Brief Communication / Comunicación Breve

A taste for fruit: first record of *Rekoa marius* (Lucas, 1857) (Lepidoptera: Lycaenidae: Eumaeini) on *Averrhoa carambola* L. (Oxalidales: Oxalidaceae)

Gusto por la fruta: primer registro de *Rekoa marius* (Lucas, 1857) (Lepidoptera: Lycaenidae: Eumaeini) sobre *Averrhoa carambola* L. (Oxalidales: Oxalidaceae)

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Abstract. Information on the natural history of *Rekoa marius* (Lucas, 1857) is presented through the first record of the species on *Averrhoa carambola* L. The larvae of this lepidopteran were collected on *A. carambola* and reared under laboratory conditions. Eggs were found on the flower bud, inflorescence and peduncle near the flower. All larval stages feed on flower buds, while the last larval stage also feeds on green and ripe fruits. Pupae with egress holes of different diameters were found, probably of parasitoids. Since Oxalidaceae species are rich in oxalic acid, *R. marius* may be a potential model for future studies on the mechanisms involved in the response of this species to oxalic acid present in its host plant.

Key words: Brazil; hairstreak; immature; Neotropical region; star fruit.

Resumen. Se presenta información sobre la historia natural de *Rekoa marius* (Lucas, 1857) a través del primer registro de la especie en *Averrhoa carambola* L. Las larvas de este lepidóptero fueron recolectadas en *A. carambola* y criadas en condiciones de laboratorio. Los huevos fueron encontrados en el botón floral, la inflorescencia y el pedúnculo cerca de la flor. Todos los estadios larvarios se alimentan de botones florales, mientras que el último estadio larval también se alimenta de frutos verdes y maduros. Se encontraron pupas con orificios de emergencia de diferentes diámetros, probablemente de parasitoides. Dado que las especies de Oxalidaceae son ricas en ácido oxálico, *R. marius* puede ser un modelo potencial para realizar futuros estudios sobre los mecanismos involucrados en la respuesta de esta especie al ácido oxálico presente en su planta hospedante.

Palabras clave: Brasil; carambola; hairstreak; inmaduro; región neotropical.

The genus *Rekoa* Kaye, 1904 comprises seven species widely distributed in the Neotropical region, with records reaching as far as southern Texas (United States of America), with *Rekoa*

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marius (Lucas, 1857) being one of the most common species, occurring in disturbed, wet and dry habitats (Robbins 1991). The hairstreak larvae feed on diverse botanical plant families, with polyphagy being common (Robbins and Aiello 1982; Silva *et al*. 2011; Kaminski *et al*. 2012). Larvae of *Rekoa* species have been recorded on Boraginaceae, Asteraceae (=Compositae), Combretaceae, Fabaceae (=Leguminoseae), Malpighiaceae, Melastomataceae, Ochnaceae, Polygonaceae, Solanaceae, Ulmaceae and Verbenaceae (Robbins 1991). For the polyphagous larvae of *R. marius* are reported Apocynaceae, Araliaceae, Bignoniaceae, Boraginaceae, Combretaceae, Fabaceae, Malpighiaceae, Melastomataceae, Myrtaceae, Ochnaceae, Polygonaceae, Proteaceae, Sapindaceae, Verbenaceae and Vochysiaceae (Monteiro 1991; Robbins 1991; Torezan-Silingardi 2007; Silva *et al*. 2011).

Another family reported as food for lycaenids is Oxalidaceae, however, only for hairstreaks of the African region (Robinson *et al*. 2023). In Brazil, the only records on Oxalidaceae are limited to *Hemiargus hanno* (Stoll, 1790) (Polyommatini) (Barcant 1970) and *Strymon bubastus* (Stoll, 1780) (Eumaeini) (Silva *et al*. 2011, 2016). Oxalidaceae is widely distributed throughout the world, mainly in tropical and subtropical regions (Shaw 2022). In Brazil, approximately 103 species are recorded, in three genera of Oxalidaceae: *Averrhoa* L., *Biophytum* DC. and *Oxalis* L. (Abreu and Fiaschi 2015). *Averrhoa* occurs subspontaneously (Souza and Lorenzi 2008), with *Averrhoa carambola* L. (star fruit), native to Indonesia and Malaysia, introduced and widely distributed in Brazil (Oliveira and Abreu 2020), mainly in gardens.

