NOTES ON THE CACAO PLUME MOTH IN HONDURAS AND DESCRIPTION OF THE LARVAE AND PUPAE (LEPIDOPTERA: PTEROPHORIDAE)

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Abstract- Observations on the life history of the Cacao Plume Moth, *Michaelophorus nubilus* (Felder & Rogenhofer), in Honduras are presented along with diagnoses and images of adults, and the first detailed descriptions and illustrations of the final instar larva and pupa. The species is reported for the first time from Honduras. Larvae are pests of *Theobroma cacao* L. and feed primarily on developing leaves.

Key words: Pterophoroidea, Pterophorinae, Platyptiliini, *Oxyptilus*, cocoa, cacao, chocolate, cacauais, cacueiro, pests, Malvaceae, Sterculiaceae, *Theobroma cacao*, chaetotaxy, morphology, immatures, *Michaelophorus nubilus*, *M. indentatus*, *M. dentiger*

The genus *Michaelophorus* includes seven species, all from the Neotropical Region. This genus was reviewed by Gielis (1999), with two species added in a subsequent review covering part of the Neotropical pterophorid fauna (Gielis 2006). Two species of the genus are known from Honduras. *Michaelophorus dentiger* (Meyrick, 1916) was reported by Gielis (1999) and is known from one male (Francisco Morazán: 5 km S El Zamorano, Lorenzano Road 17.v.1994 B. D. Gill, prep. CG 2735, Gielis Collection). In June 2009, DLM and JYM found a previously undetermined specimen of a second species, the Cacao Plume Moth, *M. nubilus* (Felder & Rogenhofer, 1875), from La Masica, Atlántida Department, Honduras, in the arthropod collection at Escuela Agricultura Panamerica en Zamorano (EAPZ). This specimen is apparently the first record of this species for the country. In addition, field work during June and November 2009, and May 2010, resulted in the observation and collection of numerous individuals of *M. nubilus* at Pico Bonito Lodge (PBL), and CURLA (Centro Universitario Regional del Litoral Atlantico) Reserve, Parque Nacional Pico Bonito, La Ceiba, Honduras, as part of a cooperative biodiversity survey with EAPZ, CURLA, PBL, and the McGuire Center for Lepidoptera and Biodiversity, Florida Museum of Natural History (MGCL/FLMNH).

Previous reports of the life history of this species are very limited. Lamont and Callan (1950) listed *Platyptilia* sp. from "flush leaves of cacao" in Trinidad. Entwistle (1972) includes a paragraph on the feeding habits of the larvae, listed as *Oxyptilus* sp., and de Brito Silva (1980) reported an *Oxyptilus* sp. on "cacauais" in Pará, Brasil. The latter publication is the most extensive, including a small black and white photograph of the larva and brief description indicating size and color. More recent literature includes the current names and classification of moth and hostplant (Gielis 2003, 2006; Matthews & Lott 2005) as well as redescriptions of the adult (Gielis 1999, 2006).

Cacao beans, harvested from the mature pods of the cacao tree, *Theobroma cacao* L. (Fig. 5a,b), are the source of cocoa powder for chocolate products. While plume moth larvae feed primarily on the new leaves and have not been reported in the literature to attack the flowers, beans, or developing pods, substantial damage to leaves of seedling plants is a concern for nursery growers (de Brito Silva 1980). Previously undetermined larvae from Ecuador (see material examined) are from a vial labeled "in cacao flowers" indicating the possibility that larvae will indeed feed on flowers as well as cause leaf damage. The identity, recognition characters, and distribution of this moth are thus of general interest, not only as pest species, but as a natural associate of a plant of both economic and cultural significance.

We present field observations of *M. nubilus* herein, along with an adult diagnosis, illustrations, and the first detailed descriptions of the morphology and chaetotaxy of the final instar larva and pupa. Certain morphological characters of the immatures are discussed with regard to their potential usefulness in generic and higher level systematic studies. The current status of knowledge of the biodiversity of the family Pterophoridae in Honduras is also discussed.

Michaelophorus nubilus (Felder & Rogenhofer, 1875)
(Figs. 1-4, 5c-j)

Diagnosis. This species is best determined based on characters of the male and female genitalia, most notably the long cucullar spine of the males, but it can also be recognized by external characters. Adults are dark brown, including both wing surfaces and the dorsal surface of the abdomen, while the ventral surface of the abdomen is strikingly white in marked contrast, with a narrow brown band across the posterior margin of A2 and variable light grayish scaling along the posterior segment margins, especially on A3-A5. The forewing first and second lobes each have a distinct termen with a faint subterminal line and the costa along the first lobe includes a distinct white spot anteriad of the cleft base. The hindwing has characteristic dark scale tufts in the fringes of both the second and third lobes as opposed to just the third lobe in related species. The second lobe posterior margin includes two scale clusters situated at different distances from the base of the cleft between the second and third lobes. One is a cluster of dark scales midway between cleft base and lobe apex. The second is a larger tuft at the lobe tornal angle three-fourths from the base. The third lobe is extremely thin and short, with two minute dark scale tufts near the base and one near the apex with a few complementary scales within the fringe of the anterior margin. The scales of the most basal scale tuft are very short so that only the middle and apical tufts may be distinguishable. The apical tuft is the largest. The distinctly shallow cleft between the first and second hindwing lobes, combined with the short third lobe (apex not reaching cleft base between first and second lobe) is also useful for distinguishing worn specimens with missing fringe scales.

