Life Cycle, Adult and Immature Stages of a New Species of *Copestylum* (Diptera: Syrphidae) from Mexico Reared from Cactaceae

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ABSTRACT *Copestylum alberlena*, sp. nov. (Diptera: Syrphidae) was reared from larvae collected in decaying platyclades of *Opuntia* Mill. (Cactaceae) in the state of Veracruz (México). The third-instar larva, puparium, and adult morphology are described. Preliminary data about its life cycle and breeding behavior are included. This species is close to *Copestylum tamaulipanum* (Townsend), also breeding in Cactaceae, whose male genitalia are also described and compared with *C. alberlena.* The most important morphological differences between immature stages and adults of *C. alberlena* and *C. tamaulipanum* are illustrated and analyzed in a comparative table.

KEY WORDS Neotropic, new species, Syrphidae, *Copestylum*, immature stages, life cycle.

THE GENUS *Copestylum* Macquart, 1846 is endemic to the New World where it constitutes one of the five largest syrphid genera with >300 described species (Vockeroth and Thompson 1987). Only four species of *Copestylum* have been found outside Nearctic and Neotropical regions (Vockeroth and Thompson 1989 and Báez 2000), where they were probably introduced as larvae inside Cactaceae. Despite the large number of species in this genus in Central America, the Mexican species of *Copestylum* are still poorly known. In the regional catalog of Thompson et al. (1976), >70 species of *Copestylum* are listed from Mexico, and more recently Ramírez-García (1997) adds seven new records from Los Tuxtlas (Veracruz), where the larvae and one adult of a new species here described have also been captured.

The rearing records indicate that the larvae of *Copestylum* develop in various kinds of decaying matter (Hubbard and Schwarz 1899, Sack 1921, Greene 1923, Ryckman and Ames 1953, Myles 1986) and in the water-filled bracts of *Heliconia* spp. (Seifert and Seifert 1976a, 1976b), but rotting Cactaceae are the recorded food resource for most reared *Copestylum.* Decaying cactus, whether prickly pear or other types, offers a very suitable breeding ground for saprophagous syrphids, mainly *Copestylum* species but also some species of *Nausigaster* Williston, 1883 (Hunter et al. 1912, Rotheray et al. 2000), *Eumerus* Meigen, 1822 and *Syritta* Lepeletier & Serville, 1828 (Pérez-Bañón and Marcos-García 1998, 2000). These syrphids are attracted to cactus that are damaged by other insects, mainly Lepidoptera and Coleoptera, or are attacked by bacterial and fungal diseases (Bugbee and Reigel 1945, Santana 1961, Mann 1969). Many *Copestylum* species have been reared from *Opuntia* spp. in the New World (Johnston 1921, Sack 1921, Williams 1939, Bugbee and Reigel 1945, Ryckman and Ames 1953, Mann 1969, Wallace and Lavallee 1973, Telford 1973, Maldonado Capriles and Berrios 1977, Zimmerman et al. 1979, Maier 1982, Pérez-Bañón and Marcos-García 2000). However, the life history, morphology and biology of the immature stages of *Copestylum* species are still poorly known, and only the immature stages of 22 species of *Copestylum* have been described.

The objectives of the current study were as follows: (1) to describe the third-instar larva (L3), puparium, and adult of *Copestylum alberlena* sp. nov.; (2) to summarize in a comparative table the morphology of the immature stages of this species with closely related species and provide a key to the third instar larvae of *Copestylum* species breeding in decaying Cactaceae; and (3) to present rearing data for this new species.

Materials and Methods

Three males and six females were reared from larvae collected on decaying platyclades of *Opuntia* sp. in the state of Veracruz.

Rearing took place in a growth chamber at 16–22°C, 80–85% RH with a constant photo-period of 15:9 (L:D) h. Plastic cages (30 cm wide, 15 cm deep, 20 cm high) containing decaying platyclades of *Opuntia* were checked daily, and the L3 instars were kept in a cylindrical plastic cage (40 mm high, 80 mm wide) together with small pieces of dry platyclades to facilitate pupation. Puparia were placed individually in 55-mm-diameter petri dishes and inspected daily until the emergence of the adults.

Larvae selected for preservation were L3 instars. Typically, the larvae of this instar when fully grown

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have two discs of differentiated cuticle on the dorsal surface of the first abdominal segment. They were killed by immersion in cold water and boiled slowly for about four minutes to extend them. Afterward, they were preserved in 70% alcohol.

Descriptions are based on preserved specimens with larval characters checked against living specimens to minimize errors due to preservation. Illustrations and dimensions (mean ± SE) were made on preserved material using a binocular microscope with an eyepiece micrometer and FSA 25 PE drawing tube. The photographs were taken with a scanning electron microscope operated at 20 kV.

Terminology used for descriptions of the larvae follows Hartley (1961) and Rotheray (1993) and that for the puparia follows Pérez-Bañón and Marcos-García (1998, 2000) for other saprophagous syrphid species. The positions of the sensilla were numbered sequentially from the dorsal to the ventral surface for each segment (Rotheray 1991). The terminology used for the adult description follows Thompson (1999).

