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# Revision of the proctotrupoid genus *Pelecinus* Latreille (Hymenoptera: Pelecinidae)

N. F. JOHNSON and L. MUSETTI

*Department of Entomology, Museum of Biological Diversity, The Ohio State University, 1315 Kinnear Road, Columbus, OH 43212-1192, USA*

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The extant Pelecinidae consist of the single genus *Pelecinus* Latreille. This group is restricted to the continental New World; miscellaneous reports and specimens from Jamaica, Australia, India and Malaysia are errors. Three species are recognized: the widespread *Pelecinus polyturator* (Drury), found from the southern portions of the eastern provinces of Canada, the eastern USA (west to North Dakota, Colorado and New Mexico) and Mexico south to northern Argentina; *Pelecinus thoracicus* Klug **revised status**, from western Mexico; and *Pelecinus dichrous* Perty **revised status** from northern Argentina, Uruguay, Paraguay and south-eastern Brazil. *Pelecinus rufus* Klug, 1841 and *Pelecinus annulatus* Klug, 1841 are treated as junior synonyms of *Pelecinus dichrous* Perty, 1833. The status of *Pelecinus polyturator* var. *apicalis* Roman is discussed and the name is treated as a synonym of *P. polyturator*. The only recorded host species for the genus are for *P. polyturator*: *Phyllophaga anxia* (LeConte), *P. drakei* Kirby, *P. futilis* (LeConte), *P. rugosa* (Melsheimer) (Coleoptera: Scarabaeidae, Melolonthinae); and *Podischnus agenor* Olivier (Coleoptera: Scarabaeidae, Dynastinae).

KEYWORDS: Parasitoid wasps, Proctotrupoidea, systematics, Neotropical, Nearctic.

## Introduction

The elegant females of *Pelecinus polyturator* (Drury) (Hymenoptera: Pelecinidae, figure 1A–C) are a familiar sight in deciduous woodlands in late summer and early fall in the eastern USA and Canada. They are large, slow-flying, and frequent the lower strata of the forest at the same level with human observers. Despite this, little is known of their natural history and biology.

Although there has been some disagreement concerning the relationships of the family with other Hymenoptera, for over a century the accepted wisdom has been that the family consists of only the single widespread species, extending from southern Canada to northern Argentina (e.g. Muesebeck and Walkley, 1951; Muesebeck, 1979; Masner, 1993, 1995). Therefore, when we began efforts to develop the structure and applications for a specimen database, *Pelecinus* quickly became our choice as

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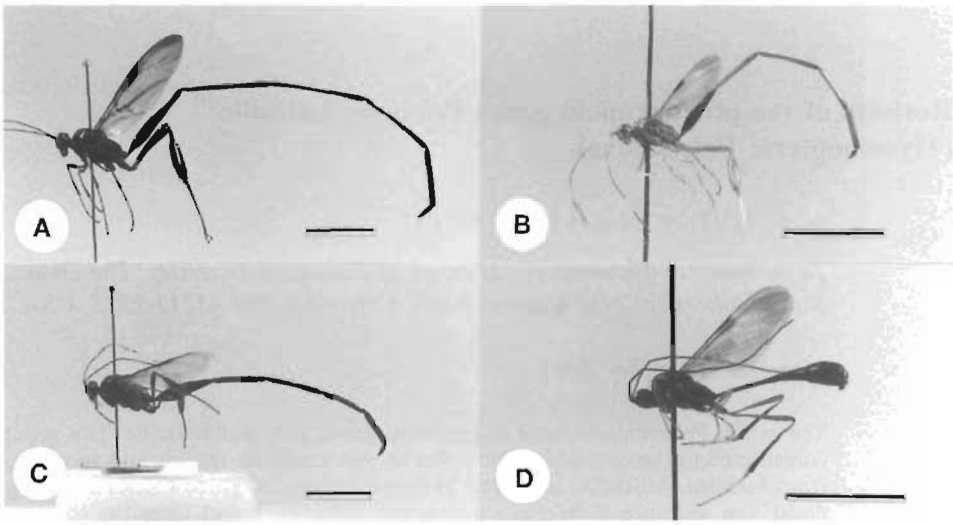


FIG. 1. Habitus of *Pelecinus*: (A) *P. polyturator* (Drury), ♀ (specimen ID: OSUC 1079). (B) *P. thoracicus* Klug, ♀ (OSUC 7246). (C) *P. dichrous* Perty, ♀ (OSUC 7350). (D) *P. thoracicus*, ♂ (OSUC 7154). Scale: 10 mm.

an exemplar organism: as a large creature it is easily collected and preserved; it is immediately recognizable with the naked eye; with only a single species we would not be confronted with taxonomic problems; and its biology was intriguing because of the phenomenon of geographic parthenogenesis described by Brues (1928). Most of these features have proven to be virtues, but the basic systematics has turned out to be more complicated and interesting.