In the last years, studies on chemical ecology have investigated the aspects involving the interaction amongst host plants or food plants and butterflies, both in relation to the immune response of larva and in understanding how the biochemistry of plants can affect the chemicals released from the androconial regions in the adult stage, as well as in understanding host plant change (Yoon *et al*. 2019; Darragh *et al*. 2019; Robbins *et al*. 2021); furthermore, also elucidating the factors that affected species diversification (Allio *et al*. 2021; Robbins *et al*. 2022). Therefore, in order to provide information on aspects of the natural history of a hairstreak, here is reported the first record of a *Rekoa* species on *A. carambola* .

Larvae of *R. marius* (n = 6) were collected on star fruit trees on May 2019, at the Universidade Federal de Alagoas, Campus A.C. Simões, Maceió, Alagoas (9°33'25''S, 35°46'33''W, 98 m). The immatures were taken to the Laboratório de Bioecologia de Insetos, where they were reared up to the emergence of adult (Fig. 2), at temperatures ranging from 23.96 to 25.91 °C and humidity from 56.17 to 74.71%, individualized and maintained in acrylic containers 2 cm high and 5 cm in diameter, with a paper towel covering the bottom and moistened daily with a drop of water using a Pasteur-pipette. Upon reaching the prepupa, the specimens were individualized in cages (Lima and Carvalho 2017). The voucher of *Rekoa* was deposited in the Coleção Entomológica Pe. Jesus Santiago Moure, Departamento de Zoologia (DZUP), Universidade Federal do Paraná, Brazil, under the code DZ 56.685. Voucher specimen of the food plant was deposited in the MAC Herbarium, Instituto do Meio Ambiente do Estado de Alagoas, Maceió, Alagoas, Brazil, under the code MAC 65041.

A single egg is deposited per oviposition site and can be found on the inflorescences (Fig. 1A), on flower buds or peduncles near the flowers of *A. carambola*. The following aspects were observed in the field: hatched eggs; early instars larvae feeding on flower buds; last instar larva feeding on green fruit; ant interacting with prepupa; and pupal exuviae. In the laboratory, in addition to floral buds, last instar also fed on green and ripe fruits (Figs. 1B-D). Although larvae of other lycaenid species have been reported for Oxalidaceae, such as *H. hanno* on *Oxalis barrelieri* L. (Barcant 1970) and *S. bubastus* on *Oxalis* sp. and on *O. cordata* A. Saint-Hilaire (Silva *et al*. 2011, 2016); these records highlight the leaf as food for larvae. Hairstreaks can cause damage to crops, such as *Strymon megarus* (Godart, 1824) on *Ananas comosus* (L.) Merr. (pineapple) (Bromeliaceae) and other bromeliads; and *Deudorix isocrates* (Fabricius, 1793) on *Punica granatum* L. (pomegranate) (Lythraceae) (Frank and Lounibos 2009; Robbins 2010; Ksentini *et al*. 2011), and also *Oenomaus ortygnus* (Cramer, 1782) on

flowers of *Annona muricata* L. (soursop) (Annonaceae) (Lima *et al*. 2016), and on fruits of *Annona reticulata* L. and *Annona diversifolia* Saff. (Castañeda-Vildózola *et al.* 2011); in addition, *Thecla* sp. was first reported on soursop (Lima 1992)