The cephalopharyngeal skeleton was removed from the leading ventral edge of the interior of the puparia and was then placed in warm potassium hydroxide (KOH) for 3–4 min. Finally, they were washed in distilled water and preserved in glycerine until examination. Morphological terminology of this stage follows Hartley (1963).

Copestylum alberlena Marcos-García & Pérez-Bañón, sp. nov.

Description of Adult

Male. *Head.* Antenna light brown, yellowish apically; basoflagellomere elongate, about three times as long as wide; arista yellow, plumose, and longer than basoflagellomere. Face mainly yellow, with three dark brown longitudinal vittae, one medial and two lateral vittae from eye to mouth. Gena black and yellow. Facial tubercle slightly protuberant in profile, rounded and closer to the mouth than the antenna. Epistome projecting beyond facial tubercle. Face with long pale hairs except some shorter, black, and reclined hairs on brown band from facial tubercle to oral margin. Vertex black, with yellow and some black long pile. Frontal triangle yellow except shiny brown along lunule. Frons yellow with long yellow pile intermingled with black ones. Postocular orbit black covered with dense white pollinosity and short pale pile. Eyes holoptic, covered by abundant long black hairs; eye suture approximately as long as ocellar triangle (≈20 ommatidia in contact). Ocellar triangle black, yellow pilose; ocelli in equilateral triangle.

Thorax. Mainly brownish black with yellow maculae. Postpronotum whitish yellow, bare anteriorly with a posterior tuft of yellow pile. Scutum black except for yellow lateral vitta from postpronotum to postalar callus, a pair of yellow spots (rounded anteriorly) in the center of posterior margin of scutum and a long triangular yellow macula on posterior callus. Scutum without prescutellar bristles. Pile of the scutum whitish yellow in anterior half and where cuticle is yellow; posterior part with black pile. Scutellum without preapical depression; yellow with black hairs posteriorly and yellow hairs basally; posterior margin of the scutellum with longer and black hairs. Pleura blackish brown except yellow dorsal to procoxae; all pile yellow except some black in dorsal part of anterior anemiperon. Posterior anepisternum continuously pilose; posterior katepisternum continuously pilose; posterior anepimeron and meron bare. Calypters yellow with long and plumose marginal setae. Halteres with yellow head and black stem. *Legs.* Femorae shiny black, only yellow in the apical extreme, gray pilose except the apical-ventral surface with short, black pile. Tibiae shiny black (pale basally), black pilose. All tarsi yellow basally and black apically. *Wing.* Alulae broad, entirely microtrichose. Cell R1 broadened apically and petiolate. Wing membrane hyaline except for dark maculae on crossveins, on the stigma, on basal part of spurious vein, and on the apex of the wing. M2 absent.

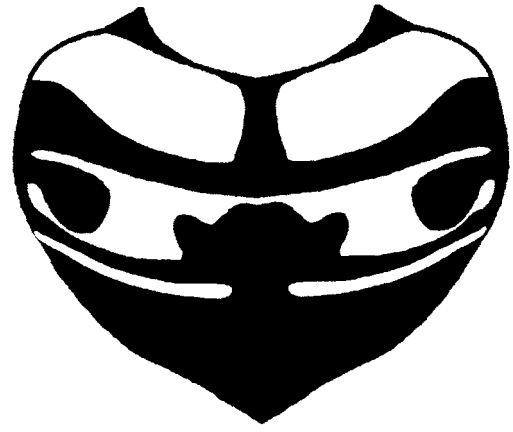

Fig. 1. Pattern of the abdominal spots in *C. alberlena.*

Abdomen. Dark, shiny brown, with yellow basal fasciae; first tergum brownish black, white pilose laterally, black pilose elsewhere; second and third terga black with antero-lateral yellow spots, not reaching lateral margins of tergum and distinctly separated in midline; yellow spots of the third tergum have a distinctive black rounded spot laterally, anterior margin of this tergum yellow; fourth tergum brown except yellow basal band, with a pair of conspicuous dorsal prominences; fifth tergum shiny black (Fig. 1). First sternum brown, white pilose; second and third sterna yellow, black laterally and on the posterior margin of third sternum; fourth and fifth sterna brown with some black pile on margin of the fourth sternum. Terminalia black. Abdomen pile matches cuticle except all sterna and fourth and fifth terga with gray pile.

Length. 7.76 ± 0.108 mm; wing, 6.55 ± 0.086 mm (n = 6).