The species *Ichneumon polyturator* was first described 225 years ago (Drury, 1773). The biological exploration of America resulted in a minor flurry of additional species descriptions in the first half of the 19th century (see species list below). The definitive taxonomic treatment (Schletterer, 1890) relegated all of these described forms to synonymy with *Pelecinus polyturator*. This conclusion has basically been followed ever since.

## Materials and methods

Data were obtained from a total of 7718 specimens in 97 institutional and individual collections (collection codens follow Arnett *et al.*, 1993 where possible): **AEIC**: American Entomological Institute; **AMNH**: American Museum of Natural History; **ANSP**: Academy of Natural Sciences; **BMNH**: The Natural History Museum, London; **BMSC**: Buffalo Museum of Science; **CASC**: California Academy of Sciences; **CIDA**: Albertson College of Idaho; **CMNH**: Carnegie Museum of Natural History; **CNCI**: Canadian National Collection of Insects; **CSUC**: Colorado State University; **CUIC**: Cornell University; **CUMZ**: Cambridge University; **DEIC**: Deutsches Entomologisches Institut; **DENH**: University of New Hampshire; **DFEC**: SUNY College of Environmental Science & Forestry; **DNHC**: Denver Museum of Natural History; **EAPZ**: Escuela Agrícola Panamericana, Honduras; **EBCC**: Estación de Biología 'Chamela'; **EDNC**: North Carolina Department of Agriculture; **EMEC**: University of California, Berkeley; **EMUS**: Utah State University; **ESUW**: University of Wyoming; **FIOC**: Fundação Instituto Oswaldo Cruz; **FMNH**: Field

Museum of Natural History; **FSCA**: Florida State Collection of Arthropods; **IMLA**: Instituto Miguel Lillo; **INBC**: Instituto Nacional de Biodiversidad; **INHS**: Illinois Natural History Survey; **INPA**: Instituto Nacional de Pesquisas da Amazônia; **IRCW**: University of Wisconsin; **IZAV**: Universidad Central de Venezuela; **KSUC**: Kansas State University; **LACM**: Los Angeles County Museum of Natural History; **LUCI**: Loyola University, Chicago; **MAIC**: M.A. Ivie private collection; **MCPM**: Milwaukee Public Museum; **MCZC**: Museum of Comparative Zoology; **MEMU**: Mississippi State University; **MHNG**: Museum d'Histoire Naturelle, Geneva; **MLPA**: Universidad Nacional de La Plata; **MNHN**: Museum National d'Histoire Naturelle, Paris; **MSUC**: Michigan State University; **MTEC**: Montana State University; **MZSP**: Museu de Zoologia da Universidade de São Paulo; **NCSU**: North Carolina State University; **NDSU**: North Dakota State University; **NHRS**: Naturhistoriska Riksmuseet, Stockholm; **NYSM**: New York State Museum; **OSEC**: Oklahoma State University; **OSUC**: Ohio State University; **PKLC**: P.K. Lago private collection; **PMNH**: Peabody Museum of Natural History; **PSUC**: Pennsylvania State University; **PURC**: Purdue University; **QBUM**: Museu Nacional, Rio de Janeiro; **QCAZ**: Pontifícia Universidad Católica del Ecuador; **RMNH**: Nationaal Natuurhistorisch Museum, Leiden; **ROME**: Royal Ontario Museum; **RSMC**: R.S. Miller private collection; **RUIC**: Rutgers State University; **RWFC**: R. Willis Flowers collection; **SDSU**: South Dakota State University; **SEAN**: Servicio Entomológico Autónomo, Nicaragua; **SEMC**: University of Kansas; **SIUC**: Southern Illinois University; **STRI**: Smithsonian Tropical Research Institute; **TAMU**: Texas A&M University; **TKPC**: T.K. Philips private collection; **UADE**: University of Arkansas; **UAIC**: University of Arizona; **UCCC**: Universidad de Concepción, Chile; **UCDC**: University of California, Davis; **UCMC**: University of Colorado; **UCMS**: University of Connecticut; **UCRC**: University of California, Riverside; **UDCC**: University of Delaware; **UGCA**: University of Georgia; **ULKY**: University of Louisville; **UMDE**: University of Maine; **UMEC**: University of Massachusetts; **UMIC**: University of Mississippi; **UMMZ**: University of Michigan; **UMRM**: University of Missouri; **UMSP**: University of Minnesota; **UNAM**: Museo de Zoología 'Alfonso L. Herrera', Universidad Nacional Autónoma de México; **UNCB**: Universidad Nacional de Colombia; **UNSM**: University of Nebraska; **USNM**: National Museum of Natural History, Washington; **UVCC**: University of Vermont; **VPIC**: Virginia Tech University; **WFBM**: University of Idaho; **WSUC**: Washington State University; **WVUC**: West Virginia University; **ZMHU**: Humboldt Universität, Berlin; **ZSMC**: Zoologische Staatssammlung, Munich; Universidad Autónoma de Tamaulipas.

