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DISTRIBUTION AND HOSTPLANT RECORDS FOR *EUPACKARDIA CALLETA* FROM SOUTHEASTERN TEXAS WITH NOTES ON MANDIBULAR MORPHOLOGY OF ATTACINI (SATURNIIDAE)

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ABSTRACT. *Eupackardia calleta* (Westwood) is recorded on privet (*Ligustrum*) from Kingwood, Texas. This new county record represents a northeastern range extension of 100 miles and confirms privet as a hostplant under natural conditions. The role of the mandible in digestion of the hostplant is discussed.

The last instar larval mandible of most Attacini either lacks teeth or has the cutting edge bluntly serrated with reduced teeth. In contrast, the distinctive mandible of *E. calleta* contains three large teeth and deep molar ridges, an autapomorphy for the genus. Well-developed mandibular teeth are present on the last instar of a few unrelated Saturniinae and Ceratocampinae; therefore this character is homoplastic in Saturniidae. A structurally complex mandible of the "sphingid-type" occurs in several saturniids such as *Antheraea pernyi* (Guér.- Mén.) (Saturniidae). This mandible type is illustrated.

There are two ontogenetic patterns of mandibular development in Saturniidae. In one case, teeth are present in the first instar, then lost in later molts. The mandibular development of *E. calleta* represents an alternative scenario where teeth are present throughout the larval stage.

Additional key words: *Ligustrum*, ontogenetic development, Sphingidae, Notodontidae.

Eupackardia calleta (Westwood) is a member of the Attacini, usually considered the sister group to *Rothschildia* (Ferguson 1972, Peigler 1989, Friedlander et al. 1998). This species is distributed from Central America (Honduras, Guatemala) north to Arizona and southern Texas (Victoria Co., Calhoun Co.) (Ferguson 1972, Wolfe 1995, Tuskes et al. 1996). The systematics and biology of *E. calleta* have been reviewed by several authors including Ferguson (1972), Weast (1989), Miller (1976), Lemaire (1978), and Tuskes et al. (1996).

Weast (1989) suggested that systematic studies of *E. calleta* are needed. Tuskes et al. (1996) illustrated three larval forms of the United States populations, but did not study their mandibular morphology. In this paper we present biological data on *E. calleta* from southeastern Texas, then compare the mandibular

morphology to other Attacini, with emphasis on related nearctic taxa. Ontogenetic and phylogenetic observations are also included.

MATERIALS AND METHODS

In order to survey saturniid mandibles, preserved larval specimens or exuviae associated with cocoons and emerged adults were taken from the authors' collection and dissected. The mandible was either slide mounted in Euperal or preserved in alcohol. For analysis with a J.O.E.L. JSM 820 scanning electron microscope, each sample was attached to a stub with carbon paint and coated with a thin conductive layer of gold-palladium. Mandibular terminology is based on Godfrey (1972).

Material examined: *Eupackardia calleta*: TEXAS (various localities, ex ova from female moths in lab culture): 10 eggs, 10 first instars, 27 second to fourth in-

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TABLE 1. Mandibular morphology of selected late instar Attacini larvae occurring in the Western Hemisphere. Locality data designate source of the study specimens.

Species examined	Source	Cutting edge of mandible
<i>Callosamia angulifera</i> (Wlk.)	USA	Teeth reduced, margin bluntly serrate
<i>Callosamia promethea</i> (Drury)	USA	Teeth reduced, margin bluntly serrate
<i>Callosamia securifera</i> (Maas.)	USA	Teeth reduced, margin bluntly serrate
<i>Eupackardia calleta</i> (Ww.)	Texas, Mexico	Teeth present, well-developed
<i>Hyalophora cecropia</i> (L.)	USA	Teeth absent
<i>Hyalophora columbia</i> (S. I. Smith)	USA	Teeth absent
<i>Hyalophora euryalus</i> (Bdv.)	USA	Teeth reduced, margin bluntly serrate
<i>Hyalophora gloveri</i> (Stkr.)	USA	Teeth reduced, margin bluntly serrate
Prob. <i>Rothschildia cincta</i> (Tepp.)	Prob. Baja California	Teeth reduced, margin bluntly serrate
<i>Rothschildia erycina</i> (Shaw)	USA	Teeth reduced, margin bluntly serrate
<i>Rothschildia forbesi</i> Benj.	Texas	Teeth absent
<i>Rothschildia lebeau</i> (Guér.-Mén.)	Honduras	Teeth absent
<i>Rothschildia orizaba</i> (Ww.)	Ecuador	Teeth reduced, margin bluntly serrate
<i>Samia cynthia</i> (Drury)	USA	Teeth reduced, margin bluntly serrate