Male Genitalia (Fig. 2). Brown and black pilose. Cercus symmetrical in lateral view, rounded with long pile (Fig. 2A). Surstylus three times longer than wide, tapering apically with rounded apex (Fig. 2C). Inner

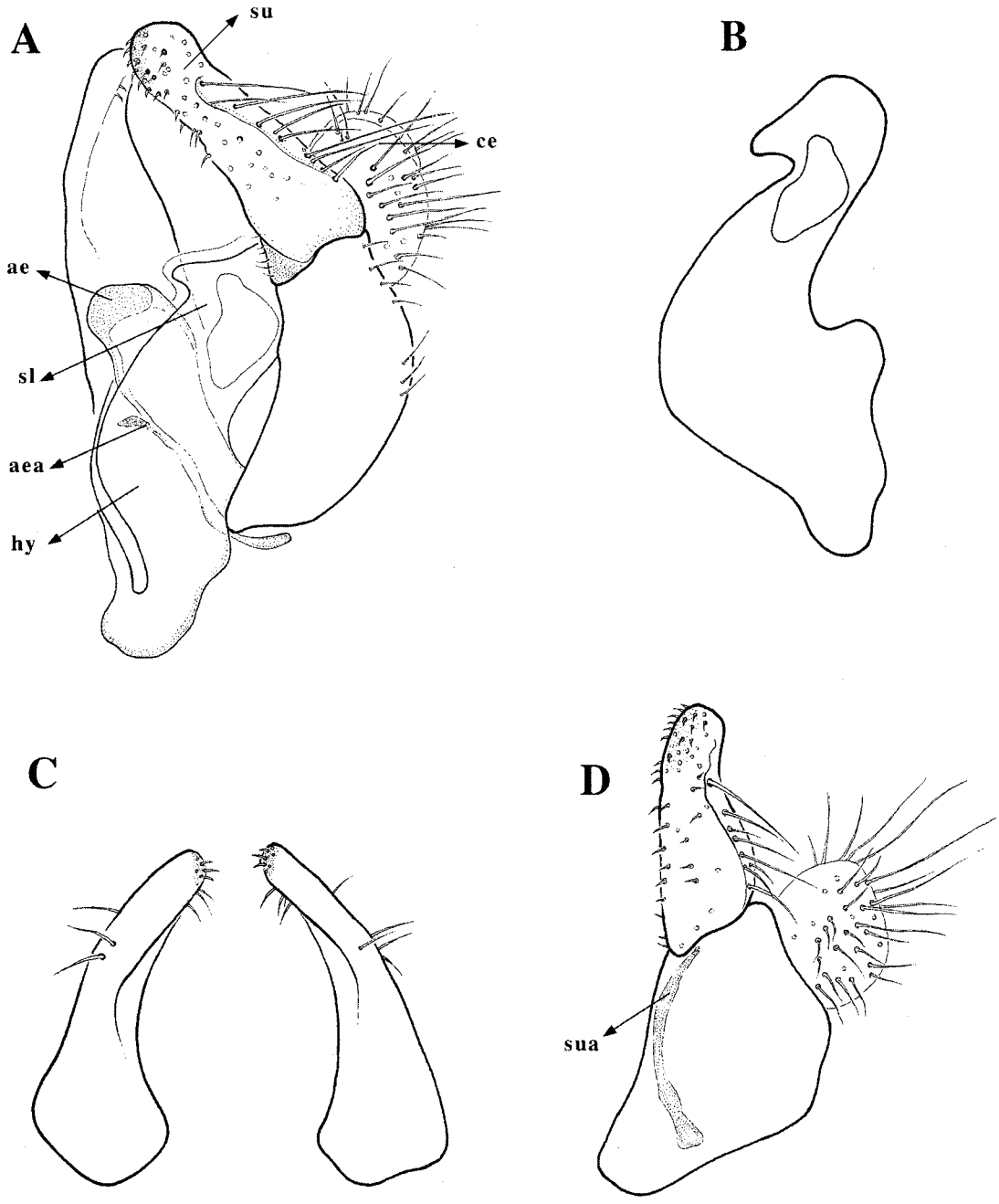

Fig. 2. Male genitalia of *C. alberlena.* (A) Lateral view (aea: aedeagal apodeme, ae: aedeagus, ce: cercus, hy: hypandrium, sl: superior lobe, su: surstylus). (B) Superior lobe of the hypandrium in lateral view. (C) Surstyli in ventral view. (D) Epandrium in lateral view (sua: surstylus apodeme).

face of the surstylus with thicker setae, dense near apex, and with long pile laterally in a long row extending almost the entire length. Basal part of the surstylus without conspicuous protuberance (Fig. 2C). Surstylus apodeme more sclerotized than epandrium, slighty incurved in lateral view and with its dorsal arm fused to base of surstylus (Fig. 2D). Postanal plate not sclerotized. Epandrium without setae below surstyli (Fig. 2D). Hypandrium not indented at base of lingular space (Fig. 2B). Superior lobe rounded apically with a ventral prominence beaked in appearance and with a rounded interior hole (Fig. 2B). Aedeagus rounded apically with the aedeagal hood more sclerotized, club shaped (Fig. 2A). Aedeagal apodeme in lateral view clearly sinuous (Fig. 2A). Lingular space rectangular.

