Defoliation of *Terminalia catappa* by Larvae of *Thagona tibialis* (Lepidoptera: Erebidae) in Viçosa, Brazil[1]

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ABSTRACT Larvae of *Thagona tibialis* (Walker) (Lepidoptera: Erebidae) have been reported to defoliate tropical almond plants, *Terminalia catappa* L. (Combretaceae), in urban areas of Belo Horizonte (2005), Viçosa (2006), Morro Reuter (2007), and Brasília (2012), Brazil. The origin of *T. tibialis* is uncertain, but it is now dispersed throughout urban areas of all Brazilian states that have *T. catappa*. This pest not only has the capacity for high infestation and defoliation rates on *T. catappa*, but it also can invade houses and cause allergies to humans because of larval hairs and adult scales that are easily dislodged. The objectives of this research were to describe the morphological and ecological characteristics of *T. tibialis* and to evaluate defoliation of *T. catappa* by *T. tibialis* larvae in Viçosa. The specimens collected for this study were a variant of *T. tibialis* that does not have dark dots on the forewings. Larvae were bluish-white, with orange sub-dorsal stripes and black spots throughout the body. Final instars were approximately 40 mm long. Adults exhibit sexual dimorphism. Females were always white, while males varied from white to light or dark brown. Eggs were round, except for the flattened base and micropyle regions, with the greatest diameters being 0.86 mm long and 0.62 mm wide. Larvae of *T. tibialis* injured from 3.6% to 98.9% of the leaves on *T. catappa* trees. From 78.2% to 96.9% of mature leaves and from 3.2% to 21.8% of young leaves were injured, indicating *T. tibialis* larvae prefer mature leaves of *T. catappa*.

KEY WORDS Atlantic Rainforest, defoliation, ecology, morphology, tropical almond

The tropical almond, *Terminalia catappa* L. (Combretaceae), which is probably native to the tropical regions of Africa, Asia, and Oceania, was introduced into many countries as a shade tree because its leaves are long and

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wide (Hayward 1990, Santos & Teixeira 2010). Fruit of *T. catappa* is eaten by bats (Rodriguez-Duran & Vazquez 2001), and its branches are a protein source for small ruminants in semi-arid African countries (Nwosu et al. 2008, Ogunbosoye & Babayemi 2010). Secondary metabolites of *T. catappa* are used in pharmacology (Polesna et al. 2011, Tavares et al. 2012a). This plant has astringent, aphrodisiac, antibiotic, anti-carcinogenic, anti-clastogenic, antispasmodic, antioxidant, antiseptic, laxative, and vermifuge properties (Yang et al. 2010, Hnawia et al. 2011). Its bark and roots are used to treat gastric and bile fevers, dysentery, and intestinal parasites (Annegowda et al. 2010). Leaves are used to treat colic, hemorrhoids, and premature ejaculation (Vrushabendra Swamy et al. 2006). Green fruits of *T. catappa* are astringent, whereas mature ones have laxative properties, and oil from the fruit is used as an emulsifier (Attarpour Yazdi 2009). Products from leaves of *T. catappa* can control fish parasites in pisciculture waters (Chansue 2007). Humic and tannic acids and some flavonoids, especially quercetin and kaempferol, are found in *T. catappa* leaves. Humic acids have antiviral properties and stimulate macrophage production in humans. Tannic acid has antioxidant, anticancer, and antibacterial properties, and it is effective against herpes simplex (lip and vaginal sores). Quercetin is an anti-inflammatory compound, and kaempferol has anti-allergic, anticoagulants, anti-inflammatory, antiviral, and diuretic properties (Goun et al. 2003, Eloff et al. 2008).

Insect pests in the orders Coleoptera, Diptera, and Hemiptera are known to damage fruits and leaves of *T. catappa* in Africa, Asia, Central and South America, and Oceania. *Aleurodicus dispersus* Russell (Hemiptera: Aleyrodidae) damages branches of *T. catappa* in Australia (Lambkin & Zalucki 2010). *Anastrepha* spp. (Diptera: Tephritidae) injures fruits in Puerto Rico (Jenkins & Goenaga 2008), while *Bactrocera carambolae* Drew & Hancock (Diptera: Tephritidae), *B. correcta* (Bezzi), *B. dorsalis* (Hendel), *B. papayae* Drew & Hancock, and other *Bactrocera* species damage fruits in Thailand and Malaysia (Clarke et al. 2001, Somta et al. 2010), and *B. invadens* Drew, Tsuruta & White injures *T. catappa* fruits in Kenya (Rwomushana et al. 2008). *Lamprosoma amethystinum* Perty (Coleoptera: Chrysomelidae) and *L. bicolor* Kirby damage fruits of this plant in Brazil (Casari & Teixeira 2008).