Redescriptions for *M. nubilus* and all six congeners are available in Gielis (2006). Although Gielis noted two distinct groups within the genus, the characteristics of the two groups were not specifically outlined. We note that based on Gielis' descriptions and illustrations, *M. hodgesi* Gielis, *M. shafferi* Gielis, and *M. bahieaensis* Gielis, have a paler ground color compared to the other species and appear to lack a distinct termen on the forewing lobes as in *Trichoptilus* Walsingham. *Michaelophorus nubilus*, the type species of the genus, is most similar to *M. dentiger* (Meyrick), *M. margaritae* Gielis, and *M. indentatus* (Meyrick). These are all dark brown species, but *M. nubilus* is distinct from the other three in lacking the white transverse band dorsally across the metathorax and anterior half of the first abdominal segment. It also differs in having a shallower hindwing second cleft and shorter third lobe as mentioned above, and the third lobe with only two or three scale clusters (teeth) distinguishable along the anal margin, as opposed to at least four in the other three species. *Michaleophorus nubilus* is further distinguished by the presence of scale teeth on the hindwing second lobe, which are absent in the other species and present in only a few other genera, such as *Cnaemidophorus* Wallengren. The abdomen is plain brown dorsally in *M. nubilus*, whereas *M. indentatus* has paired dorsal scalloped white lines along the first four segments forming an elaborate pattern. A brief description of the male and female genitalia of *M. nubilus* follows.

Fig. 1. Male genitalia of *Michaelophorus nubilus* with aedeagus in situ, slide DM 1517.

Male genitalia (Fig. 1). Uncus curved, longer than tegumen, with minutely hooked apex and sclerotized base. Valvae symmetrical, with characteristic long, curved cucullar spine, exceeding valva length. Sacculus undeveloped. Valva apex rounded with dense setal tuft. Juxta with long tapered arms flanking aedeagus. Aedeagus curved, gradually tapered, with blunt apex. Cornuti absent.

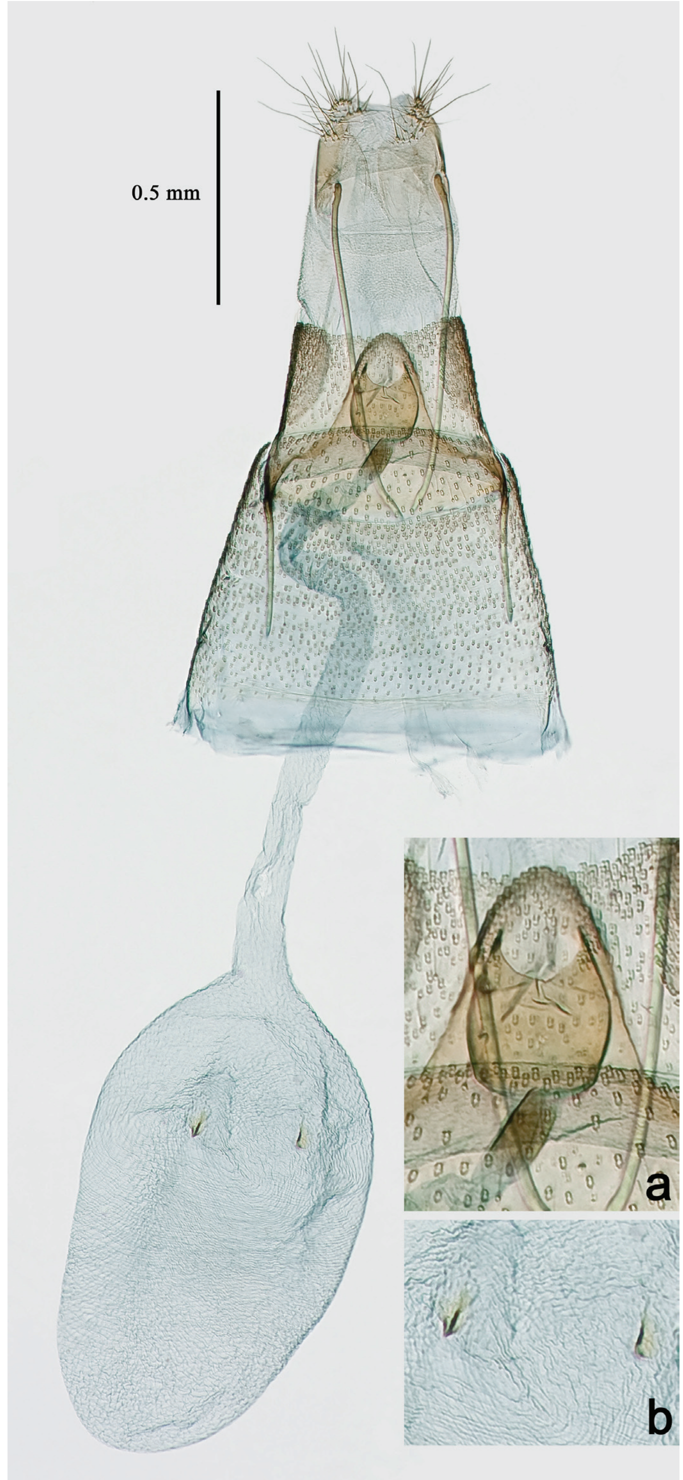

Fig. 2. Female genitalia of *Michaelophorus nubilus*, slide DM 1551. Inset **a)** enlargement of ostium, antrum, and lamina antevaginalis; **b)** enlargement of signa.