Female. Similar to male except for normal sexual dimorphism. *Head.* Pile shorter than male. Frons yellow with a dark longitudinal vitta from lunule to ocellar triangle. Pile on frons yellow except on brown band where they are black. Width of vertex ≈28% width of head. *Thorax.* Pile shorter than male. Upper part of anepisternum with a yellow spot.

Description of Immature Stages

Third Larval Instar (L3). Length 16–18 mm, maximum width 2.5–3 mm ($n = 2$). Overall appearance: A short-tailed larva with internal mouth-hooks, bearing two pairs of fleshly lappets located on the anal segment. Subcylindrical in cross-section with a flattened ventral surface, slightly truncate anteriorly, and tapering posteriorly. Cuticle translucent when alive, cream to off-white after fixation. Dorsal body surface coated in short, pointed, backwardly directed unpigmented spicules, which are shorter and more scarce on the ventral surface except for the anal segment (hind end).

Head. Mouth-hooks and mandibular lobes internal [mouthparts adapted for filter-feeding Roberts (1969)]. Antenno-maxillary organs well developed. Cephalopharyngeal skeleton: Mouth-hook slightly crescent-shaped, dorsally angular, not sharply pointed nor toothed; mandibular lobes small, about as wide as mouthhook length, ribbed, with combs of filaments on inner ridges; pharyngeal sclerite with posteriorly projecting: clypeal sclerites connected by dorsal bridge; these sclerites are short and strongly pigmented medially and on tentorium; basal sclerite long, narrow and slightly sclerotized. T-ridges with ribbed cibarial filter.

Thorax. Lateral lips rounded and well developed (in profile projecting forward from the anterior part of the prothorax) and coated in long, fine unpigmented setae. Dorsal lip covered with short, fine setae at base and longer setae at tip. Anterior fold on dorsal surface of the prothorax with longitudinal grooves and narrow band (<35% of anterior fold) of densely aggregated, backwardly directed, sclerotized spicules which become progressively shorter posteriorly. Dorsal surface of the prothorax with anterior respiratory process sclerotized, short and trilobed apically. Lateral margin of mesothorax with two patches of sclerotized spicules arranged as follows: a group of 10–12 just anterior to fourth sensilla of mesothorax and another group of 15–20 in front of the fifth sensilla of mesothorax. Antero-dorsal surface of mesothorax with two patches of slightly sclerotized spicules. Mesothorax bearing well-developed prolegs with ≈50 crochets each one arranged in two semicircular patches. Ventral surface of metathorax with a narrow band of small, slightly sclerotized crochets.

Abdomen. Primordia of pupal spiracles obvious on the dorsal surface of first abdominal segment. Ventral prolegs small and multi-serial, six abdominal pairs on segments 1–6. Each proleg with 30–40 brown crochets. Central crochets slightly bigger than those anterior and posterior, all of them directed posteriorly. Anal segment with three pairs of fleshly lappets, second pair located ventrolaterally and reduced to just sensilla and surrounding setae, first pair located dorsolaterally and the third pair placed ventrolaterally, just anterior to base of the posterior respiratory process. Posterior respiratory process (prp). Length 1.90 ± 0.08 mm; width: at base 0.430 ± 0.013 mm, at tip 0.310 ± 0.006 mm; ($n = 5$); lustrous, sclerotized and brown in color. Spiracular plates fused into a single plate, slightly constricted medially. Six spiracular slits with a clearly sinuous shape arranged around two central scars (Fig. 3C). Periphery with four pairs of long and plumose spiracular setae with at least five basal branches. Basal two-thirds of the posterior respiratory process finely ridged to just below the smooth and shining tip (Fig. 3A).

Puparium. Length including posterior respiratory process 11.00 ± 0.16 mm, maximum width 4.00 ± 0.16 mm ($n = 5$). Subcylindrical in cross-section. Extreme truncated anteriorly tapered posteriorly and flattened ventrally. Integument rough, with segmentation of larvae persisting as transverse folds and wrinkles (Fig. 3D). Brown in color. Thoracic respiratory processes project from middle of upper half of operculum, separated by distance slightly more than the length of one spiracle. These processes are subcylindrical structures ≈0.9 mm in length, bearing a crown of irregularly-spaced and rounded tubercles usually extending no >1/3 the length of the upper surface (Fig. 4A). Surface between tubercles smoothly polished with a very fine and scattered setae (Fig. 4C). Each tubercle has from two to six oval openings (Fig. 4C). Basal part of the thoracic respiratory processes with a granular surface, each minute projection bearing a single apical seta (Fig. 4E). Base of the processes encircled by pointed spicules.

Biological Data. The life cycle is completed inside decaying platyclades that characteristically occur on the branches of *Opuntia.* The necrotic process seems to be produced by microorganisms, possibly by bacteria as in the giant saguaro (*Cereus giganteus* Engl.) (Lightle et al. 1942). The infected region becomes liquid with destruction of the internal tissues. The larvae of this species were found during the later stages of decay when most of the internal tissues had been reduced to a syrupy, malodorous liquid. One damaged platyclade can contains numerous larvae. Some puparia were found on dried parts of platyclades. Pupal period was 7–11 d ($n = 9$).