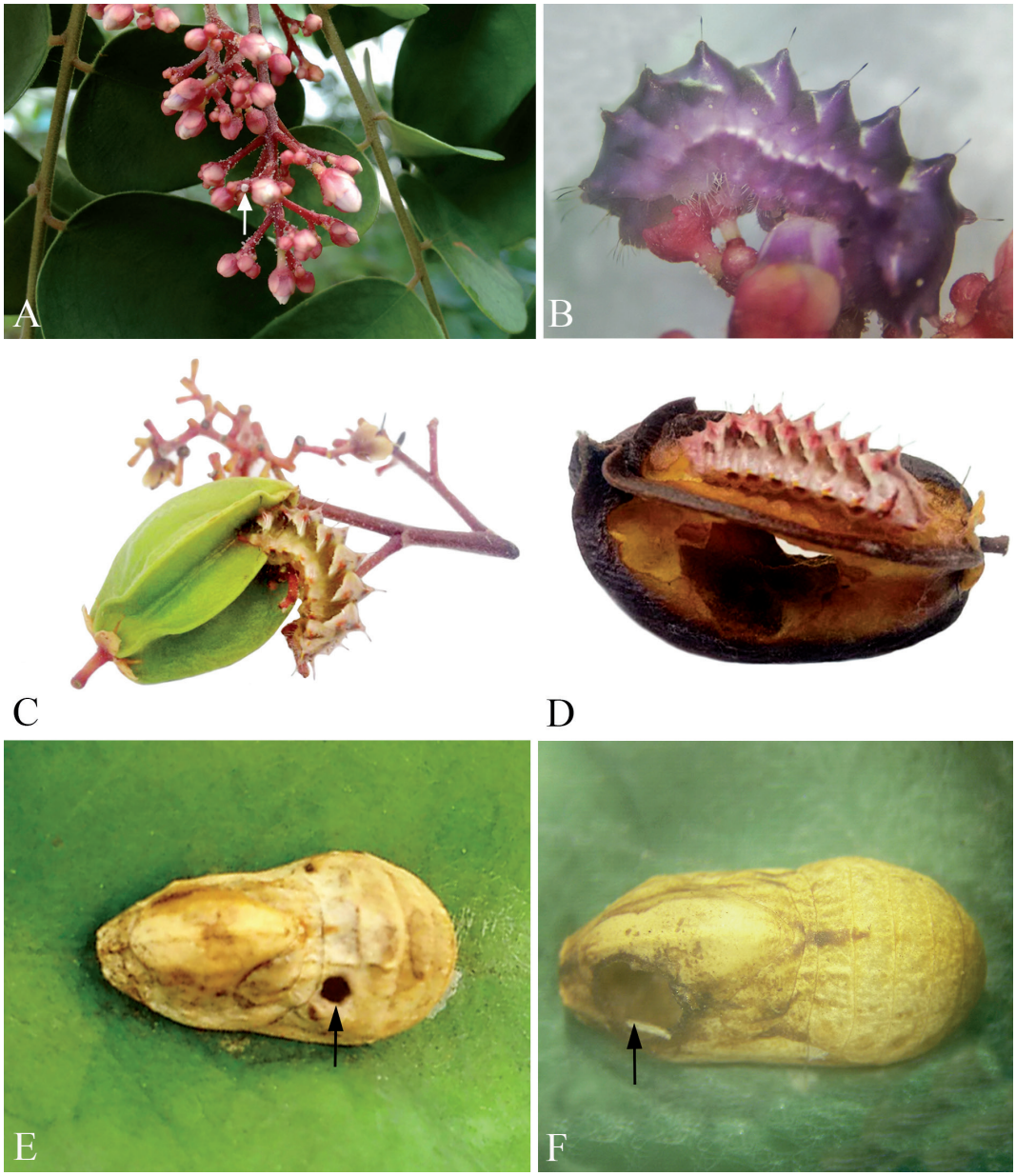

Figure 1. Immatures of *Rekoa marius* (Lucas, 1857) on *Averrhoa carambola* L. **A.** Egg (white arrow). **B.** Last instar feeding on flower bud. **C.** Last instar feeding on green fruit. **D.** Last instar feeding on mature fruit. **E.** Pupa with supposed parasitoid egress holes on the side of the abdomen (black arrow). **F.** Pupa with supposed parasitoid egress holes on the side of the thorax. / **Figura 1.** Inmaduros de *Rekoa marius* (Lucas, 1857) sobre *Averrhoa carambola* L. **A.** Huevo (flecha blanca). **B.** Último estadio se alimenta del botón floral. **C.** Último estadio se alimenta de frutos verdes. **D.** Último estadio se alimenta de frutos maduros. **E.** Pupa con supuestos orificios de emergencia de parasitoide en el lateral del abdomen (flecha negra). **F.** Pupa con supuestos orificios de emergencia de parasitoide en el lateral del tórax.