Female genitalia (Fig. 2). Papilla analis weakly sclerotized along lateral margin. Apophysis posterioris slender, long, exceeding 2.5× length of papilla analis. Apophysis anterioris length just less than 0.5× that of apophysis posterioris, basally widened at anterior margin of tergite VIII. Ostium round, ventral margin well-defined as excavate caudal margin of antrum, proximal portion of ostium/antrum formed by lamina antevaginalis (Fig. 2a). Antrum moderately sclerotized, width 2× ostium diameter. Lamina antevaginalis fused with distal margin of sternite VII, extending posteriad as acutely tapered median sclerite, bordering antrum laterad and terminating as rounded lip posteriad of ostium. Ductus bursae at least 1.5× length of corpus bursae; width 0.5-0.75× that of antrum, with small sclerite at juncture with antrum; inception of ductus seminalis near base. Corpus bursae ovate, with pair of minute signa (Fig. 2b).

Comments. The cucullar spine of males is most developed in *M. nubilus* in comparison with the other species. This structure arises along or near the costa of the valve in *M. nubilus*, along with *M. dentiger*, *M. indentatus*, and *M. margaritae*. In the paler species, males of *M. bahieaensis* are unknown, and males of *M. hodgesi* and *M. shafferi* have spines at the apex of the valvae along with a subapical spine in *shafferi*. The uncus is well developed in *M. nubilus* but absent or not differentiated from the tegumen in all other species of the genus. Signa are present in females of the four dark species, but very small in *M. nubilus* and *M. margaritae*. Signa are absent in *M. bahiaensis* and the female genitalia are unknown for *M. hodgesi* and *M. shafferi*.

Material examined – adults. Honduras: Atlantida: La Masica, La Masica, 1 Dic 1988.09 rcol M. Osorio, *Theobroma cacao*, follaje defoliacion (1 adult, no abdomen) [EAPZ]; Pico Bonito Lodge, N15°41'48.00" W86°54'4.40", 28-29.vi.2009 D. Matthews & J. Y. Miller, ex. new leaves of *Theobroma cacao* L. (3 ♂, 3 ♀, 6 PC) [MGCL, DMC]; same data except 9-17.xi.2009 (11 ♂, 12 ♀, 18 PC) [MGCL, EAPZ, USNM, DMC, CG]; same data except 7-15.v.2010 (3 ♂, 5 ♀) [MGCL, DMC]; Parque Nacional Pico Bonito, vicinity Estación CURLA N15°42'07.0" W86°51'16.0" 12.v.2010 D. Matthews & J. Y. Miller (4 ♂, 2 ♀) [MGCL]. PC = Pupa case/exuvium, DMC = D. Matthews Collection, USNM = National Museum of Natural History, Washington, D.C., CG = Cees Gielis Collection/Nationaal Natuurhistorisch Museum, Leiden, Netherlands.

LIFE HISTORY AND IMMATURES

Larvae feed on the new "flush" leaves of cacao, *Theobroma cacao* L. (Malvaceae). These leaves (Fig. 5b) are reddish when small, changing to pale or whitish green with a pink cast as they reach full size and are still very limp compared to the robust mature dark green leaves. Larvae and pupae are found on both the reddish and pale green leaves. The larvae move quite rapidly when disturbed and will readily drop off the edge of a leaf on a silk line. This behavior is in contrast to many other external feeding Pterophoridae (DLM pers. observations), which tend to be sluggish. Pupae may also be found on mature leaves, petioles, and small branches, but usually adjacent to new leaves. Pupae are found on both the upper and undersurface of leaves, often along the midvein (Fig. 5c) and are anchored to a silk pad by two patches of hooked hamuli (setae) on the tenth abdominal segment. Several pupae may be found on a single leaf.

New leaves occur at the ends of branches, but also may occur on shoots from the main trunks. Trees which have been cut for removal or trimmed back for cultivation produce more shoots. We found larvae and pupae more frequently in an area of PBL where trees had been cut, but we also found more parasitized pupae in this area. These pupae were parasitized by a chalcid wasp, *Conura* sp. A single wasp develops in each pupa and emerges from a hole near the forewing base. Developing wasps are visible though the pupal cuticle. Six out of 34 pupae examined at PBL in November were parasitized by *Conura*, indicating that about 18% of the general population is parasitized, though the parastized individuals were all from the open area where trees had been cut. A dipteran parasite *Actia panamensis* Curran (Tachinidae) was reported from larvae in Brazil (de Brito Silva 1980). While large ants *Dolichoderus bispinosus* (Olivier) (determination courtesy, J. Longino) were also very common on cacao and sometimes found on the same shoot with *M. nubilus* larvae at PBL, no predation or other interactions were observed with *M. nubilus*.