One female was captured flying around *Opuntia* sp. at 1200 hours.

Etymology. The specific epithet is an invariable substantive in apposition which refers to the combined names of my (first author) children Alberto and Elena, to whom the senior author wishes to dedicate this new species as a small sign of gratitude for all their patience and understanding.

Type Material. HOLOTYPE: 1 ♂, Mexico, Veracruz, San José de Romerillas, Tatatila, 1,920 m (19° 40′ 13″ N, 97° 10′ 12″ W); 27-VII-98 (larva collected in *Opuntia* sp.), 13-VIII-1998 (adult). PARATYPES: 2 ♂♂ and 5 ♀♀, same data. All type specimens (except one female caught flying) were reared from larvae collected by

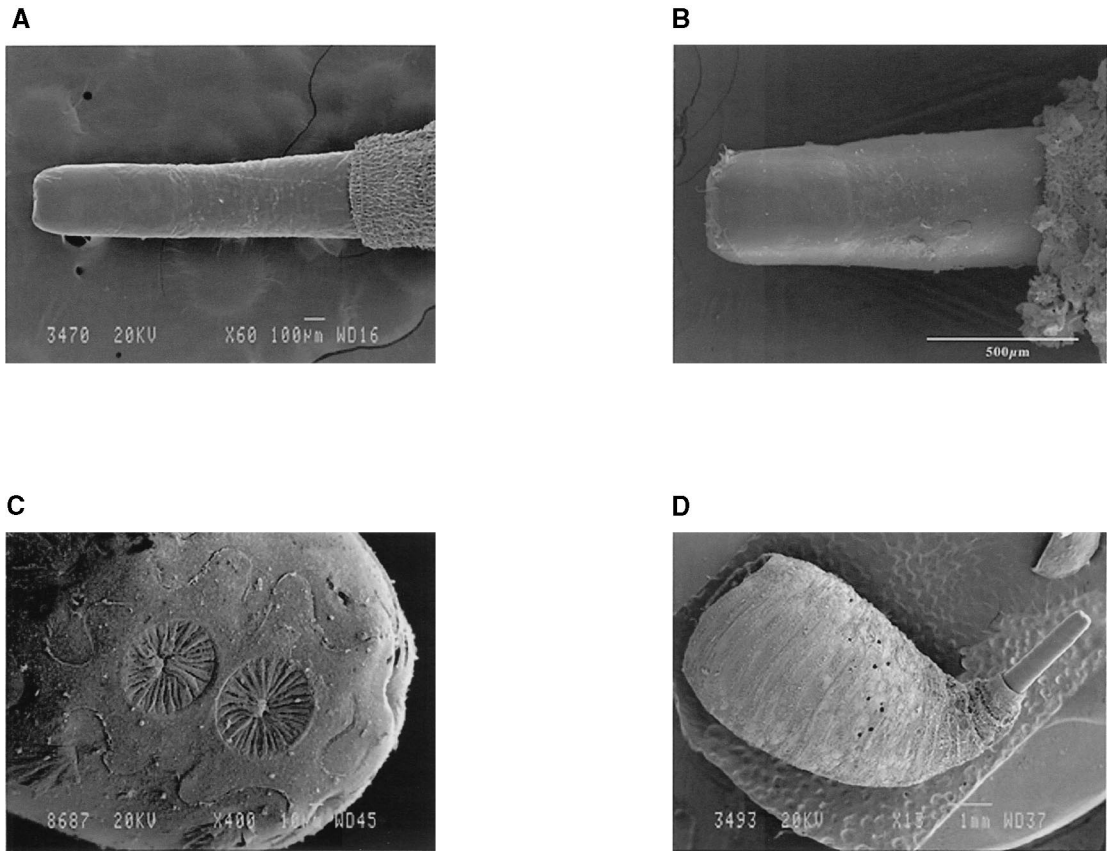

Fig. 3. Dorsal view of the posterior respiratory process in (A) *C. alberlena* and (B) *C. taumalipanum.* (C) Spiracular plates of the posterior respiratory process of *C. alberlena.* (D) Puparium of *C. alberlena,* dorsal view.

M[a] A. Marcos-García, in decaying platyclades of *Opuntia* sp.; adults emerged from 13 to 16 August 1998.

Voucher specimens of adult and immature stages of *Copestylum alberlena* are stored in the Entomological Collection of Alicante University (CEUA), except one male deposited in the Entomological Collection of the Smithsonian Museum (Washington, DC) and one pupa in the National Museums of Scotland (Edinburgh).