stars, 6 pupal cases (with larval exuviae), det. V. A. Passoa, mandible slides #581, 582 S. Passoa collection; Harris Co., Kingwood, XII-1995, on *Ligustrum*, V. A. Passoa, 6 mature larvae, det. V. A. and S. Passoa, mandible slide # 616 S. Passoa coll.

MEXICO: various localities, collection data unknown, 2 first instars, 18 second to fourth instars, 3 pupal cases (with larval exuviae), det. V. A. Passoa; Mich. [Michoacan], Uruapan (sic) [Uruapan], 2-X-1941, coll. [D. M.] DeLong, det. V. A. and S. Passoa (1 last instar larva with mandibles slide mounted (The Ohio State University collection).

One to ten mandibular pairs of each species (Table 1) were examined, depending on material available.

RESULTS AND DISCUSSION

During November 1995, the senior author collected seven third instar larvae of *E. calleta* on privet (*Ligustrum*) from her backyard in Kingwood, Harris Co., Texas. This is a northeastern range extension of approximately 100 miles (161 km) and a new county record. It remains to be determined if *E. calleta* is now established in Harris County.

Tuskes et al. (1996) considered *Leucophyllum frutescens* (ceniza, purple sage) to be the main host-plant for *E. calleta* in Texas. Privet is normally treated

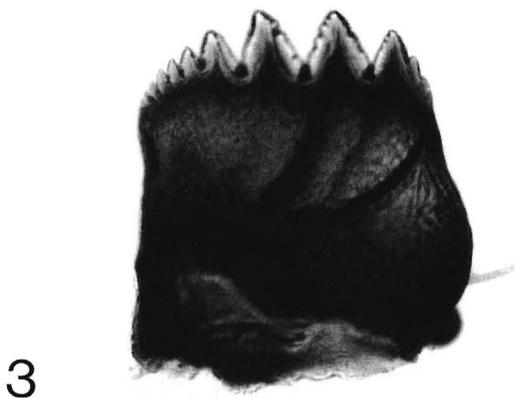
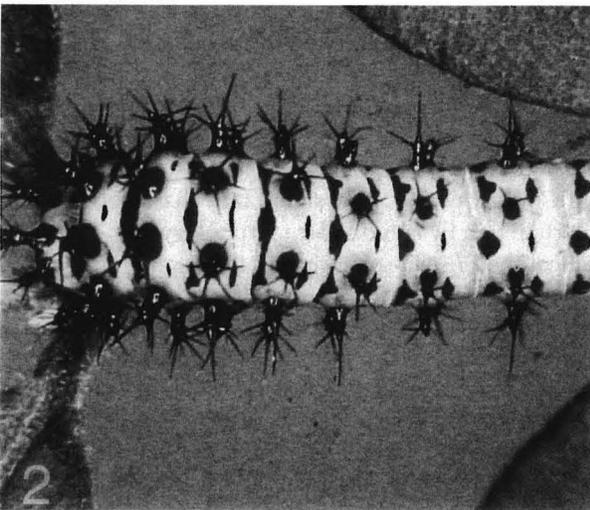
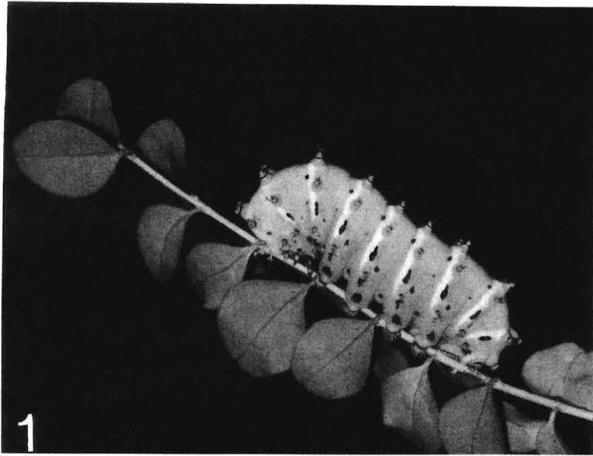
as an artificial laboratory host (Ferguson 1972, Tuskes et al. 1996). Ours is the second published record for *E. calleta* eating ornamental privet under natural conditions, supporting the suggestion of Weast (1989) that privet is an important hostplant of this species near urban areas of Texas. In fact, *E. calleta* appears to be oligophagous on several genera of Oleaceae, including privet in Texas (present study) and Mexico (Peigler pers. comm.), *Fraxinus greggii* A. Gray in western Texas (Peigler pers. comm.), and *Forestiera angustifolia* Torrey (Stone 1991). A mature larva of *E. calleta* on privet from Kingwood, Texas, is illustrated in Fig. 1. At maturity, the larva lacks long and dark scoli which are characteristic of earlier instars (Fig. 2). In spite of the availability of ceniza nearby, *E. calleta* was found only on privet in the senior author's backyard.