Although first instar larvae were not collected, head capsule measurements of material examined indicate four instars with widths ranging as follows: instar II (0.26–0.29 mm, n=8), III (0.41–0.46 mm, n=19), IV (0.65–0.74 mm, n=15). The following descriptions are based on fourth (final) instar larvae and pupae. Earlier instar larvae are generally similar to the final instar, but differ primarily in having fewer secondary setae. Time constraints of fieldwork did not allow for sequential rearings; however, these tiny moths develop quite rapidly, with the larval stage reportedly lasting only about 12 days and the pupal stage 5 days (Entwistle 1972).

Final instar larva. Figures 3a-g, 5d. Maximum length 9.5 mm, width 1.2 mm. Cuticle shiny and translucent, showing reddish to light yellowish green or grayish green gut contents. Primary setae simple, short to long, longest setae; D2 on T2, A1, and A9, reaching about 1.75 mm or up to 1.5× maximum body width. Primary setae simple with pointed apices, on conical clear tubercles; D, SD, and L1-L2 tubercles most developed. Short to minute secondary setae present, associated with primary setae, apices blunt to slightly expanded.

Head: Mean width 0.71±0.027 mm (n=15). Adfrontal sclerite nearly reaching anteclypeus ventrad and extending to near vertex dorsad. Pore AFa absent. Tactile setae lengths less than or approaching clypeal width except P1. Seta P1 longest, length about 1.5× clypeal width. Seta A1 just less than clypeal width. Labrum with 6 setae present, L2 and M2 longest. Seta M1 distad of M2. Labrum with obtuse notch, median fissure present. Mandible 5-toothed, ventral tooth subtended by strong ridge extending obliquely to base. Mandible length just exceeding width, condyle small, distal seta present, length less than 0.25× that of proximal seta.

Thorax: Prothorax with primary XD, D, and SD setae on separate small clear tubercles. Setae XD1, XD2, and SD1 along anterior margin, XD1 and SD1 clear, lengths similar, about equal to segment width. Seta XD2 brown tinged, length about half XD1. Seta SD1 posteriad of SD2, length and pigmentation as on XD2. Seta D1 posteriad of XD1 midway between anterior and posterior margins, D2 posterolaterad of D1. Length and pigmentation of D1 similar to SD2 and XD2, D2 clear and equal or slightly longer than XD1. Setae D1 and D2 curved anterad. Prothoracic shield area not sclerotized but bordered by primary and secondary setae anteriad and laterad and fringe of secondary setae posteriad. Secondary setae mostly brown-tinged, about 10-20 total with 1-2 posteriad of D2. Prespiracular (L) setae with L1 and L3 brown tinged, L1 length about equal to XD2, L3 a bit shorter, L2 ventrad of L1, clear and about 2× L1 length, L tubercle joined near base. About 4 minute secondary setae

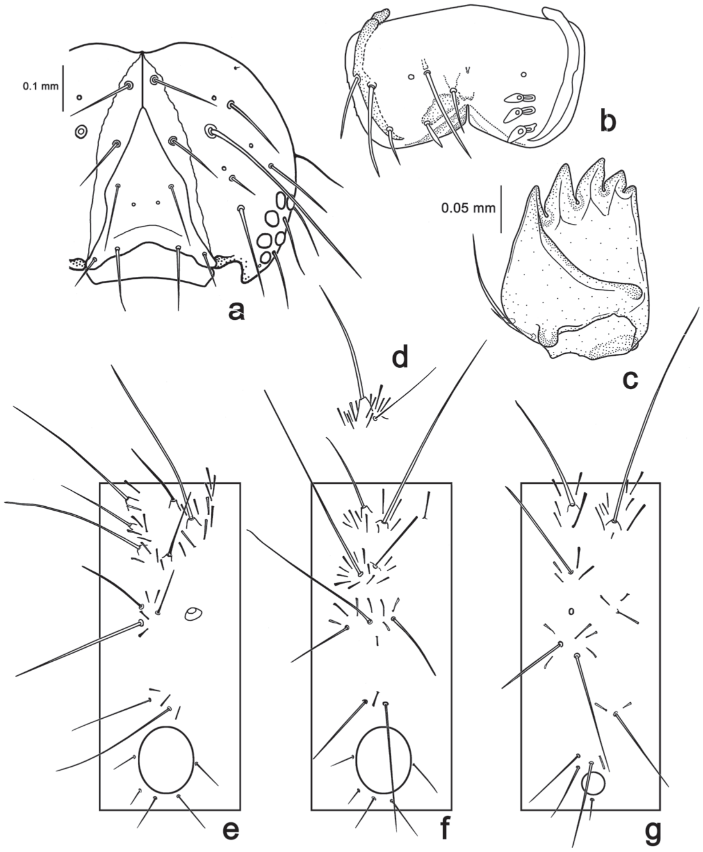

Fig. 3. Larval morphology of final instar *M. nubilus*: **a)** head, frontal view; **b)** labrum, epipharyngeal surface on right; **c)** right mandible; **d)** dorsal (D) tubercle on segment T3 showing primary D1 seta, thin, reduced D2 seta, and surrounding secondary setae; **e)** chaetotaxic map of segment T1; **f)** segment T2; **g)** segment A3.