Discussion

Copestylum alberlena sp. nov. belongs to the *pictum* group. In the adults, these species are readily recognized by their black and yellow coloration, maculate wings, petiolate and bulbous cell R1, lack of prescutellar bristles, and preapical depression on the scutellum. In the last published key to the species of *Copestylum* (as *Volucella* of authors; Curran 1939), these species run out to the couplets starting at 120. Adults of *C. alberlena* will key out to and are very similar in appearance to *C. tamaulipanum* (Townsend, 1898). Though all specimens of *C. alberlena* are larger than studied specimens of *C. tamaulipanum,* we do not consider this character as diagnostic, because the majority of the specimens examined of both species have been reared in the laboratory. Nevertheless, both species can be easily distinguished by the basoflagellomere and morphology of the male genitalia, those of *C. tamaulipanum* here described and illustrated for the first time (Fig. 5).

Copestylum tamaulipanum has the basoflagellomere darker (only slightly yellow ventrally) and longer (four to five times as long as wide) than *C. alberlena.* The genitalia of these two species mainly differ in the shape of the surstylus, superior lobe, surstylar apodeme, hypandrium, and aedeagal apodeme. The surstylus of *C. tamaulipanum* has a conspicuous protuberance on the inner basal part (Fig. 5C), which is absent in *C. alberlena.* The surstylar apodeme in lateral view is clearly sinuous in *C. tamaulipanum* (Fig. 5D) and slightly in-curved in *C. alberlena.* The hypandrium of *C. tamaulipanum* in lateral view is indented at base of lingular space and this indentation is lacking in *C. alberlena* (Fig. 5B). The hole of the superior lobe in *C. tamaulipanum* is longer and narrower than in *C. alberlena* (Fig. 5B). The aedeagal apodeme in lateral view is in a straight line or slightly curved in *C. tamaulipanum* (Fig. 5A) and sinuous in *C. alberlena.*

Volucella taumalipana Towsend was described from 24 males and 11 females, all collected near Browns-