Examination of *E. calleta* mandibles from Texas showed that these structures are atypical compared to other saturniids described in the literature. Bernays and Janzen (1988) characterized late instar saturniid mandibles as "short, with a broad base, and without obvious teeth". This definition does not fit *E. calleta* which has large teeth in both the early (Fig. 3) and last instars (Figs. 4, 5, and 6).

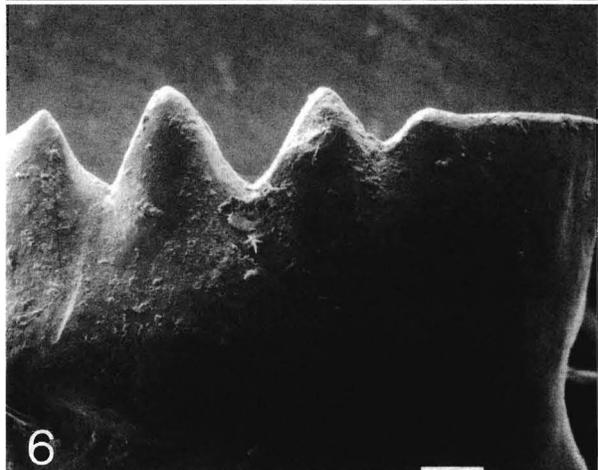
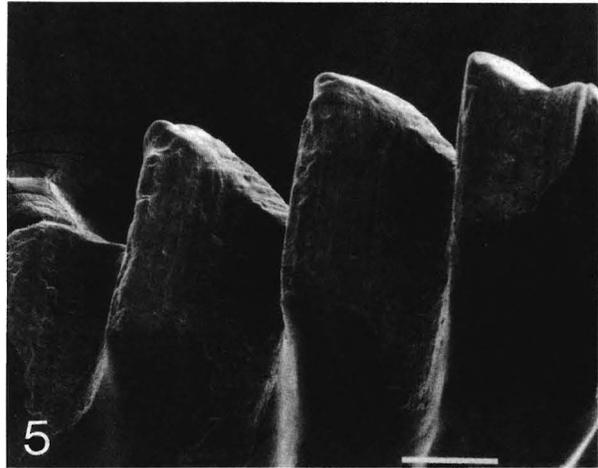
Except for *E. calleta*, members of the Attacini typically lack well-developed mandibular teeth in the last instar or have the cutting edge of the mandible serrated with blunt lobes (Table 1). Mandibular teeth are also absent in mature larvae of two Indo-Australian Attacini, *Attacus atlas* (L.) (Heppner et al. 1989) and *Coscinocera hercules* (Miskin) (specimens in Passoa collection).

Our data on saturniid mandibles agree with results of a survey of notodontid mandibles published by Godfrey et al. (1989) in several respects. Last instar mandibles of the Notodontidae usually lack teeth, except for a few apparently unrelated exceptions. This is also true in Saturniidae. Outside of the Attacini, mature larvae of *Actias selene* (Hbn.), *A. luna* (L.), *Argema mittrei* (Guér.-Mén.) (Saturniinae) and *Citheronia regalis* (F.) (Ceratocampinae) (specimens in Passoa collection) have well-developed mandibular teeth, so the presence of teeth on saturniid mandibles is homoplastic across several subfamilies.