present. Spiracle slightly exserted, peritreme round, lightly sclerotized. Two SV setae above thoracic leg, SV2 longer than SV1, tubercles joined, 1-3 minute secondary setae present. Coxa with 5 short to minute setae. Segments T2-T3 with setae D1 and D2 together on slightly elevated round tubercle, with about 8-20 minute secondary setae. Seta D1 brownish tinged, medium length, about half segment width on T2, slightly longer on T3 and clear, setal tubercles distinct from combined round tubercle. Seta D2 very long on T2, at least 2× D1 length and exceeding 1.5× segment width, with distinct setal tubercle. Seta D2 reduced on T3, less than half D1 length, very thin, without distinct tubercle. One isolated minute secondary seta or a cluster of up to 5 posteriad of D tubercle on T2, usually absent on T3. Setae SD1 and SD2 on T2-T3 on combined round tubercle, less elevated than D tubercle, with 5-15 minute secondary setae. Seta SD1 anterad on tubercle, clear, moderately long, slightly longer on T2 than on T3. Seta SD2 posterodorsad of SD1, less than half SD1 length, brownish tinged, directed posterodorsad. Lateral setae grouped together with about 4-8 minute secondary setae, primary setae longitudinally aligned with body, L2 central and longest, L1 and L2 clear, L3 slightly brownish tinged. Subventral setae as on T1 but with secondary setae fewer or absent. Coxa as on T1.

Abdomen: Segments A1-A8 with setae D1 and D2 on separate tubercles at about one and two-thirds from anterior margin with D2 posterolaterad of D1. Seta D1 curved anterad, lengths moderate but gradually decreasing on more posterior segments. Seta D2 straight or slightly curved posteriad, all longer than D1 on each segment but with alternating lengths, long on A1, A3, A5, and A7, slightly shorter than on adjacent segments on A2, A4, A6, and A8. Minute secondary setae surrounding D tubercles, about 4-12, with D1 tending to have more than D2; number of associated setae decreasing on more posterior segments. Seta SD1 moderate in length, directed anterad as on T3, with lengths gradually decreasing to A8, 1-6 minute secondary setae surrounding tubercle. Spiracles small round, A1-A7, with lightly sclerotized peritremes, diameter about 2× diameter on A8 but not conspicuously exserted. Segments A1-A7 with a cluster of 1-3 minute secondary setae posteriad of spiracle, absent on A8. Setae L1 and L2 grouped together on tubercle ventrad of spiracle, with L2 posteroventrad of L1 and slightly longer, up to 5 minute secondary setae on tubercle. Seta L3 posteroventrad of L1-L2 tubercle, closer to SV setae, length moderate, with 0-2 associated minute secondary setae. Subventral setae short, dorsad of prolegs on A3-A7, 2 present on A1 and A7, 3 on A2-A6, and 1 on A8-A9. Prolegs A3-A6 elongate, length up to 5× middle width, 6-8 crochets in mesopenellipse, seta V1 mesad at proleg base. Segment A9 similar to preceding segments but with D setae together on tubercle, and D2 longer than on A8. Seta SD2 posterolaterad on tubercle with SD1, as long as D2 on A7. Seta L1 and L2 grouped together as on A8 but with L1 more dorsad. Seta L3 absent. Segment A10 with caudal margin more or less rounded, without sclerites. Setae D2 and SD2 longest setae along margin but not as long as on A9. Seta D1 and SD1 just anteriad of D1 and SD2 respectively. A few minute secondary setae present

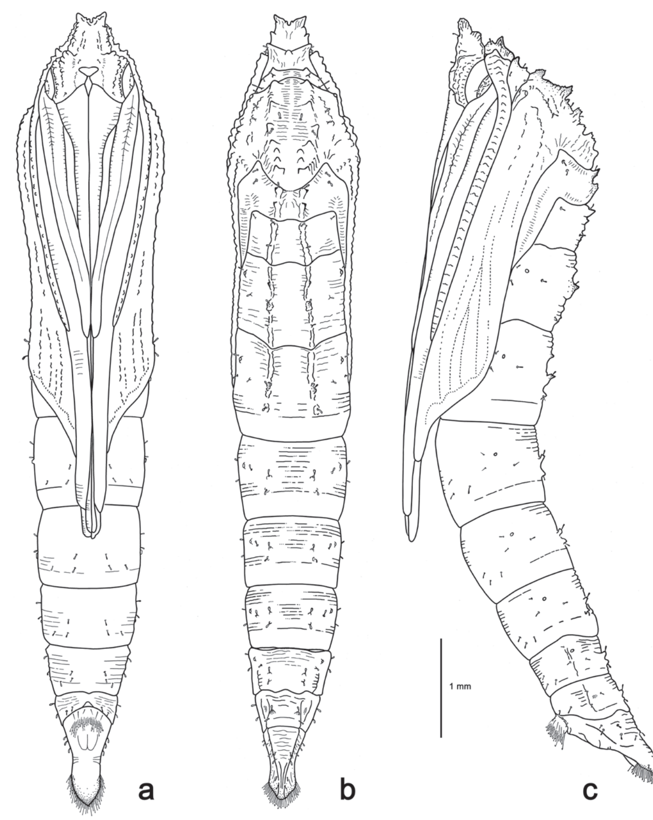

Fig. 4. Pupa of *Michaelophorus nubilus*: **a)** ventral view, **b)** dorsal view, **c)** lateral view.

along margin and between D1 setae. One short seta, nearly as long as D1, present along caudal margin between D2 and SD2. Numerous short to minute simple setae present ventrad of caudal margin and on anal proleg. Proleg with 8-9 crochets.