The diversity and phylogeny of Lymantriinae (Lepidoptera: Erebidae) is poorly understood. This subfamily was originally designated as the family Lymantriidae, but it was moved by Kristensen et al. (2007) to Noctuidae, and later to Erebidae by Zahiri et al. (2011). Species of Erebidae are found at a low frequency and density per plant in the Atlantic Rainforest biome in Minas Gerais State, Brazil, and collection data normally result in scarce or rare species (Diniz et al. 2011). Four species of Lymantriinae have been found on plants of the Cerrado (savannah-type) biome in Brasília, Federal District, Brazil. They are *Thagona tibialis* (Walker) (=*Stilpnotia tibialis* Walker) (http://lepidoptera.pro/taxonomy/85339), *Eloria subapicalis* Walker, and two unidentified species of *Caviria* (Diniz et al. 2001). In addition, *Sarsina violascens* Herrich-Schäffer was found on plants of *Eucalyptus* spp. (Myrtaceae) in Goiás State, Brazil (Zanuncio et al. 2000).

Thagona tibialis occurs from Argentina to Costa Rica, and it was recently introduced into Brazil. Larvae of this species defoliated *T. catappa* plants in urban areas of Belo Horizonte, Minas Gerais State in 2005; Viçosa, Minas Gerais State in 2006; Morro Reuter, Rio Grande do Sul State in 2007 (Zenker et al. 2010);

and Brasília in 2012. Now, *T. tibialis* is dispersed throughout Brazilian states cultivated with *T. catappa*. Defoliation of *T. catappa* by *T. tibialis* larvae in urban areas, such as gardens, parks, streets and parking lots, has been frequent in Brazil, and damage has been reported in newspapers and on television programs. As reported from Belo Horizonte in 2005, this insect can be a public health problem when it invades houses, because larval hairs and adult scales are easily dislodged and can induce human allergies.

Thagona tibialis belongs to a genus in which the adult females of all species are white and difficult to distinguish (Vitor Osmar Becker, person. comm.). Adult males have wing patterns that vary depending on the region of occurrence (Zenker et al. 2010).

Adults of *Trichospulus pupivorus* Ferrière (Hymenoptera: Eulophidae) and *Palmistichus elaeisis* Delvare & LaSalle (Hymenoptera: Eulophidae) emerged from *T. tibialis* pupae collected on a *T. catappa* tree in Viçosa (Tavares et al. 2011a, 2012b, 2013a,b). These natural enemies also parasitized pupae of *Anticarsia gemmatalis* Hübner (Lepidoptera: Noctuidae), *Citioica anthonilis* Herrich-Schaeffer (Lepidoptera: Saturniidae), *Heraclides anchisiades capys* Hübner (Lepidoptera: Papilionidae), *Methona themisto* Hübner (Lepidoptera: Nymphalidae), and *Tenebrio molitor* L. (Coleoptera: Tenebrionidae) in the laboratory, which opens possibilities for their use in biological control programs against pests in crops of agricultural and forestry importance (Tavares et al. 2012c, 2013c).

The objectives of this research were to identify and to describe the main morphological and ecological characteristics of *T. tibialis* in the field and when it is reared on *T. catappa* leaves in the laboratory, and to report and quantify defoliation of *T. catappa* by larvae of this species.

Materials and Methods

Collection site. Insects were collected in May 2010 from an urban area of Viçosa, Minas Gerais State, Brazil (20°45′S, 42°51′W, 651 m average elevation). This collection site has an Atlantic Rainforest biome that takes up about 6.2% of the southeastern part of Minas Gerais State (Tavares et al. 2011b). The area studied has flat terrain with fragments of secondary forest that have diversified fauna and flora (Zanuncio et al. 2011).

Fifty recently formed *T. tibialis* pupae from seventy pre-pupae observed on the previous day were collected on the campus of the Federal University of Viçosa (UFV) from a site that had ten *T. catappa* trees spaced about five meters apart. Some pupae were collected on the trunks of *T. catappa*, under the soil, or from nearby shrubs, but most were found attached to the walls or windows of buildings. Pupae were placed into 500-mL plastic containers lined with cotton and brought to the Laboratory of Biological Control of Insects at UFV. Ten pupae were preserved for later morphological descriptions.

Rearing procedures. Forty *T. tibialis* pupae were placed individually into Petri dishes (9 cm diameter × 1.2 cm height) in a rearing cage (32 cm long × 30 cm wide × 30 cm high). They were maintained at 25 ± 1°C, 12-h photoperiod, and 70 ± 10% R.H. Twenty-eight moths emerged from these pupae. Eight adults (four males and four females) were mounted and sent to the Uiraçu Institute in Camacan, Bahia State, Brazil, where they were identified by Vitor Osmar Becker as a form of *T. tibialis* without dots on the forewings.

Twenty *T. tibialis* moths were kept in rearing cages lined with white paper that contained fresh branches with young and mature *T. catappa* leaves as substrate for oviposition. A dental tube filled with water was placed on the petiole of each branch to reduce leaf wilting. Twelve egg masses were obtained, four were removed with a fine-tipped brush for morphological analysis, and the others were kept in the rearing cages until larvae hatched.