Label data are stored in a relational database implementation of the information model developed by the Association of Systematics Collections (Association of Systematics Collections, 1993). The basic structure of this model was enhanced, particularly in areas dealing with literature and unvouchered records. Structured query access to this database and full details on specimen data may be obtained at URL *http://iris.biosci.ohio-state.edu/Pelecinus*.

Estimates of the potential distribution of species were developed following the guidelines for BIOCLIM (Busby, 1991). These protocols delimit a distributional envelope based upon climatic values of variables within limits defined by existing collecting records. Sixteen climatic variables were used based on $5' \times 5'$ rectangular grids of monthly mean temperature and precipitation (data from ZedX, Inc., analyses conducted using Arc/Info 7.03) annual mean temperature, annual precipitation, maximum monthly temperature, minimum monthly temperature, temperature of the warmest quarter, temperature of the coolest quarter, maximum monthly precipitation, minimum monthly precipitation, precipitation of wettest quarter, precipitation of driest quarter, annual temperature range, coefficient of variation of monthly precipitation, precipitation of warmest quarter, precipitation of coolest quarter, temperature of wettest quarter, temperature of driest quarter. The maximum, minimum, 95th percentile, and 5th percentile values of each variable were determined for the known collecting localities. Areas in which the value of any variable fell outside of the range defined by existing collections were designated as unsuitable. Areas with one or more variables falling between the maximum and 95th percentile or minimum and 5th percentile were classified as marginal. Remaining regions of 'suitable' habitat thus have all variables falling in the middle 90th percentile. Distribution models were created separately for North and South America.

Measurements of head (width, length and malar length) were made in frontal view. The length of the female metasomatic segments included the anterior ball-like articulation. Fore wing length was measured from the apex of the tegula to the apex of the wing.

We have been unable to locate the primary type material for any of the described species-level taxa other than *Pelecinus polyturator* var. *apicalis* Roman and *Pelecinus polyturator* var. *peruvianus* Brèthes. Our interpretations of the older names are therefore based upon the original descriptions and the interpretations of Klug (1841), De Romand (1840a, b), and Schletterer (1890).

## Results and discussion

### *Distribution*

The geographic limits of distribution of *Pelecinus* are illustrated in figures 7–11. It is found in the southern parts of eastern Canada (Ontario, Québec, Prince Edward Island, Nova Scotia and New Brunswick) and throughout the eastern USA, west into Colorado and New Mexico. Specimens in Mexico, Central America and northern South America (Venezuela and Colombia) seem to be concentrated in areas of moderate elevation (generally 1000–3000 m). Individuals are fairly common in the mountains of Ecuador, Peru and Bolivia; the Atlantic coastal forest of south-eastern Brazil; and in northern Argentina.

There are some notable gaps in this general characterization of the distribution. No specimens have been collected in peninsular Florida (generally south of Gainesville), the Antilles (see discussion below) or the Yucatán peninsula (including Belize). No *Pelecinus* have been collected in the mountains of Trinidad. In South America proper individuals commonly are collected in the Andean forests in Venezuela, Colombia, Ecuador, Peru and Bolivia, but none is known from Chile. *Pelecinus* certainly is found in the Amazon Basin, as several specimens have been collected in the vicinity of Manaus and Belém, but they must be either very rare or limited to particular habitats. Schulz (1904), for example, commented that he never observed a *Pelecinus* during 3 years of work on the lower Amazon. Only single specimens are known from Iquitos, Peru and Cayenne, French Guiana. One female was collected in La Gran Sabana in Venezuela and a series of 35 specimens from Chapada in the state of Mato Grosso, Brazil. In north-eastern Brazil, presumably corresponding to the extent of the moist forest habitats, several specimens were collected in Pernambuco, one from Alagoas, and three from unspecified sites in Bahia. No specimens are known from Espírito Santo, but *Pelecinus* is fairly common