Comments. In addition to the general chaetotaxy and arrangement of secondary setae, the most diagnostic feature of *M. nubilus* larvae is the alternating lengths of seta D2 on the abdominal segments, with all D2 setae long, but noticeably shorter on A2, A4, A6, and A8 than on adjacent segments.

Pupa. Figures 4, 5c,e,f. Maximum length 7.5 mm. Dorsum widest at mesothorax, about 1.4 mm. Color uniform light yellowish green, head, thorax, and appendages changing to dark brown prior to emergence. Front protruding as bilobed angular process. Adfrontal area and dorsal carina of T1-T3 conspicuously dentate. Dorsal carina extending to D1 on A3. Primary setae minute, apices blunt to slightly expanded, lengths of most not exceeding 0.05 mm. Longest seta D2 on T1, about 0.14 mm. Secondary setae absent.

Head: Dorsum of front elongate, vertex inconspicuous. Anterior margin produced, notched at middle, appearing bilobed, with a smaller lateral lobe posteriad. Adfrontal area adjacent to antenna base with bilobed dentate process. Seta AF2 laterad of larger point of process, AF1 borne on apex of smaller, anterior lobe. Venter of front sculpted with seta F1 on cephalic lobe. Frontoclypeal suture indistinct but clypeal area smoother. Seta C1 present. Clypeolabral suture distinct. Clypeal area and pilifers rugose, labial palpus smooth. Pilifers basally joined or separate. Gena strongly rugose with double ridge bordering smooth eye. Genal seta minute. Sculpted eye rugose, both setae present. Maxilla with transverse striations, basal portion extending to about 0.5× T2 leg length, covered with apex of T1 leg or with a very thin section, sometimes visible along meson and more so just posteriad of T1 leg apex. Distal portion of maxilla exceeding and visible between T2 legs. Antenna extending to at least 0.5× T2 leg, not reaching T1 leg apex; segments (about 32) marked by small central bump, these most developed near base.

Thorax: Pronotum sculpted, with 2 dentate prominences along dorsal ridge. Four setae present. One D (D1) seta present on ridge anteriad at base of posterior prominence. Seta D2 more than 2× length of D1, positioned along posterior margin between ridge and T2 spiracle. One SD seta at posterolateral angle, another dorsad but closer to anterior margin. Foreleg extending to at least 0.5× T2 leg length with median ridge for at least 0.6× length. Coxa/trochanter exposed. Mesothorax with dorsal ridge consisting of 3 evenly spaced prominent dentate processes followed posteriad by contiguous dentate ridge on keel area. The first prominence near anterior margin. Seta D1 midway between second and third prominence and midway between ridge line and dorsal midline. Seta D2 directly posteriad at base of third prominence. Seta SD1 and SD2 laterad of second prominence with SD2 transversely aligned with D1. Transverse striae conspicuous on T2 dorsum, lateral areas and wing base sculpted with numerous minute bumps which continue in rows marking wing veins. Spiracle on T2 anterior margin slightly protruding. Forewing apex reaching about 0.8× T2 leg length. T2 leg extending nearly to A4 posterior margin.

Abdomen: Cuticle with fine transverse striations. Segment A1 with dorsal ridge forming strong dentate process near anterior margin and minute process at middle. Seta D1 anteriad on first process, seta D2 laterad on ridge near middle process. Seta SD1 at anterolateral angle. Segments A2-A3 with three processes along ridge, middle (D1) process most developed, with seta D1 anteriad. D1 process tending to be largest on A2. Seta D2 posteriad on third process. Dorsal ridge terminating at D1 process on A3 with the third, D2 process a separate tubercle. Seta SD1 dorsad and slightly posteriad of spiracle. Setae L1 and L2 ventrad of spiracle along wing margin. Segments A4-A6 with D1 and D2 on separate but approximate tubercles longitudinally aligned near middle of segment, D1 directed anteriad, D2 posteriad. SD1 as on preceding segments. Setae L1 and L2 longitudinally aligned with L1 closest to spiracle. Seta L3 ventrad and posteriad of L2, closer to SV setae. Two SV setae present, longitudinally aligned. Segment A7 as on A6 but with L1 and L2 along weak ridge. Segment A8 with weak dorsal ridge bearing D tubercles, spiracular scar, lateral ridge stronger than on A7, and with only 1 SV seta. Segments A9-A10 fused. Dorsal ridge strong on A9, nearly converging on A10. Seta D1 on ridge near middle on A9, D2 laterad on ridge and slightly longer than D1. Seta SD2 present on A9, slightly longer than SD1. Seta L1 and L2 close together along lateral ridge bordering ventral plate. One SV seta present laterad of anterior hamuli patch. A10 acutely tapered, dorsum with 1 D seta on ridge near tip. Two setae present laterad, the ventral most of the two mixed with hamuli. Anterior and posterior hamuli hooked, dense. Anterior hamuli patch somewhat protruding on lobe.