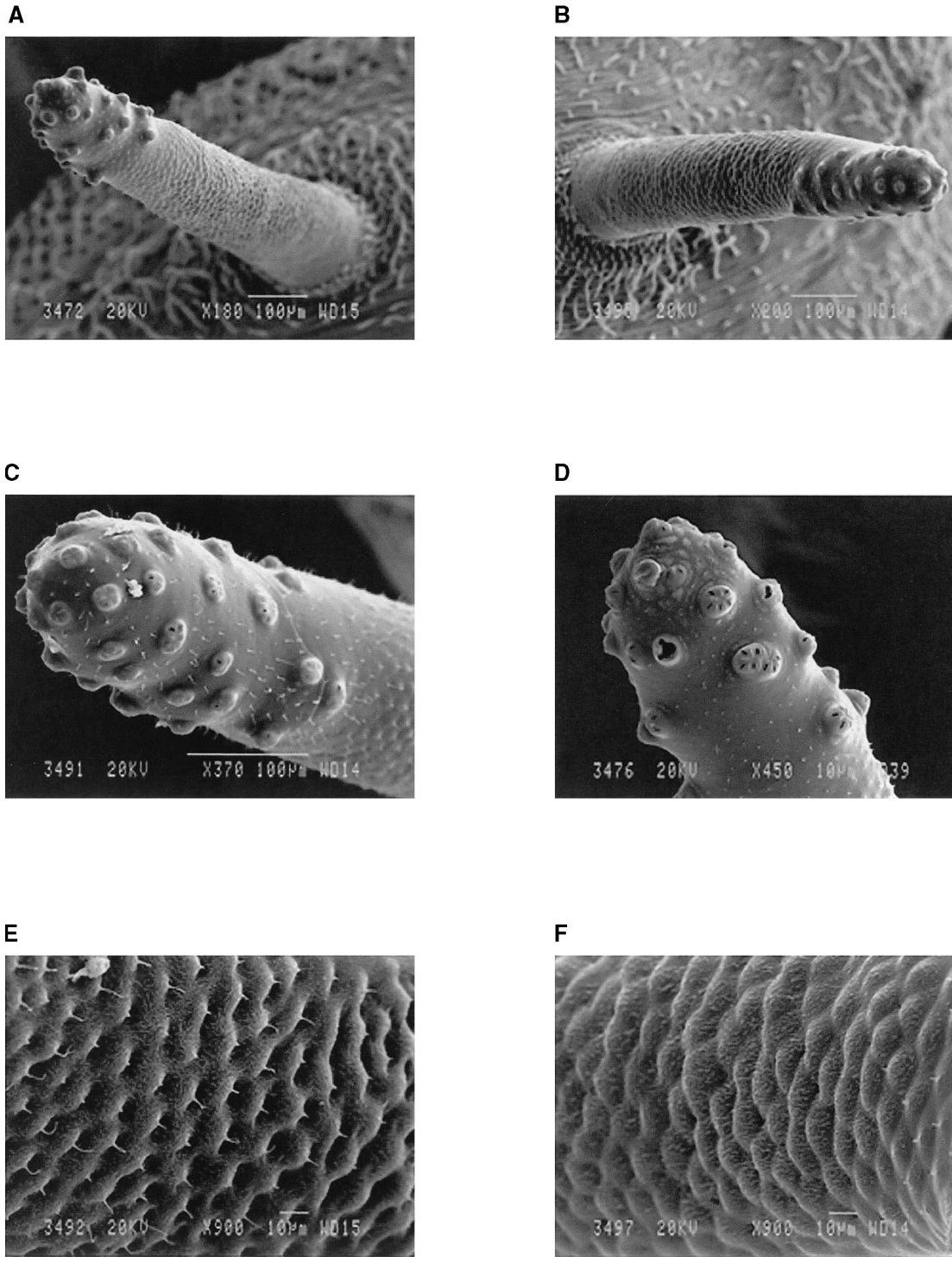

Fig. 4. Thoracic respiratory process in *C. alberlena* (A) and *C. taumalipanum* (B). Ornamentation of apical extreme of thoracic respiratory process in *C. alberlena* (C) and *C. taumalipanum* (D). Ornamentation of base of thoracic respiratory process in *C. alberlena* (E) and *C. taumalipanum* (F).

ville, TX. A male specimen in The Natural History Museum (BMNH), London, labeled "Brownsville, 6.24. Tex," "Coll. Townsend" and with round blue BMNH syntype label, is here designated lectotype to fix the name and to ensure consistent interpretation of the taxonomic concept. There are an additional 12

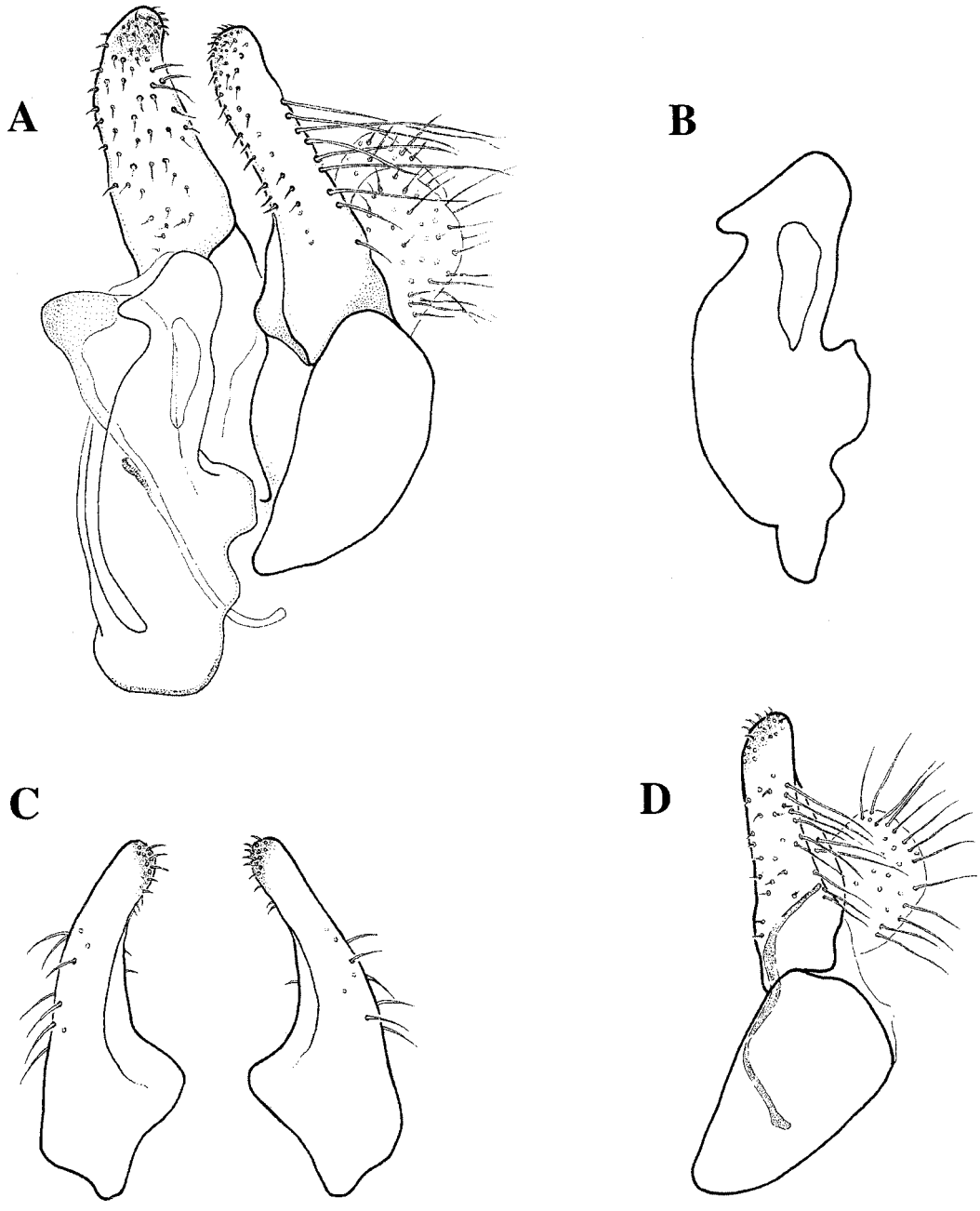

Fig. 5. Male genitalia of *C. tamaulipanum.* (A) Lateral view. (B) Superior lobe of the hypandrium in lateral view. (C) Surstyli in ventral view. (D) Epandrium in lateral view.

males and 10 females in London all acquired from the Brunetti Collection. The location of the other male and female paralectotype is not known.