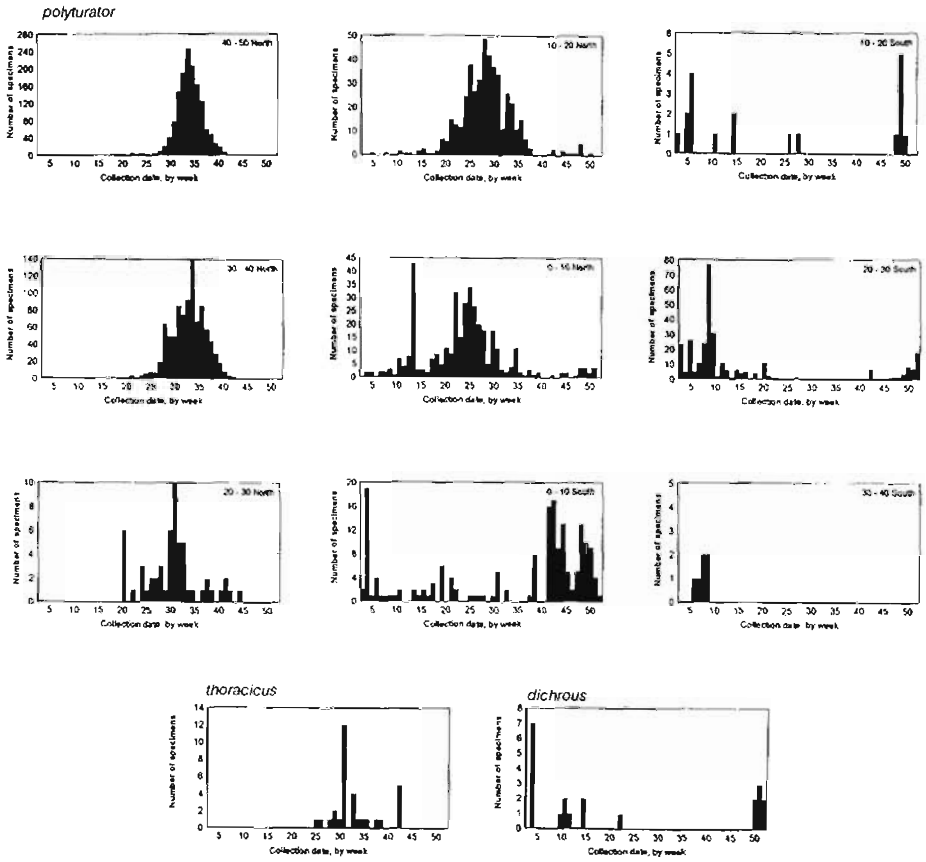


FIG. 2. Collecting dates, by week, of specimens of *Pelecinus*, data for *P. polyturator* divided into 10° bands of latitude.

from Rio de Janeiro south. Inland, material is fairly commonly found in Minas Gerais, and we have a single specimen from Goiás (from a site, São Miguel, we have been unable to georeference).

In the tropics *Pelecinus* seems to be largely absent from the lowlands. At mid elevations (1000–3000 m), for example, Rancho Grande in northern Venezuela or any of a series of the national parks in Costa Rica, females are commonly seen flying or perched on the vegetation. In contrast, well-collected lowland areas such as La Selva (Costa Rica) and Barro Colorado Island (Panama) have no recorded specimens. The absence of *Pelecinus* from low elevations is also clearly seen in Mexico, and perhaps is true of the Atlantic Coastal Plain of the USA (at least south of the Chesapeake Bay).