Immature material examined. ECUADOR: Guayas: San Antonio 15.viii.1969 R. Gutierrez, 69-11460, in cacao flowers "sp. of Pterophoridae DMW '69" (3 L) [USNM]; HONDURAS: Atlantida: Pico Bonito Lodge, N15°41'48.00" W86°54'4.40" 28-29.vi.2009 D. Matthews & J. Y. Miller, on new leaves of *Theobroma cacao* (42 L, 2 P); same data except 9-17.xi.2009 (6 L, 5 LS, 10 P {includes 6 parsitized}, 6 PC, 1 ♂ adult male preserved with immatures); same data except 7-15.v.2010 (38 L, 10 P) [MGCL, EAPZ, USNM, DMC]; Parque Nacional Pico Bonito, vicinity Estación CURLA N15°42'07.0" W86°51'16.0" 12.v.2010 D. Matthews & J. Y. Miller (8 L, 3 P) [MGCL, EAPZ, DMC]. L = larvae, LS = larval skin/exuvium, P = pupa.

Distribution and phenology. The female holotype of *M. nubilus*, originally figured by Felder & Rogenhofer (1875) and currently in the Natural History Museum, London, is from Bogotá, Colombia. In addition to Honduras, this species also occurs in Brazil, Costa Rica, and Trinidad (Lamont & Callan 1950, de Brito Silva 1980, Gielis 1999). Additional specimens at USNM also include Venezuela and Peru in the distribution (R. Watkins, personal communication). Larval material was also identified from Ecuador (material examined). The species is reported to be common throughout the year in Trinidad (Entwistle 1972) and adults have been collected in January in Brazil, and February in Costa Rica (Gielis 1999). Specimens from Honduras were collected in May, June, and November. The species appears to have continuous broods but may be more frequent when local conditions promote the flush of new leaves.

Although the host is cultivated in other tropical areas such as West and Central Africa, *M. nubilus* is thus far known only from the Neotropical Region. Alibert (1951) included an account of *Oxyptilus* sp. from cacao in western Africa. While this account may refer in part to *M. nubilus*, it will need to be