Newly hatched larvae, up to one-day-old, were placed in 5-liter plastic pots with *T. catappa* branches as food. The branches were moistened with water and changed every day. Every 24 h, some of these caterpillars were removed from the pots for morphological description of all instars.

Larvae, pupae, and adults of *T. tibialis* were photographed through a stereoscopic microscope. Eggs were characterized and photographed using a scanning electron microscope. Samples of egg masses, larvae, pupae, and adults were fixed, mounted, and deposited in the Regional Museum of Entomology of the Department of Entomology at UFV. Some mounted adults also were deposited in the Uiraçu Institute in Camacan, Bahia State, Brazil.

Leaf damage. The behavior and ecology of *T. tibialis* on *T. catappa* was observed in the field and in rearing cages in the laboratory. The percentage of injured leaves on ten *T. catappa* trees on the campus of UFV was evaluated in May 2010 and 2011. This evaluation was done after defoliation of plants when insects were in the pupal stage. Fifty leaves (injured or not) from the 10 treatment plants (50 leaves from each tree) were chosen at random and classified as young or mature. The experimental design was a randomized block. Data for young or mature injured leaves were submitted to analysis of variance (ANOVA) and the means were compared by Tukey test at 5% probability with SAEG software (SAEG 2007).

Results

This is a report of *T. tibialis* caterpillars defoliating *T. catappa* plants in Brazil. The specimens collected were a form of *T. tibialis* that does not have dots on the forewing.

Larvae. Larvae of *T. tibialis* are bluish-white, with orange sub-dorsal stripes and black details extending throughout the body. The last-instars can reach 40 mm long. Larvae have yellow spots and a black border on the dorsal region of abdominal segments 5–7 (Ab5–7). The dorsal region of Ab6 and Ab7 has a conspicuous gland, with the same background color. Verrucas are present on prothorax Ab9 (Tol-Ab9) in the sub-ventral, lateral, and sub-dorsal regions. White bristles of varying length are present in the verrucas. Generally, larvae have a yellow head (Figure 1b). The pre-pupal stage of *T. tibialis* starts when caterpillars have stopped movement and folded the body (Figure 1d).

Pupae. At the end of their development, larvae seek shelter among leaves, where they build a rudimentary cocoon with folded leaves or a cluster of other plant parts from a host (pieces of leaves, sticks, etc.). They add body bristles and beige silk threads, which are secreted by the caterpillar. Some larvae may not construct a cocoon, leaving the pupa exposed. Pupae are semitransparent and greenish white with black detailed bristles, and they have a conspicuous black cremaster (Figure 1e).

Adults. Adults of *T. tibialis* exhibit sexual dimorphism. Females are always white (Vitor Osmar Becker, person. comm.). Males vary in color from light to dark brown [insects from Morro Reuter, Rio Grande do Sul State, Brazil (Zenker et al. 2010)] to white (insects from Viçosa), but those from the same egg mass have the same color. The costal margin of the female forewing may have a narrow black stripe. The hind wing is the same color as the forewing. The costal margin of the forewing of males is often darker than it is in females. The hind wing of males is sometimes darker than the forewing [insects from Morro Reuter (Zenker et al. 2010)]. Wings are without ornamentation. Commonly, females and males have a small black spot in the lower middle region of the forewing discal cell, and another in the base between wing cells M2 and M3, and, less frequently, a narrow black stripe below and between the two spots (Figures 1f–1h).

Eggs. The adult female of *T. tibialis* secretes beige silk threads that harden after exposure and protect the eggs. These silk threads are secreted by a gland at the tip of the abdomen. The eggs masses also are covered by foam produced in low quantities by the female (Figure 1a). Eggs are rounded, except at the micropyle region that is flattened. They are about 0.86 mm in diameter at the greatest width and 0.62 mm at the greatest height. Eggs have sculpturing on the chorion, with cells most defined in the four microprobes rosettes. Rosettes are characterized as corium depressions not forming radial ridges. The primary rosette is the only one well defined, and it has eight pyriform-shaped cells; cells of the other rosettes vary in shape, size, and number (Figures 1i–1k).

Defoliation. Leaves on all ten *T. catappa* trees on the UFV campus had some injury from *T. tibialis* larvae, and it ranged from 3.6% to 98.9% (Table 1). Mature leaves made up 78.2% to 96.9% (average = 90.2%) of the damaged foliage, while the remainder were young leaves. This significant difference ($P = 0.02$, $F = 3.95$) reflects a preference for older leaves by *T. tibialis* larvae.

Discussion

The typical form of *T. tibialis* adults, reported from Panama, has two to four dots on the forewings (Forbes 1939). The biology of this species was studied in Argentina (Jörgensen 1928). Some Brazilian publications referred to *T. tibialis* in error as being a species in the genus *Norape*, probably because many species in this genus also are white like *T. tibialis* (Vitor Osmar Becker, personal communication). *Thagona tibialis* tends to reach population peaks at the end of the rainy season during April and May in Viçosa. However, from the second half of November, this species can be observed on *T. catappa*, but their populations were reduced as the relative humidity increased from November to January. This is similar to the occurrence of *S. violascens* in colder and drier months of the year on *Eucalyptus* sp. plants in Goiás State, Brazil (Zanuncio et al. 2000).

