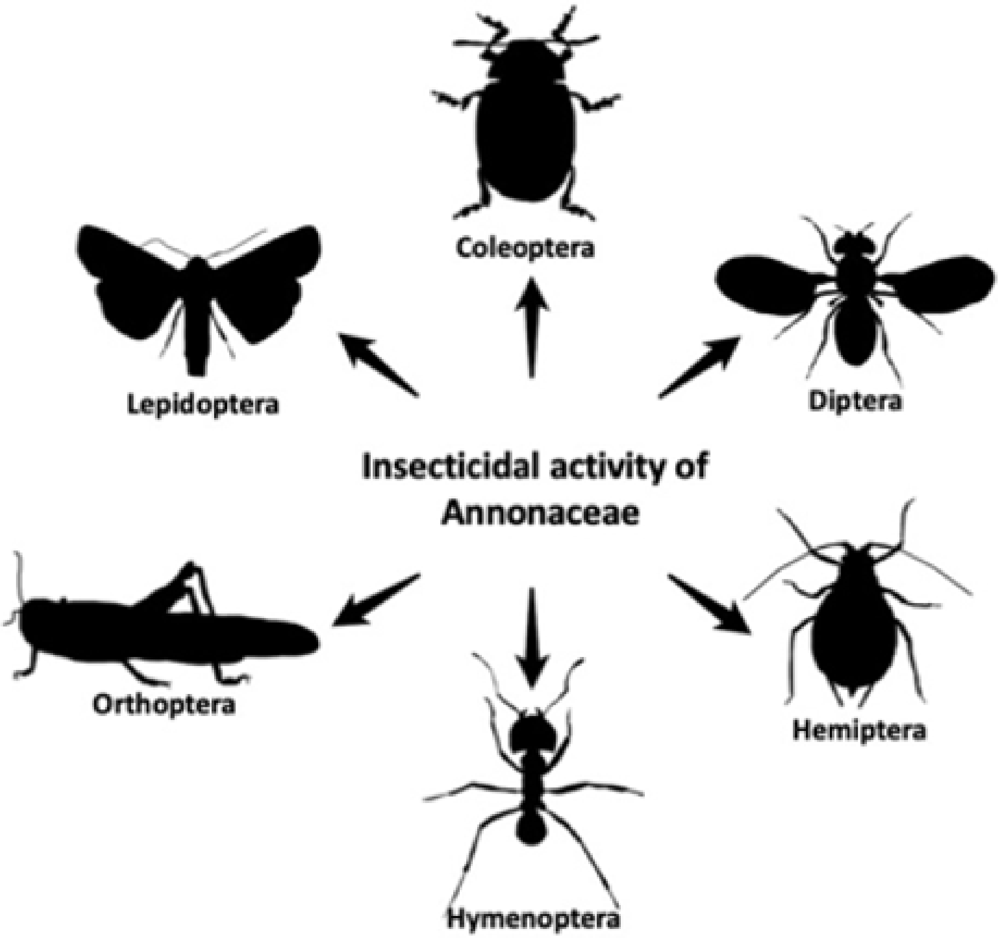

Figure 1: Insecticidal activity of Annonaceae reported on six orders of crop pests. The artwork was made using the free online drawing application Sketchpad®, version ©2021 Sketch.IO.

Importance of the Insecticidal Activity of Annonaceae in Basic Science

Research on extracts and acetogenins (ACGs) isolated from Annona squamosa seeds has revealed interesting insecticidal properties, leading to insights into the mechanism of action of ACGs. Studies using annonin I on the mitochondria of *Plutella xylostella* [17] and asimicin on the midgut of larvae from *Ostrinia nubilalis* [18], the corn borer, as well as on Sf-9 cells from the

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ovaries of pupae of the fall armyworm *S. frugiperda* [19-21], have shown that acetogenins inhibit mitochondrial respiration. This effect is specifically linked to their action on NADH-ubiquinone oxidoreductase (Mitochondrial Complex I), a finding that has been widely supported in eukaryotic cells [20, 22-28].

Conclusion

Secondary metabolites of Annonaceae species have significant potential for ecological pest management alternatives in economically important crops.