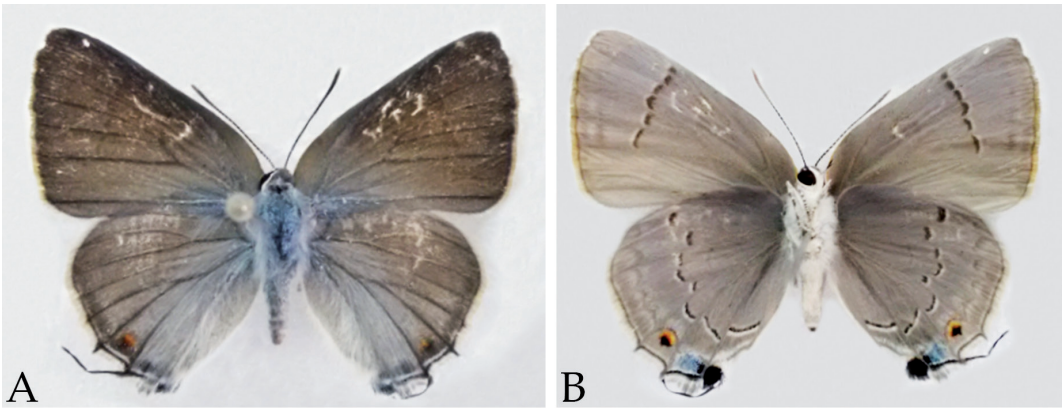

Figure 2. Adult female of *Rekoa marius* (Lucas, 1857). **A.** Dorsal view. **B.** Ventral view. / **Figura 2.** Hembra adulta de *Rekoa marius* (Lucas, 1857). **A.** Vista dorsal. **B.** Vista ventral.

Interestingly, Oxalidaceae species are characterized by the biosynthesis and accumulation of oxalic acid (Yamaguchi *et al*. 2016), detected in various organisms including fungi, plants, and animals, with high concentrations in their leaves (Çalişkan 2000), but is also found in their fruits (Wagner *et al*. 1975). In insects, oxalic acid functions as an antibiotic factor that inhibits the larval growth of *Helicoverpa armigera* (Hübner, 1809) (Noctuidae) (Yoshida 1995). On the other hand, compounds sequestered from plants by larvae can function as pheromone precursors in butterflies (Schulz and Francke 1988; Trigo and Motta 1990; Vane-Wright and Boppré 1993). Data suggest that differences in plant biochemistry affect the chemicals released by the androconial and genital regions of the adult butterfly (Darragh *et al*. 2019).

Studies involving Lycaenidae species have investigated larval responses to different concentrations of oxalic acid present in the leaves of *Oxalis corniculata* L. (Yamaguchi *et al*. 2016). To date, there are no studies evaluating the responses of larvae that feed on *A. carambola* fruits. Therefore, given that *R. marius* is a common butterfly and it can be found in disturbed habitats in wet and dry areas (Robbins 1991), it may be a potential model organism for further studies to understand the mechanisms involved between the plant biochemistry and the butterfly response at different stages of development. When feeding on fruit, *R. marius* may be avoiding large amounts of secondary metabolites present in the leaves of *A. carambola*.

In the field, pupae were also found, each exhibiting a singular circular opening on the lateral surface of the abdomen or thorax (Figs. 1E-F). The variation in size suggests different parasitoids. Parasitoids reported for *R. marius* are Hymenoptera, with *Telenomus* sp. (Scelionidae) on eggs, Braconidae on larvae, and *Conura* sp. (Chalcididae) as larvipupal parasitoid (Monteiro 1991). Silva *et al*. (2014) reports *Baryscapus* sp. (Eulophidae) as larvipupal parasitoid. Besides these, there are also records of Tachinidae (Diptera) as larvipupal parasitoid (Monteiro 1991).

This study presents the first record of *Rekoa marius* on *A. carambola* and also provides information on parasitoidism. Furthermore, this discovery, combined with the fact that *R. marius* is a common species, makes it a potential model for further physiological studies on the mechanisms involved in the response of phytophagous insects to oxalic acid.

Author Contributions

SC: Conceptualization, investigation, writing - original draft, review and editing. **JDM:** Investigation, writing - original draft, review and editing. **ASB:** Investigation, writing - original draft, review and editing. **IMML:** Supervision, writing, review and editing.

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Literature Cited

Abreu, M.C. de and Fiaschi, P. (2015) Oxalidaceae in Lista de Espécies da Flora do Brasil. Jardim Botânico do Rio de Janeiro. Accessed on: 1 March 2024. Available from: http://floradobrasil2015.jbrj.gov.br/jabot/floradobrasil/FB181

Allio, R., Nabholz, B., Wanke, S., Chomicki, G., Pérez-Escobar, O.A., Cotton, A.M., Clamens, A.L., Kergoat, G.J., Sperling, F.A.H. and Condamine, F.L. (2021) Genome-wide macroevolutionary signatures of key innovations in butterflies colonizing new host plants. *Nature Communications, 12*(354): 1-15. https://doi.org/10.1038/s41467-020-20507-3

Barcant, M. (1970) *Butterflies of Trinidad and Tobago*. London, Collins. 314 pp.