The bristles of *T. tibialis* larvae break easily, and they may cause irritation to the skin or the mucous of the eyes, mouth, and nose. These larvae use the bristles for defense and later incorporate them into their cocoon. Although larvae prefer mature leaves of *T. catappa*, they also feed on young leaves of this species and leaves of Euphorbiaceae [e.g., *Euphorbia cespitosa* Lam., *E. pulcherrima* (Willd. Ex Klotzsch), *E. ovalifolia* Engelm., and *Sebastiania commersoniana* (Baill.) L. B. Sm. & Downs], Sapindaceae [e.g., *Allophylus edulis* (St.-Hil.) Radlk.], Lauraceae,

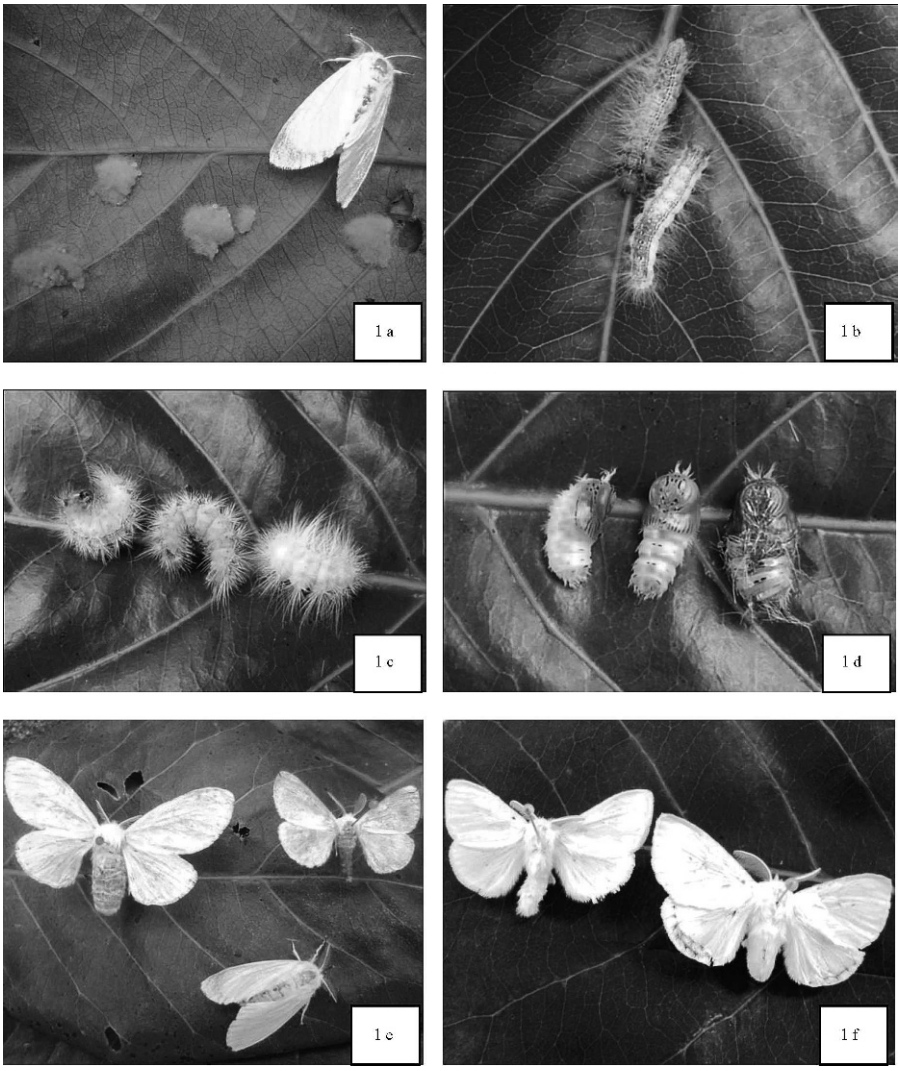

Fig. 1. *Thagona tibialis* (Lepidoptera: Erebidae) female moth and egg masses (1a); larvae (1b); pre-pupae (1c); pupae (left two are healthy and the right one is parasitized) (1d); adults (females on the left and center and a male on the right) (1e); dorsal view of adult moths (male on the left and a female on the right) (1f); ventral view of adult female without dots on the forewings, which is characteristic of moths from Viçosa, Minas Gerais, Brazil (1g); leaves of *Terminalia catappa* (Combretaceae) defoliated by *T. tibialis* larvae (1h); general view of a *T. tibialis* egg (1i); lateral view of an egg (1j); and micropilar region of an egg (1k). Figures 1i–1k were provided by Maurício Moraes Zenker.