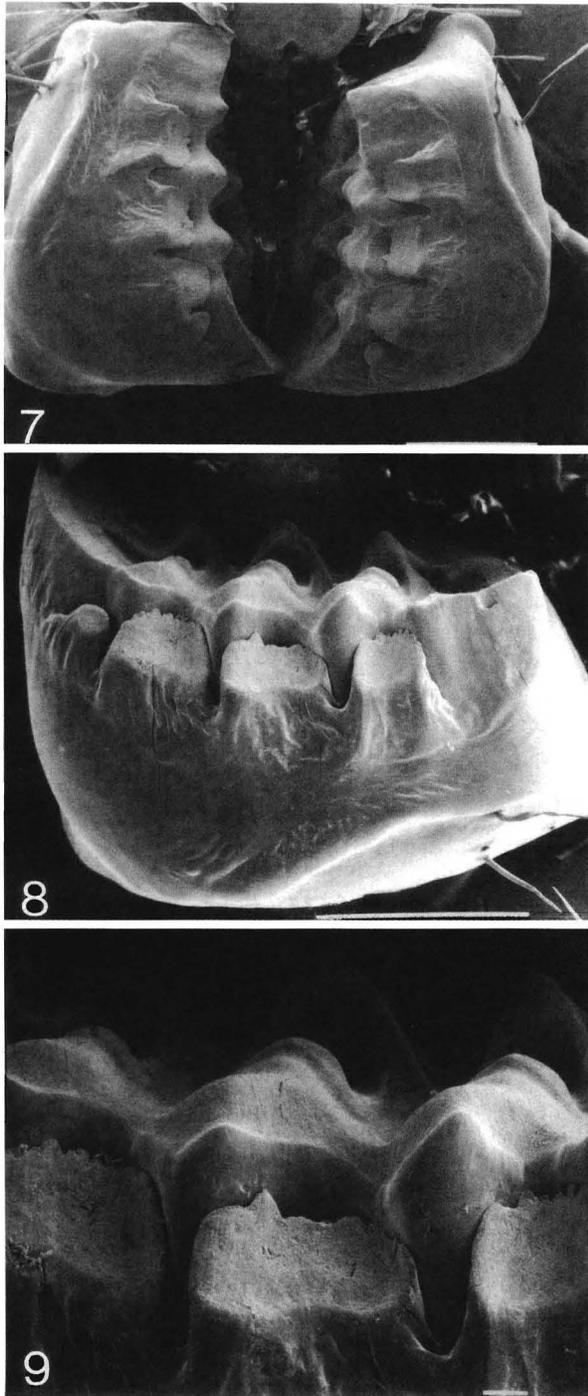
Large teeth also occur in the *Antheraea* genus complex, for example, *Antheraea pernyi* (Guér.-Mén.) and its purported synonym *A. hartii* (Moore), *A. polyphemus* (Cram.), and *Opodiphthera eucalypti* (Scott) (spms. in Passoa coll.). In addition, the mandible of *A. pernyi* is unusual because it matches the "sphingid-type" as defined by Bernays and Janzen (1988). Sphingid mandibles were characterized as being "ridged in a



FIGS. 1-3. *Eupackardia calleta* (Westwood) from Texas. **1**, late instar larva on privet (lateral view). **2**, mid-instar larva on privet (dorsal view). **3**, early instar mandible, oral surface, ventral view, photographs under polarized light, 100 \times .



FIGS. 4-6. Mandible of last instar *Eupackardia calleta* (Westwood), scale line = .10 mm in all figures. **4**, oral surface, ventral view, 70 \times . **5**, teeth and deep molar ridges, ventral view, 150 \times . **6**, teeth on cutting margin, dorsal view, 95 \times .



FIGS. 7-9. Mandible of last instar *Antheraea pernyi* (Guér.-Mén.). **7**, complex pattern of teeth on dorsal and oral surfaces, ventral view, 27 \times , scale line = 1 mm. **8**, overlapping teeth of dorsal surface, ventral view, 33 \times , scale line = 1 mm. **9**, tooth of dorsal surface, ventral view, 70 \times , scale line = .1 mm.

variety of complex ways". The mandible of *A. pernyi* (Figs. 7, 8, and 9) has a series of complex ridges on the dorsal surface that appear to form overlapping teeth, in addition to several smaller toothlike projections on the oral surface. The mandibles of *E. calleta* and *A. pernyi* suggest it is wiser to characterize saturniid mouthparts with ecological or physiological criteria (cutting versus grinding), instead of using a phylogenetic approach at the family level as did Bernays and Janzen (1988) in their study of saturniid and sphingid mandibles.