Çalişkan, M. (2000) The metabolism of oxalic acid. *Turkish Journal of Zoology*, *24*(1): 103-106.

Castañeda-Vildózola, A., Nava-Díaz, C., Duarte, M., Franco-Moura, O. and Hernández-Fuentes, L.M. (2011) New host plant records for *Oenomaus ortygnus* (Cramer) (Lepidoptera: Lycaenidae) in Mexico. *Neotropical Entomology*, *40*(4): 512-514.

Darragh, K., Byers, K.J R.P., Merrill, R.M., McMillan, W.O., Schulz, S. and Jiggins, C.D. (2019) Male pheromone composition depends on larval but not adult diet in *Heliconius melpomene*. *Ecological Entomology, 44*(3): 397-405. https://doi.org/10.1111/een.12716

Frank, J.H. and Lounibos, L.P. (2009) Insects and allies associated with bromeliads: a review. *Terrestrial Arthropod Reviews, 1*(2): 125-153.

Kaminski, L.A., Rodrigues, D. and Freitas, A.V.L. (2012) Immature stages of *Parrhasius polibetes* (Lepidoptera: Lycaenidae): host plants, tending ants, natural enemies and morphology. *Journal of Natural History*, *46*(11/12): 645-667.

Lima, I.M.M. (1992) Registro de *Thecla* sp. (Lepidoptera, Lycaenidae) e de Curculionidae (Coleoptera) em *Anona muricata* (Anonaceae) em Alagoas e Pernambuco. In: 9º Encontro Nordestino de Zoologia, Resumos do 9º Encontro Nordestino de Zoologia, 118-118.

Lima, I.M.M. and Carvalho, M.B. (2017) Garrafas PET como alternativa para a confecção de recipientes para criação de insetos em laboratório. *Revista Ciência Agrícola*, *15*(1): 79-86.

Lima, I.M.M., Costa, T.M. and Santos, G.S. (2016) *Oenomaus ortygnus* (Cramer) (Lepidoptera: Lycaenidae): florivoria em *Annona squamosa* L. (Annonaceae). *In*: XXVI Congresso Brasileiro de Entomologia, IX Congresso Latino-Americano de Entomologia Anais, Aracaju: Embrapa Tabuleiros Costeiros, 1: 158-158.

Monteiro, R.F. (1991) Cryptic larval polychromatism in *Rekoa marius* Lucas and *R. palegon* Cramer (Lycaenidae: Theclinae). *Journal of Research on the Lepidoptera*, *29*(1/2): 77-84.

Oliveira, Y.R. and Abreu, M.C. (2020) Sinopse taxonômica de Oxalidaceae no Estado de Alagoas, Brasil. *Hoehnea, 47*: e842019. https://doi.org/10.1590/2236-8906-84/2019

Robbins, R.K. (1991) Evolution, comparative morphology, and identification of the eumaeine butterfly genus *Rekoa* Kaye (Lycaenidae: Theclinae). *Smithsonian Contributions to Zoology, 498*: 1-64.

Robbins, R.K. (2010) The "upside down" systematics of hairstreak butterflies (Lycaenidae) that eat pineapple and other Bromeliaceae. *Studies on Neotropical Fauna and Environment, 45*(1): 21-37. https://doi.org/10.1080/01650521003751712

Robbins, R.K. and Aiello, A. (1982) Foodplant and oviposition records for Panamanian Lycaenidae and Riodinidae. *Journal of the Lepidopterists' Society, 36*(2): 65-75.

Robbins, R.K., Cong, Q., Zhang, J., Shen, J., Riera, J.Q., Murray, D., Busby, R.C., Faynel, C., Hallwachs, W., Janzen, D.H. and Grishin, N.V. (2021) A switch to feeding on cycads generates parallel accelerated evolution of toxin tolerance in two clades of *Eumaeus* caterpillars (Lepidoptera: Lycaenidae). *Proceedings of the National Academy of Sciences, 118*(7) (e2018965118): 1-6. https://doi.org/10.1073/pnas.2018965118