A few distributional records appear to be errors. In the original description of *Ichneumon polyturator* Drury (1773) reported 'I have received it from Jamaica'. This record has never been corroborated by later collections, and we believe that it must be incorrect. The confusion between West and East Indies was exacerbated in the 13th edition of *Systema Naturae* (1790) in which the species is said to be found in India. Schletterer (1890) corrected this second error, but perpetuated the notion that *Pelecinus* is found in the Antilles. Naumann (1985) discussed the Rick (1970)

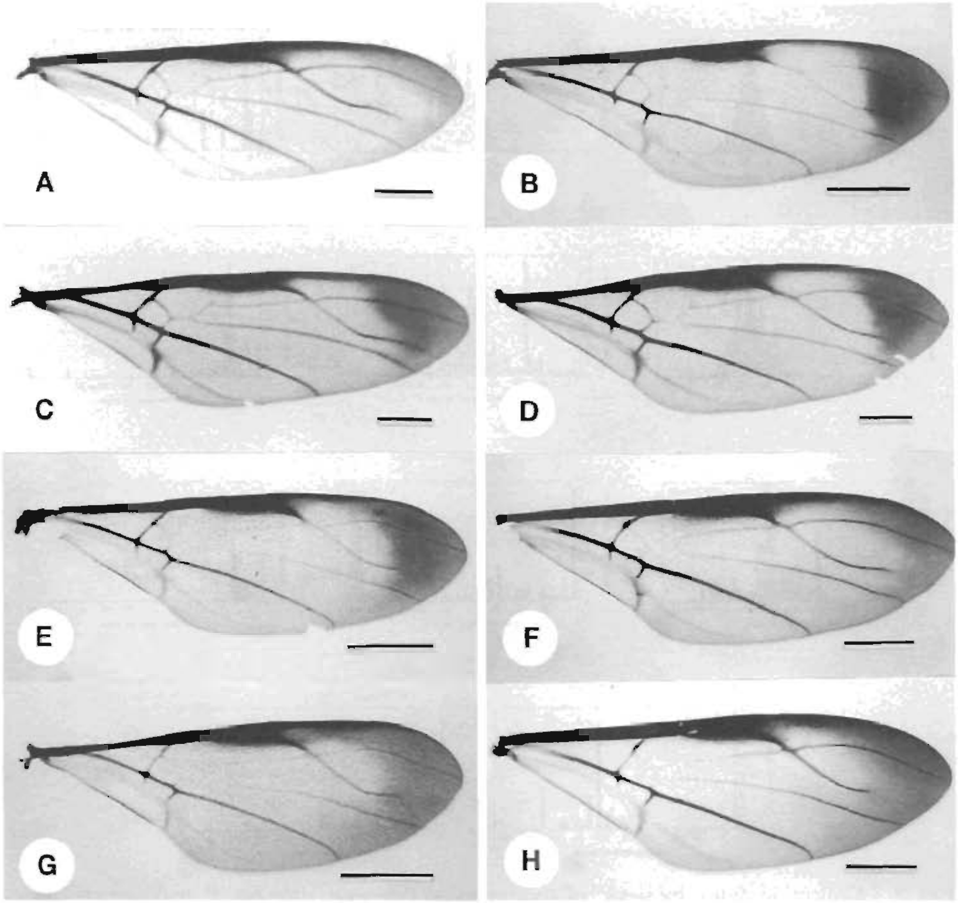


FIG. 3. Fore wing infuscation in *Pelecinus polyturator*. (A) OSUC 3397, Crystal Mayu, Bolivia, ♀. (B) OSUC 3452, Santa Isabel, Peru, ♀. (C) OSUC 3114, Reserva Campinas, Amazonas, Brazil, ♀. (D) OSUC 3440, Crystal Mayu, Bolivia, ♀. (E) OSUC 1771, Chapada, Mato Grosso, Brazil, ♀. (F) INBC 587254, Parque La Amistad, Costa Rica, ♀. (G) OSUC 3289, Petropólis, Rio de Janeiro, Brazil, ♂. (H) OSUC 2625, Cali, Colombia, ♂. Scale: 2 mm.

claim that *Pelecinus* had been introduced into Australia and concluded that this stemmed from an error in relabelling a specimen. Finally, there are two specimens from ANSP (OSUC 1755, OSUC 1756) that are purportedly from 'Kinabalu, Borneo'. These specimens are identical to 'typical' North American *P. polyturator*, and we conclude that this too must be a labelling error.