The immature stages of few species of *Copestylum* have been described in detail. Using these scarce descriptions, Marcos-García and Pérez-Bañón (2001) concluded that the overall appearance of the larvae of *Copestylum* is characterized by a habitus that is short-tailed and subcylindrical in cross-section, mouthhooks and mandibular lobes internal, prothorax with a band of sclerotized spicules on the anterior fold; prolegs with crochets arranged in a transverse row; and anal segment with lappets. These morphological characters are shared by the larvae of *C. alberlena.*

The study of the immature stages of *C. alberlena* indicates striking similarities with those of *C. tamaulipanum.* Larvae of these two species present two pairs of well-developed lappets, apical pair bigger than

Table 1. Comparison of main morphological characters of third-instar larvae, puparia, and adults. of *C. alberlena* sp. nov. and *C. tamaulipanum*

Characters	*C. alberlena* sp. nov.	*C. tamaulipanum*
Immature stages		
Larvae		
posterior respiratory processes	5–6 times longer than wide at apex. Basal two-thirds finely ridged to just below the smooth and shining tip (Fig. 3A)	3–4 times longer than wide at apex. All surface smooth and shining without ridges (Fig. 3B)
Puparia		
Ornamentation of thoracic respiratory processes	Surface between tubercles smoothly-polished with a very fine long and scattered setae (Fig. 4C). Basal part with a granular surface, each minute projection bearing single apical seta (Fig. 4E)	Surface between tubercles smoothly polished with very fine short and scattered setae, except around apical tubercules that it is finely beaded (Fig. 4D). Basal part with a granular surface (Fig. 4F)
Adults		
Antenna		
Basoflagellomere	Elongate, about 3 times as long as wide	Elongate, about 4–5 times as long as wide
Abdomen		
Third abdominal terguite	Yellow spots have laterally a distinctive black rounded spot (Fig. 1)	Yellow spots without lateral black rounded spot
Male genitalia	Surstylus without protuberance on the inner basal part (Fig. 2A,C). Surstylar apodeme slightly in-curved in lateral view (Fig. 2D). Hypandrium sharped ventrally and not indented at base of lingular space (Fig. 2B). Superior lobe hole wider than long (Fig. 2B). Aedeagal apodeme slightly curved in lateral view (Fig. 2A).	Surstylus with a conspicuous protuberance on the inner basal part (Fig. 5A,C). Surstylar apodeme clearly sinuous in lateral view (Fig. 5D). Hypandrium indented at base of lingular space (Fig. 5B). Superior lobe hole longer and narrower (Fig. 5B). Aedeagal apodeme straight in lateral view (Fig. 5A).

anterior one, and small mandibular lobes (about as wide as mouthhook length). However, close examination revealed slight differences between the species. These are mainly in the ornamentation of the posterior respiratory process. *C. alberlena* has the basal two-thirds of the posterior respiratory process finely ridged while the whole surface of the respiratory process is smooth and shining in *C. tamaulipanum* (Table 1; Fig. 3 A and B). In relation to the puparium, the main diagnostical character between both species is the ornamentation of the thoracic respiratory processes (Table 1; Fig. 4).

The present data obtained from rearing of *C. alberlena* in the laboratory and from observations in the wild indicate saprophagous feeding habits for the larva living and feeding inside decaying platyclades. The morphology of the cephalopharyngeal skeleton of *C. alberlena* shows striking similarities with the cephalopharyngeal skeleton of other *Copestylum* species breeding on decaying cactus. All species have well developed ventral pharyngeal ridges which separate food particles from excess fluids (Roberts 1969). The main difference between these species is the size of the mandibular lobes in relation to the mouthhook length. Nevertheless, this difference seems not to be related to differences in diet between taxa.

Key to Third-Instar Larvae of Syrphid Genera Known to Breed in Decaying Cactus

1. Mouth-hooks prominently external with tips toothed and heavily sclerotized. Mandibular lobes external, fleshy and slightly obscured . . . . . *Eumerus* (Old World)
   Mouth-hooks and mandibular lobes internal . 2
2. Small prolegs with 5–6 primary crochets . . . . . *Syritta* (Old World)
   Small prolegs with >10 primary crochets . . 2
3. Dorsal surface of the prothorax with a pair of rectangular sclerotized plates with a lateral hook. *Nausigaster* . . . . . (New World)
   Dorsal surface of the prothorax without sclerotized plates . . . . . *Copestylum* (New World)

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