References

1. Chatrou L, Pirie M, Erkens R, Couvreur T, Neubig K, et al (2012) A new subfamilial and tribal classification of the pantropical flowering plant family Annonaceae informed by molecular phylogenetics. Bot J Linn Soc 169(1): 5-40.
2. Lúcio AS, Almeida JR, Da-Cunha EV, Tavares JF, Barbosa Filho JM (2015) Alkaloids of the Annonaceae: occurrence and a compilation of their biological activities. Alkaloids Chem Biol 74: 233-409.
3. Neske A, Hidalgo JR, Cabedo N, Cortés D (2020) Acetogenins from Annonaceae family. Their potential biological applications. Phytochem 174: 112332.
4. Durán-Ruiz CA, González-Esquinca AR, De-la-Cruz-Chacón I (2024) Annonaceous acetogenins: A comparative analysis of insecticidal activity. Rev Bras Frutic 46: e-508.
5. Krinski D, Massaroli A, Machado M (2014) Potencial inseticida de plantas da família Annonaceae. Rev Bras Frutic 36(spe1): 225-242.
6. Giraldo-Rivera AI, Guerrero-Álvarez GE (2019) Botanical biopesticides: Research and development trends, a focus on the Annonaceae family. Revista Colombiana de Ciencias Hortícolas 13(3): 371-383.
7. Isman MB, Seffrin R (2014) Natural Insecticides from the Annonaceae: A unique example for developing biopesticides. In: Singh, D, ed. Advances in Plant Biopesticides. New Delhi: Springer 2014. p. 21-33.
8. Cavé A, Figadère B, Laurens A, Cortés D (1997) Acetogenins from Annonaceae. Fortschr Chem Organisch Naturstoffe 70: 81-288.
9. Liaw CC, Liou JR, Wu TY, Chang FR, Wu YC (2016) Acetogenins from Annonaceae. In: Kinghorn, AD, Falk, H, Gibbons, S, Kobayashi, J, eds. Progress in the Chemistry of Organic Natural Products. Switzerland: Springer International Publishing. Pp. 114-230.
10. Makenzi AM, Manguro LOA, Owuor PO, Opiyo SA (2019) Flavonol glycosides with insecticidal activity from methanol extract of *Annona mucosa* Jacq. leaves. Trends Phytochem Res 3(4): 287-296.
11. Makenzi AM, Manguro LOA, Owuor PO (2020) Phytochemistry and insecticidal activity of *Annona mucosa* leaf extracts against *Sitophilus zeamais* and *Prostephanus truncatus*. J Asian Nat Prod Res 23(6): 596-608.
12. Alves DS, Costa VA, Machado ART, Oliveira DF, Carvalho GA (2019) *Duguetia lanceolata* A. St.-Hil. Stem bark produces phenylpropanoids lethal to *Spodoptera frugiperda* (JE Smith) (Lepidoptera: Noctuidae). Crop Protection 127: 104965-104965.
13. Cheng J, Yang K, Zhao NN, Wang XG, Wang SY, et al. (2012) Composition and insecticidal activity of the essential oil of *Cananga odorata* leaves against *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae). J Med Plant Res 6: 3568-3572.
14. Ribeiro LP, Gonçalves GLP, Bicalho KU, Fernandes JB, Vendramim JD (2020) Rolliniastatin-1, a bis-tetrahydrofuran acetogenin: The major compound of *Annona mucosa* Jacq. (Annonaceae) has potent grain-protective properties. J Stored Prod Res. 89:101686.
15. Rosetti MK, Alves DS, Luft IC, Pompermayer K, Scolari AS, et al (2023) *Duguetia lanceolata* A. St.-Hil. (Annonaceae) Essential Oil: Toxicity against *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) and Selectivity for the Parasitoid *Trichogramma pretiosum* Riley (Hymenoptera: Trichogrammatidae). Agriculture13(2): 488.
16. Food And Agricultural Organization Of The United Nations (2022) Acción mundial de lucha contra el gusano cogollero del maíz [Internet].
17. Londershansen M, Leicht W, Lieb F, Moescheler H, Weiss H (1991) Molecular mode of action of annonins. Pestic Sci 33(4): 427-438.
18. Lewis M, Arnason J, Philogene B, Rupprecht J, Mclaughlin L (1993) Inhibition of respiration at Site I by Asimicin, an insecticidal acetogenin of the Pawpaw, *Asimina triloba* (Annonaceae). Pestic Biochem Physiol 45(1): 15-23.
19. Ahammadsahib K, Hollingworth R, Mcgovren J, Hui YH, Mclaughlin J (1993) Mode of action of bullatacin: A potent antitumor and pesticidal Annonaceous acetogenin. Life Sci 53(14): 1113-1120.
20. González-Coloma A, Guadano A, Inés C, Martínez-Díaz R, Cortés D (2002) Selective action of acetogenin *mitochondrial complex* I inhibitors. Z Naturforsch C 57(11-12): 1028-1034.
21. Hollingworth RM, Ahammadsahib KI, Gadelhak G, Mclaughlin JL (1994) New inhibitors of Complex I of the mitochondrial electron transport chain with activity as pesticides. Biochem Soc Trans 22(1): 230-233.
22. Barrachina I, Neske A, Granell S, Bermejo A, Chahboune N, et al. (2004) Tucumanin, a β-Hydroxy-γ-lactone bistetrahydrofuranic acetogenin from *Annona cherimolia*, is a potent Inhibitor of *Mitochondrial Complex* I. Planta Med 70(9): 866-8.
23. Degli Esposti M, Ghelli A, Ratta M, Cortes D, Estornell E (1994) Natural substances (acetogenins) from the family Annonaceae are powerful inhibitors of mitochondrial NADH dehydrogenase (Complex I). Biochem J 301(1): 161-167.
24. Febres-Molina C, Aguilar-Pineda JA, Gamero-Begazo PL, Barazorda-Ccahuana HL, Valencia De Vera-López KJ, et al (2021) Structural and energetic affinity of annocatacin B with ND1 subunit of the human mitochondrial respiratory complex I as a potential inhibitor: an in silico comparison study with the known inhibitor rotenone. Polymers 13: 1840.
25. González M, Tormo J, Bermejo A, Zafra-Polo M, Estorell E, et al. (1997) Rollimembrin, a novel acetogenin inhibitor of mammalian *mitochondrial complex* I. Bioorg Med Chem Lett 7(9): 1113-1118.
26. Hernández-Fuentes GA, García-Argáez AN, Peraza Campos A, Delgado-Enciso I, Muñiz-Valencia R, et al (2019) Cytotoxic acetogenins from the roots of *Annona purpurea*. Int J Mol Sci 20(8): 1870.
27. Tormo J, González M, Cortés D, Stornell E (1999) Kinetic characterization of *mitochondrial complex* I inhibitors using *annonaceous acetogenins*. Arch Biochem Biophys 369(1): 119-126.
28. Zafra-Polo M, González M, Estornell E, Sahpaz S, Cortés D (1996) Acetogenins from Annonaceae, inhibitors of mitochondrial complex I. Phytochem 42(2): 253-271.

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