Robbins, R.K., Cong, Q., Zhang, J., Shen, J., Busby, R.C., Faynel, C., Duarte, M., Martins, A.R.P., Prieto, C., Lamas, G. and Grishin, N.V. (2022) Genomics-based higher classification of the species-rich Hairstreaks (Lepidoptera: Lycaenidae: Eumaeini). *Systematic Entomology, 47*(3): 445-469. https://doi.org/10.1111/syen.12541

Robinson, G.S., Ackery, P.R., Kitching, I., Beccaloni, G.W. and Hernández, L.M. (2023) HOSTS - a Database of the World's Lepidopteran Hostplants. *Natural History Museum*. Accessed: 27 February 2024. Available from: https://doi.org/10.5519/havt50xw

Silva, N.A.P., Duarte, M., Araújo, E.B. and Morais, H.C. (2014) Larval biology of anthophagous Eumaeini (Lepidoptera: Lycaenidae, Theclinae) in the cerrado of central Brazil. *Journal of Insect Science, 14*(184): 1-17. https://doi.org/10.1093/jisesa/ieu046

Silva, N.A.P., Duarte, M., Diniz, I.R. and Morais, H.C. (2011) Host plant of Lycaenidae on inflorescences in the central Brazilian cerrado. *The Journal of Research on the Lepidoptera, 44*: 95-105.

Silva, N.A.P., Lepesqueur, C., Souza, A.R. and Morais, H.C. (2016) Biology of the immature stages of *Strymon crambusa* (Lycaenidae, Theclinae) on Oxalidaceae. *Revista Brasileira de Entomologia, 60*(1): 68-72. https://doi.org/10.1016/j.rbe.2015.11.003

Shaw, J.M.H. (2022) Oxalidaceae. *In*: Eggli U, Nyffeler, R (eds) *Dicotyledons: Rosids. Illustrated Handbook of Succulent Plants*. Springer, Cham. https://doi.org/10.1007/978-3-030-93492-7

Schulz, S. and Francke, W. (1988) Volatile compounds from androconial organs of Danaine and Ithomiine butterflies. *Zeitschrift für Naturforschung C, 43*(1-2): 99-104. https://doi.org/10.1515/znc-1988-1-219

Souza, V.C. and Lorenzi, H. (2008) Botânica sistemática: guia ilustrado para identificação das famílias de fanerógamas nativas e exóticas no Brasil, baseado em APG II. São Paulo: Instituto Plantarum.

Torezan-Silingardi, H.M. (2007) A influência dos herbívoros florais, dos polinizadores e das características fenológicas sobre a frutificação de espécies da família Malpighiaceae em um cerrado de Minas Gerais. Doutorado em Entomologia, USP Ribeirão Preto, SP.

Trigo, J.R. and Motta, P.C. (1990) Evolutionary implications of pyrrolizidine alkaloid assimilation by danaine and ithomiine larvae (Lepidoptera: Nymphalidae). *Experientia, 46*: 332-334. https://doi.org/10.1007/BF01951782

Vane-Wright, R.I. and Boppré, M. (1993) Visual and chemical signalling in butterflies: functional and phylogenetic perspectives. *Philosophical Transactions of the Royal Society B, 340*: 197-205. https://doi.org/10.1098/rstb.1993.0058

Wagner J.R., C.J., Bryan, W.L., Berry, R.E. and Knight, JR.R.J. (1975) Carambola selection for commercial production. *Proceedings of the Florida State Horticultural Society, 88*: 466-469.

Yamaguchi, M., Matsuyama, S. and Yamaji, K. (2016) Oxalic acid as a larval feeding stimulant for the pale grass blue butterfly *Zizeeria maha* (Lepidoptera: Lycaenidae). *Applied Entomology and Zoology, 51*: 91-98. https://doi.org/10.1007/s13355-015-0375-2

Yoon, S.A., Harrison, J.G., Philbin, C.S., Dodson, C.D., Jones, D.M., Wallace, I.S., Forister, M.L. and Smilanich, A.M. (2019) Host plant-dependent effects of microbes and phytochemistry on the insect immune response. *Oecologia, 191*: 141-152. https://doi.org/10.1007/s00442-019-04480-3

Yoshida, M., Cowgill, S.E. and Wightman, J.A. (1995) Mechanism of resistance to *Helicoverpa armigera* (Lepidoptera: Noctuidae) in chickpea: role of oxalic acid in leaf exudate as an antibiotic factor. *Journal of Economic Entomology, 88*(6): 1783-1786. https://doi.org/10.1093/jee/88.6.1783