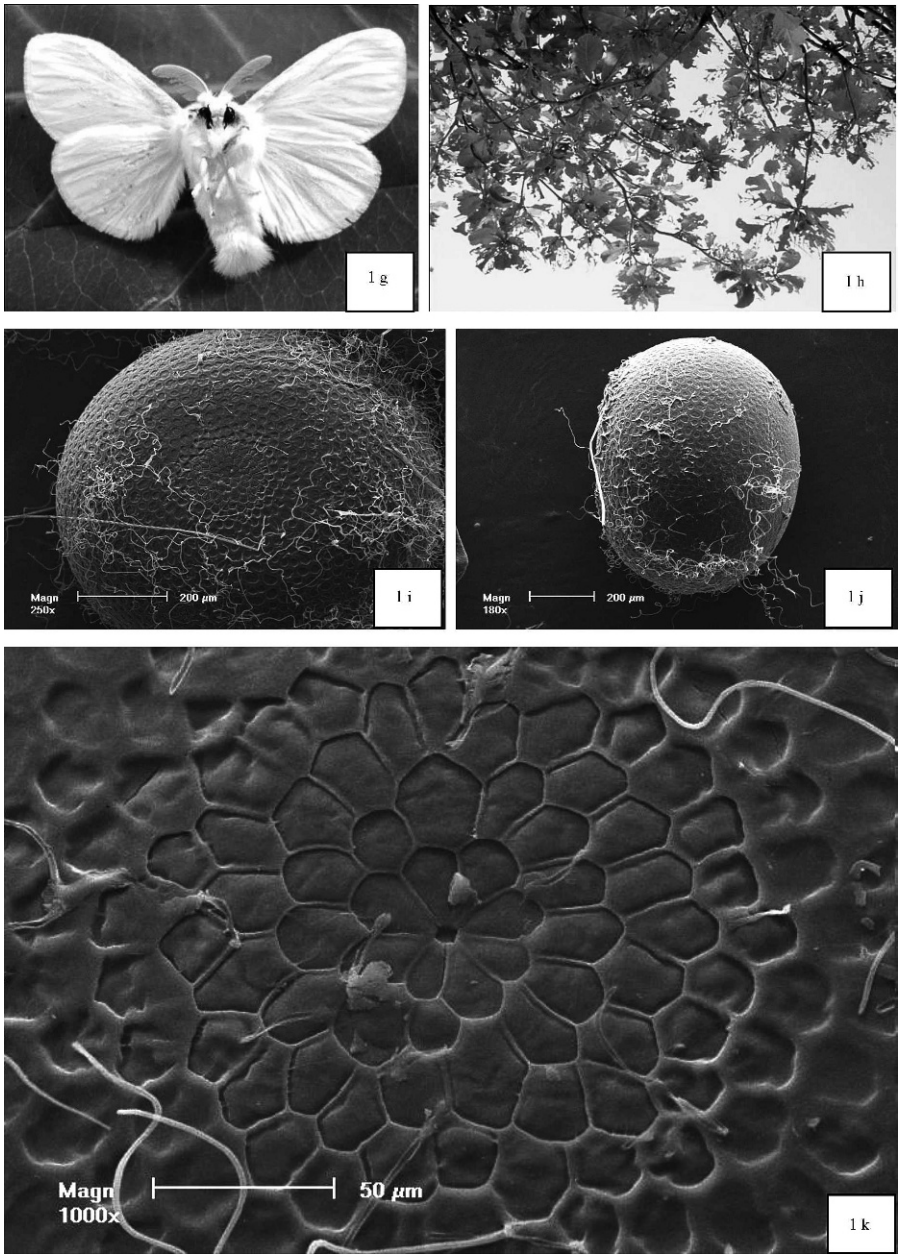

Fig. 1. Continued.

Table 1. Percentage of young and mature leaves of ten *Terminalia catappa* (Combretaceae) trees injured by *Thagona tibialis* (Lepidoptera: Erebidae) larvae on the campus of the Federal University of Viçosa, Minas Gerais, Brazil, May 2010 and 2011.

Tree Number	Total injured leaves (%) (2010)	Total injured leaves (%) (2011)	Young leaves injured (%) (2010)	Young leaves injured (%) (2011)	Mature leaves injured (%) (2010)	Mature leaves injured (%) (2011)
1	98.9 a[a]	40.4 b	13.0 b	7.8 b	87.0 a	92.2 a
2	6.3 b	81.8 a	5.8 b	11.7 b	94.2 a	88.3 a
3	5.1 b	90.2 a	4.9 b	12.5 b	95.1 a	87.5 a
4	3.6 b	75.5 a	3.2 b	6.3 b	96.8 a	93.7 a
5	0.0 b	68.2 a	-	20.8 b	-	79.2 a
6	0.0 b	91.6 a	-	14.1 b	-	85.9 a
7	0.0 b	57.3 a	-	21.8 b	-	78.2 a
8	0.0 b	92.9 a	-	8.3 b	-	91.7 a
9	0.0 b	81.7 a	-	3.1 b	-	96.9 a
10	0.0 b	75.7 a	-	3.5 b	-	96.5 a

[a]Within a line, means followed by the same small letter do not differ according to Tukey's test ($P = 0.05$).

and Piperaceae (Costa Lima 1936). Larvae leave the primary and secondary ribs of *T. catappa* intact after feeding (Figure 1c).