There appear to be two ontogenetic patterns for saturniid mandibles. In one pattern, first instar larval mandibles have teeth; subsequently these teeth are lost in later molts. This pattern is typical for Costa Rican saturniid species in four subfamilies (Bernays & Janzen 1988). A second pattern is found in *E. calleta* where early instars have mandibular teeth (Fig. 3) that are retained throughout larval life (Figs. 4, 5, and 6). This dichotomy was also noted by Godfrey et al. (1989) in notodontid genera.

Godfrey et al. (1989) stated that characterization of certain taxa by mandibular morphology was "problematical" because in some species the mandibular margin was intermediate between toothed and smooth. Intermediate conditions are common with Saturniidae, as shown in Table 1 by the term "margin bluntly serrate". A bluntly serrated mandible has round conical projections that resemble small teeth, or an irregular mandibular margin with indentations. *Callosamia* is an example of the first condition where from 10-15 small teeth cover the cutting margin of the mandible.

Irregular mandibular margins are found in *Hyalophora* and *Rothschildia* where it is difficult to discern teeth, but the mandibular margin is not straight. Dockter (1993) warned that mandibular wear must be taken into account when describing mandibles. It is unclear whether bluntly serrated teeth in Saturniidae are a transition state between toothed and smooth mandibles, as noted by Godfrey et al. (1989) in notodontids, or instead represent worn mandibular teeth as described by Dockter (1993) in *Heterocampa* and Sourakov (1996) in larvae of satyrid butterflies. Examination of unworn mandibles on freshly molted larvae are needed to resolve this question. Thus, it may be premature to characterize saturniid mandibles as usually toothless (Bernays & Janzen 1988) until more ontogenetic studies are published.

In summary, the mandibular shape of Macrolepidoptera depends on several factors including head size and food toughness (Bernays 1986), food particle size and chemistry (Bernays & Janzen 1988), the need to pierce the chorion of the egg at eclosion, and a need to

seal the oral cavity during ingestion (Godfrey et al. 1989). Unlike notodontids which use toothed mandibles to pierce the leaf epidermis (Dockter 1993), *E. calleta* does not skeletonize leaves during any instar (V. A. Passoa pers. obs.). Therefore, it seems likely that a toothed mandible is required for other reasons.

Bernays and Janzen (1988) noted that larvae which feed on toxic plants tend to be associated with mandibles that contain teeth. They (Bernays & Janzen 1988) suggested that complete mastication of the leaf tissue allows more complete digestion, a strategy not possible with hostplants containing tannins that inhibit digestive efficiency. However, the digestive physiology of *E. calleta* may be more complicated than other Saturniidae. Caterpillars of *E. calleta* secrete a pungent liquid containing phenolic compounds and biogenic amines from their scoli when disturbed, but it is unknown if plant toxins are sequestered for this secretion (Deml & Dettner 1993). Until the metabolism and defensive chemistry of *E. calleta* are clarified, it may be premature to assume mandibular teeth are an aid to coping with plant toxins. Nevertheless, *E. calleta* larvae do utilize toxic plants (Weast 1989).

Besides the need to understand mandibular morphology in an ecological context, it should be noted that a survey of saturniid mandibles would aid identification of the immatures. Minet (1994:70) mentioned mandibular secondary setae as an apomorphy of the Lasiocampidae, although these setae are also independently evolved in other macrolepidopteran families. Mandibular secondary setae are present (*Agapema*) or absent (*E. calleta*) in Saturniidae, thus this character has potential for identification purposes. Mandibular teeth associated with the cast larval exuvium can be used to separate cocoons of *E. calleta* (teeth present) and *Rothschildia* (teeth absent). Both genera are easily confused due to their similar pupal morphology. A final example is *A. luna* and *A. polyphemus*. Although these genera are often confused as larvae (Ferguson 1972:207), their mandibles are completely different, being either simple and toothed (*A. luna*) or complex with ridges (*A. polyphemus*). More descriptive studies of saturniid mandibles will no doubt yield further examples.

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Voucher specimens of *E. calleta* and its hostplant are deposited in The Ohio State University's Insect Collection and Herbarium.

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