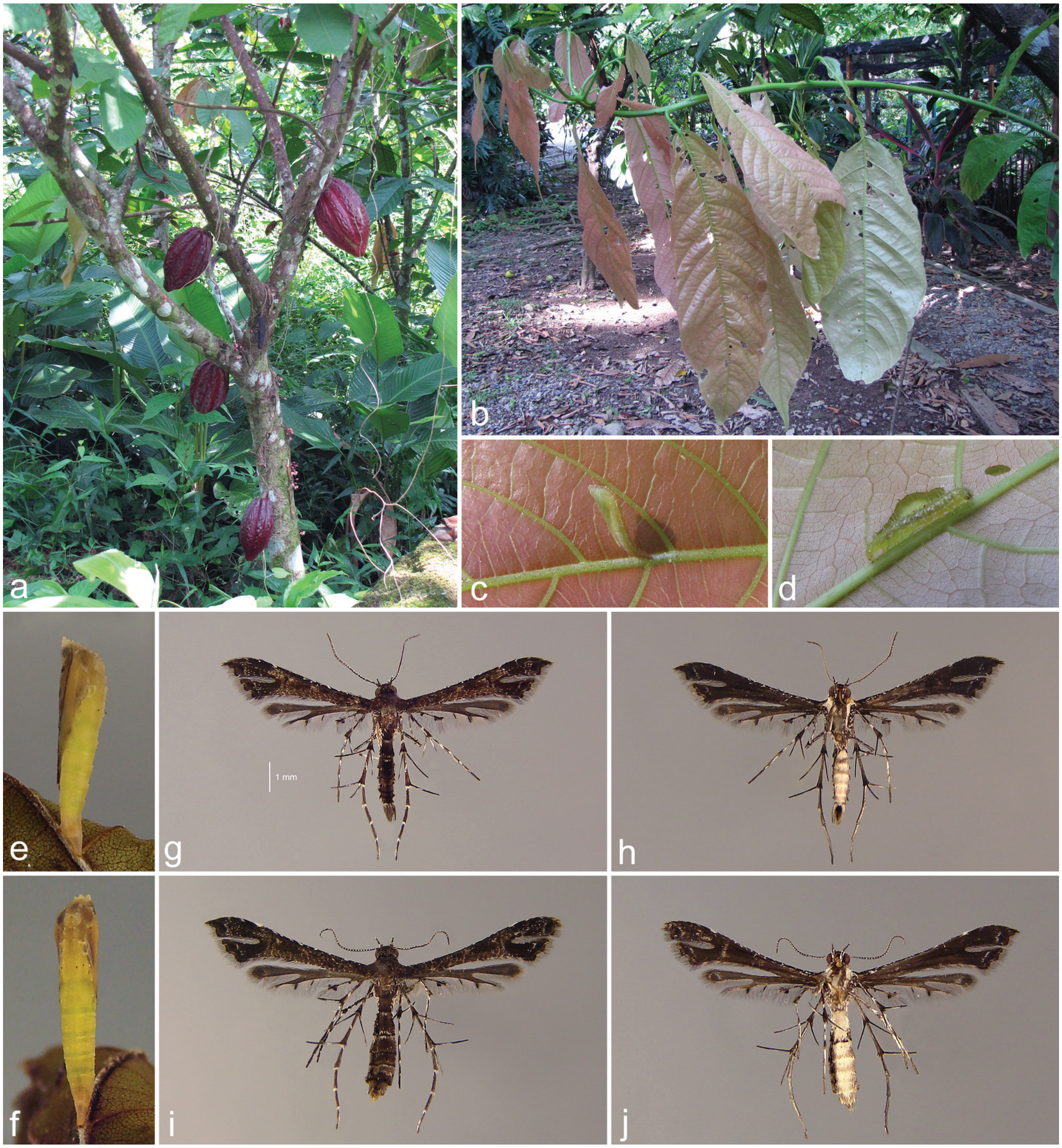

Fig. 5. Life history of *Michaelophorus nubilus*: **a)** Larval host tree, *Theobroma cacao*, with trunk and lower branches bearing both pink flower clusters and mature pods; **b)** new shoot of Cacao with young leaves showing damage (holes adjacent to midrib) by *M. nubilus* larvae; **c)** fresh pupa along midrib of leaf; **d)** final instar larva; **e)** lateral view of pupa one day before emergence; **f)** dorsal view of same individual; **g)** adult male, dorsal view; **h)** male, ventral view; **i)** female, dorsal view; **j)** female, ventral view.

verified since the included larva and pupa descriptions and illustrations are distinctly different from known material.

DISCUSSION

Although we present our observations and complete descriptions of final instar larvae and pupae, there is still much to be learned about this species. For example, information on oviposition habits, additional hosts, distribution, and more detailed examination of earlier instars are needed. As noted in the diagnosis, two groups are apparent based on male genitalia, forewing shapes, and maculation, suggesting the need for further revisionary studies as the life histories and morphology of immatures become better known and with the addition of molecular characters.

Along with *M. nubilus*, the larvae and pupae of the genus are presently only known for *M. indentatus* and were described by Matthews (2006). Larvae of *M. indentatus* are similar to *M. nubilus* in certain tribal and higher level characters such as the reduced D2 seta on T3, absence of pore AFa, and the median labral fissure. A possible generic level character is the complete mandibular ridge subtending the ventral tooth. One notable difference between the larvae of the two species is the lack of secondary setae in *M. indentatus*.

Pupae of the two species are similar in having a prominent dorsal carina and D protuberances, but differ in that *M. nubilus* has a more developed, protruding frontal area on the head and a more dentate ridge on the thorax, and smaller D protuberances on A3. Most importantly, *M. nubilus* pupae differ from *M. indentatus*, and related genera, in having the foreleg coxa/trochanter sclerite present as in Oidaematophorini and Pterophorini. This sclerite was first used as a subfamily-level key character by Yano (1963) and was further discussed by Matthews (2006). Its presence and absence within the genus indicates a possible reversal and emphasizes the need to examine pupae of unstudied genera as these become available.

The two recorded larval hosts of *M. indentatus* are bird of paradise, *Strelitzia reginae* Aiton (Strelitziaceae), and royal ponciana, *Delonix regia* (Bojer ex Hook.) Raf. (Fabaceae) (Matthews & Lott 2005, Matthews 2006). While at least one-third of all known pterophorid larval hosts are Asteraceae (Matthews & Lott 2005), it is interesting that the host of *M. nubilus* belongs to the family Malvaceae, with *Theobroma* formerly placed in the family Sterculiaceae. Only a few pterophorids (7 species in 6 genera) have been associated with Malvaceae (6 genera). A parallel between *M. indentatus* and *M. nubilus* is an association with Fabaceae, with *M. indentatus* on *Delonix* as mentioned, and a notation by de Brito Silva (1980) of *M. nubilus* (as *Oxyptilus* sp.) attacking the leaves of *Acacia* sp. in Manaus (Amazonas, Brazil).

In addition to *M. nubilus*, a polyphagous pantropical pterophorid, *Sphenarches anisodactylus* (Walker) has been reported from cacao leaves (Fletcher 1920, and others, see Matthews & Lott 2005) but has not been confirmed with recent records. Larvae of *S. anisodactylus* are easily distinguished from *M. nubilus* by having conspicuously spatulate-tipped D1 and SD1 setae on the abdominal segments as opposed to simple setae with pointed apices (Cassani et al. 1990, Matthews 2006).

To date, literature accounts (Walsingham 1915, Gielis 2003, 2006) include only six species recorded from Honduras, while 46 and 15 species are recorded form Costa Rica and Guatemala, respectively. The identification and collection of *M. nubilus* adds a seventh species to the known fauna. Recent studies and fieldwork have added two more identified species (Miller *et al.*, in prep.) with three more in the process of determination. Given the high diversity of Asteraceae, extensive range of elevation and vegetation zones, and complex geology of the country, we anticipate additional reports of several more species of Pterophoridae as our studies continue.

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