Adults of *T. tibialis* and other Lymantriinae do not feed. The small size of its eyes indicates that this insect has nocturnal habits (Schaefer 1989), remaining hidden among the leaves of the host plant during the day. At night, larvae feed on pioneer or secondary plants, which explains their abundance in urban areas. Adult females are attracted to light sources, such as residential lighting, automobile headlights, and streetlights.

In the laboratory, egg masses of *T. tibialis* were laid in one to three layers, primarily on the adaxial surface of *T. catappa* leaves, but they also are laid on young leaves and buds, although in lower numbers.

Species of Lymantriinae, including *Lymantria dispar* L. (Matsuki et al. 2011), *L. monacha* L. (Heiermann & Schutz 2008), and *Orgyia pseudotsugata* McDunnough (Torgersen 2001), are important defoliators of trees and shrubs, while some Lymantriinae species prefer lichens, Poaceae, or Vitaceae. *Thagona* spp. are important defoliators of Euphorbiaceae, Lauraceae, Piperaceae, and Sapindaceae, including native plants from the Cerrado (Diniz et al. 2001).

Trees of *T. catappa* may be nearly totally defoliated by *T. tibialis* larvae, which prefer mature leaves. There are about 40 trees of *T. catappa* on the campus of the UFV. Although *T. tibialis* was not observed on all trees during the collection period, some of these trees had been defoliated in previous years.

The origin of *T. tibialis* is uncertain, but it is dispersed in urban areas of all Brazilian states where *T. catappa* is cultivated. Problems caused by the invasion of this pest include high infestation and defoliation capacity, occupancy of houses, and allergies in humans by hairs of caterpillars and scales of adults, which are easily released from the body of the insect.

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Literature Cited

Annegowda, H. V., M. N. Mordi, S. Ramanathan & S. M. Mansor. 2010. Analgesic and antioxidant properties of ethanolic extract of *Terminalia catappa* L. leaves. Internat. J. Pharm. 6: 910–915.

Attarpour Yazdi, M. M. 2009. Antibacterial activity of *Terminalia catappa* extract against bacteria isolated from infected burn wounds. Abstract PJ160, 57th Internat. Congress Annu. Meet., Soc. Med. Plant Natural Prod. Res., 16–20 August 2009, Geneva, Switzerland. Planta Med. 75: 1070.

Casari, S. A. & E. P. Teixeira. 2008. Immatures of *Lamprosoma amethystinum* Perty, 1832 (Chrysomelidae, Lamprosomatinae). Zootaxa 1713: 39–46.

Chansue, N. 2007. Effects of dried Indian almond leaf (*Terminalia catappa* L.) extract on monogenean parasites in goldfish (*Carassius auratus*). Wien. Tierärztl. Monat. (Vet. Med. Austria) 94: 269–273.

Clarke, A. R., A. Allwood, A. Chinajariyawong, R. A. I. Drew, C. Hengsawad, M. Jirasurat, C. K. Krong, S. Kritsaneepaiboon & S. Vijaysegaran. 2001. Seasonal abundance and host use patterns of seven *Bactrocera macquart* species (Diptera: Tephritidae) in Thailand and peninsular Malaysia. Raffles Bull. Zool. 49: 207–220.

Costa Lima, A. M. 1936. Terceiro Catálogo dos Insetos que Vivem nas Plantas do Brasil [Third Catalog of the Insects that Live on Plants in Brazil]. Ministério da Agricultura, Rio de Janeiro, Brazil, 460 pp.

Diniz, I. R., H. C. Morais & A. J. A. Camargo. 2001. Host plants of lepidopteran caterpillars in the cerrado of the Distrito Federal, Brazil. Rev. Bras. Entomol. 45: 107–122.

Diniz, I. R., C. Lepesqueur, M. S. Milhomen, F. C. S. Bandeira & H. C. Morais. 2011. *Eloria subapicalis* (Lepidoptera: Noctuidae: Lymantriinae): rare and specialist species on *Erythroxylum* (Erythroxylaceae) in the cerrado. Zoologia (Curitiba, Impr.) 28: 58–62.

Eloff, J. N., D. R. Katerere & l. J. McGaw. 2008. The biological activity and chemistry of the southern African Combretaceae. J. Ethnopharmacol. 119: 686–699.

Forbes, W. T. M. 1939. The Lepidoptera of Barro Colorado Island, Panama. Bull. Mus. Comp. Zool. Harvard 85: 97–322.

Goun, E., G. Cunningham, D. Chu, C. Nguyen & D. Miles. 2003. Antibacterial and antifungal activity of Indonesian ethnomedical plants. Fitoterapia 74: 592–596.

Hayward, D. F. 1990. The phenology and economic-potential of *Terminalia catappa* L in south-central Ghana. Vegetatio 90: 125–131.

Heiermann, J. & S. Schutz. 2008. The effect of the tree species ratio of European beech (*Fagus sylvatica* L.) and Norway spruce (*Picea abies* (L.) Karst.) on polyphagous and monophagous pest species - *Lymantria monacha* L. and *Calliteara pudibunda* L. (Lepidoptera: Lymantriidae) as an example. Forest Ecol. Manag. 255: 1161–1166.

Hnawia, E., L. Hassani, E. Deharo, S. Maurel, J. Waikedre, P. Cabalion, G. Bourdy, A. Valentin, V. Jullian & B. Fogliani. 2011. Antiplasmodial activity of New Caledonia and Vanuatu traditional medicines. Pharm. Biol. 49: 369–376.

Jenkins, D. A. & R. Goenaga. 2008. Host breadth and parasitoids of fruit flies (*Anastrepha* spp.) (Diptera: Tephritidae) in Puerto Rico. Environ. Entomol. 37: 110–120.

Jörgensen, P. 1928. Sobre unas orugas de la família Lymantriidae [About some caterpillars in the family Lymantriidae]. Rev. Soc. Entomol. Argent. 2: 31–34.

Kristensen, N. P., M. J. Scoble & O. Karsholt. 2007. Lepidoptera phylogeny and systematics: the state of inventorying moth and butterfly diversity. Zootaxa 1668: 699–747.

Lambkin, T. A. & M. P. Zalucki. 2010. Long-term efficacy of *Encarsia dispersa* Polaszek (Hymenoptera: Aphelinidae) for the biological control of *Aleurodicus dispersus* Russell (Hemiptera: Aleyrodidae) in tropical monsoon Australia. Aust. J. Entomol. 49: 190–198.

Matsuki, M., N. Kay, J. Serin & J. K. Scott. 2011. Variation in the ability of larvae of phytophagous insects to develop on evolutionarily unfamiliar plants: a study with gypsy moth *Lymantria dispar* and *Eucalyptus*. Agric. Forest Entomol. 13: 1–13.

Nwosu, F. O., O. O. Dosumu & J. O. C. Okocha. 2008. The potential of *Terminalia catappa* (Almond) and *Hyphaene thebaica* (Dum palm) fruits as raw materials for livestock feed. African J. Biotechnol. 7: 4576–4580.

Ogunbosoye, D. O. & O. J. Babayemi. 2010. Potential values of some non-leguminous browse plants as dry season feed for ruminants in Nigeria. African J. Biotechnol. 9: 2720–2726.

Polesna, L., Z. Polesny, M. Z. Clavo, A. Hansson & L. Kokoska. 2011. Ethnopharmacological inventory of plants used in Coronel Portillo Province of Ucayali Department, Peru. Pharm. Biol. 49: 125–136.

Rodriguez-Duran, A. & R. Vazquez. 2001. The bat *Artibeus jamaicensis* in Puerto Rico (West Indies): Seasonality of diet, activity, and effect of a hurricane. Acta Chiropterol. 3: 53–61.

Rwomushana, I., S. Ekesi, I. Gordon & C. K. P. O. Ogol. 2008. Host plants and host plant preference studies for *Bactrocera invadens* (Diptera: Tephritidae) in Kenya, a new invasive fruit fly species in Africa. Ann. Entomol. Soc. Am. 101: 331–340.

SAEG (Sistema para Análises Estatísticas). 2007. Versão 9.1, Fundação Arthur Bernardes - Federal University of Viçosa, Viçosa, Brazil.

Santos, M. N. & M. L. F. Teixeira. 2010. Tropical almond seeds (*Terminalia catappa* L.) (Combretaceae) as a substrate for epiphytic orchid cultivation. Acta Sci. Agron. 32: 339–343.

Schaefer, P. 1989. Diversity in form, function, behavior, and ecology: an overview of the Lymantriidae (Lepidoptera) of the world, pp. 1–19. *In* W. E. Wallner & K. A. McManus (Eds.), Lymantriidae: a comparison of features of new and old world tussock moths. USDA Forest Service, Broomall, PA.

Somta, C., A. Winotai & P. A. C. Ooi. 2010. Fruit flies reared from *Terminalia catappa* in Thailand. J. Asia Pac. Entomol. 13: 27–30.

Tavares, W. S., C. Hansson, J. E. Serrão & J. C. Zanuncio. 2011a. First report of *Trichospilus pupivorus* (Hymenoptera: Eulophidae) parasitizing pupae of *Anticarsia gemmatalis* (Lepidoptera: Noctuidae). Entomol. Gener. 33: 281–282.

Tavares, W. S., J. E. Serrão, R. A. Barbosa & J. C. Zanuncio. 2011b. *Lagerstroemia speciosa* (L.) Pers. (Lythraceae), a new host for the defoliator *Oiketicus kirbyi* Guilding, [1827] (Lepidoptera: Psychidae). Trop. Lepidopt. Res. 21: 100–104.

Tavares, W. S., G. Salgado-Neto, J. C. Legaspi, F. S. Ramalho, J. E. Serrão & J. C. Zanuncio. 2012a. Biological and ecological consequences of *Diolcogaster* sp. (Hymenoptera: Braconidae) parasitizing *Agaraea minuta* (Lepidoptera: Arctiidae) and the effects on two *Costus* (Costaceae) plant species in Brazil. Fla. Entomol. 95: 966–970.

Tavares, W. S., T. V. Zanuncio, C. Hansson, J. E. Serrão & J. C. Zanuncio. 2012b. Emergence of *Palmistichus elaeisis* (Hymenoptera: Eulophidae) from pupae of *Thagona tibialis* (Lepidoptera: Lymantriidae) collected in the medicinal plant *Terminalia catappa* (Combretaceae). Entomol. News 122: 250–256.

Tavares, W. S., O. H. H. Mielke, C. F. Wilcken, L. Simon, J. E. Serrão & J. C. Zanuncio. 2012c. *Palmistichus elaeisis* (Hymenoptera: Eulophidae) parasitizing pupae of *Citioica anthonilis* (Lepidoptera: Saturniidae) collected on *Piptadenia gonoacantha* (Fabaceae). J. Lepidopt. Soc. 66: 216–220.

Tavares, W. S., C. Hansson, J. E. Serrão & J. C. Zanuncio. 2013a. *Trichospilus pupivorus* (Hymenoptera: Eulophidae): first report of parasitism on *Thagona tibialis* (Lepidoptera: Lymantriidae) in Brazil. Stud. Neotrop. Fauna E. 48: 104–105.

Tavares, W. S., C. Hansson, O. H. H. Mielke, J. E. Serrão & J. C. Zanuncio. 2013b. Parasitism of *Palmistichus elaeisis* Delvare & LaSalle, 1993 on pupae of *Methona themisto* [Hübner, (1818)] reared on two hosts (Lepidoptera: Nymphalidae; Hymenoptera: Eulophidae). Shilap-Rev. Lepidopt. 41: 43–48.

Tavares, W. S., **M. A. Soares**, **O. H. H. Mielke**, **J. C. M. Poderoso**, **J. E. Serrão** & **J. C. Zanuncio**. **2013c.** Emergence of *Palmistichus elaeisis* Delvare & LaSalle, 1993 (Hymenoptera: Eulophidae) from pupae of *Heraclides anchisiades capys* [Hübner, (1809)] (Lepidoptera: Papilionidae) in the laboratory. Folia Biol. (Krakow) 61: 233–237.

Torgensen, T. R. 2001. Defoliators in eastern Oregon and Washington. Northwest Sci. 75: 11–20.

Vrushabendra Swamy, B. M., S. M. Ahmed, P. Gopkumar, R. Dhanapal, V. M. Chandrashekar & R. S. Rao. 2006. Antidiarrhoeal activity of *Terminalia catappa* Linn. leaf extracts in rats. Asian J. Chem. 18: 1236–1242.

Yang, S. F., M. K. Chen, Y. S. Hsieh, J. S. Yang, A. I. Zavras, Y. H. Hsieh, S. C. Su, Y. T. Kao, P. N. Chen & S. C. Chu. 2010. Antimetastatic effects of *Terminalia catappa* L. on oral cancer via a down-regulation of metastasis-associated proteases. Food Chem. Toxicol. 48: 1052–1058.

Zahiri, R., I. J. Kitching, J. D. Lafontaine, M. Mutanen, L. Kaila, J. D. Holloway & N. Wahlberg. 2011. A new molecular phylogeny offers hope for a stable family level classification of the Noctuoidea (Lepidoptera). Zool. Scripta 40: 158–173.

Zanuncio, J. C., T. V. Zanuncio, E. T. Lopes & F. S. Ramalho. 2000. Temporal variations of Lepidoptera collected in an *Eucalyptus* plantation in the State of Goias, Brazil. Neth. J. Zool. 50: 435–443.

Zanuncio, J. C., A. M. R. M. Ferreira, W. S. Tavares, J. B. Torres, J. E. Serrão & T. V. Zanuncio. 2011. Rearing the predator *Brontocoris tabidus* (Heteroptera: Pentatomidae) with *Tenebrio molitor* (Coleoptera: Tenebrionidae) pupa on *Eucalyptus grandis* in the field. Am. J. Plant Sci. 2: 449–456.

Zenker, M. M., M. Botton, J. A. Teston & A. Specht. 2010. Noctuidae moths occurring in grape orchards in Serra Gaúcha, Brazil and their relation to fruit-piercing. Rev. Bras. Entomol. 54: 288–297.