*Biology*

For a group of insects as large in body size and as easily recognizable as pelecinids, surprisingly little is known of their basic biology. Host information is known only for *P. polyturator*. *Pelecinus* was first reported to have been reared from larvae of *Lachnosterna* Hope (=*Phyllophaga* Harris, Coleoptera: Scarabaeidae, Melolonthinae) by Forbes (1894). Since then, Hudson (1920), Petch and Hammond (1926), Fattig (1944), Hammond (1944) and Lim *et al.* (1980) have reared the species in the northern part of its range from larvae of *Phyllophaga*. Lim *et al.* were

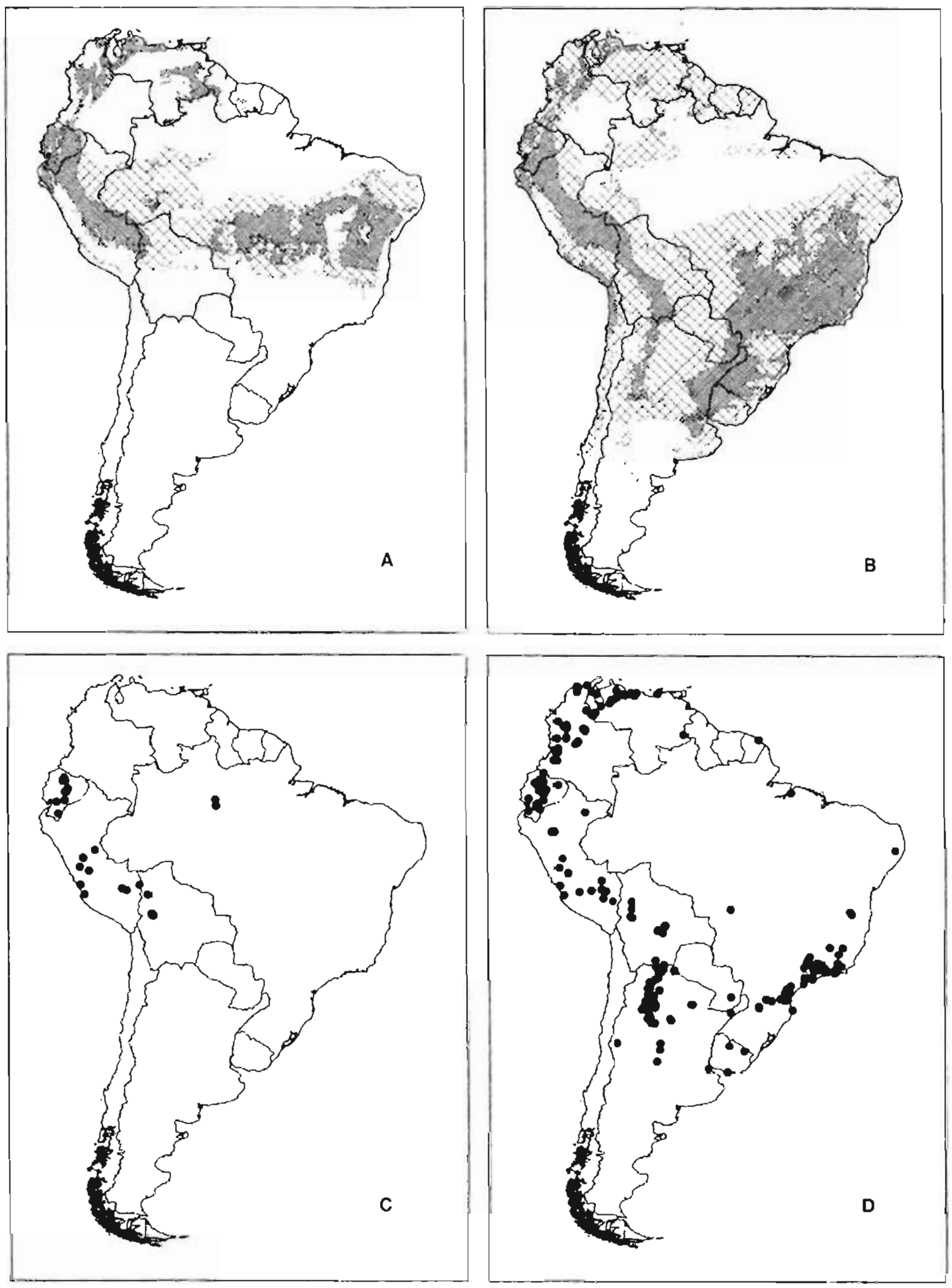


FIG. 4. Distribution of '*Pelecinus apicalis*' and typical *P. polyturator* in South America. (A) *P. apicalis*, climatic model of distribution. (B) *P. polyturator*, climatic model of distribution. (C) *P. apicalis*, collecting localities. (D) *P. polyturator*, collecting localities. Dense hatching: suitable climate; open hatching: marginal climate; unhatched areas: unsuitable climate.

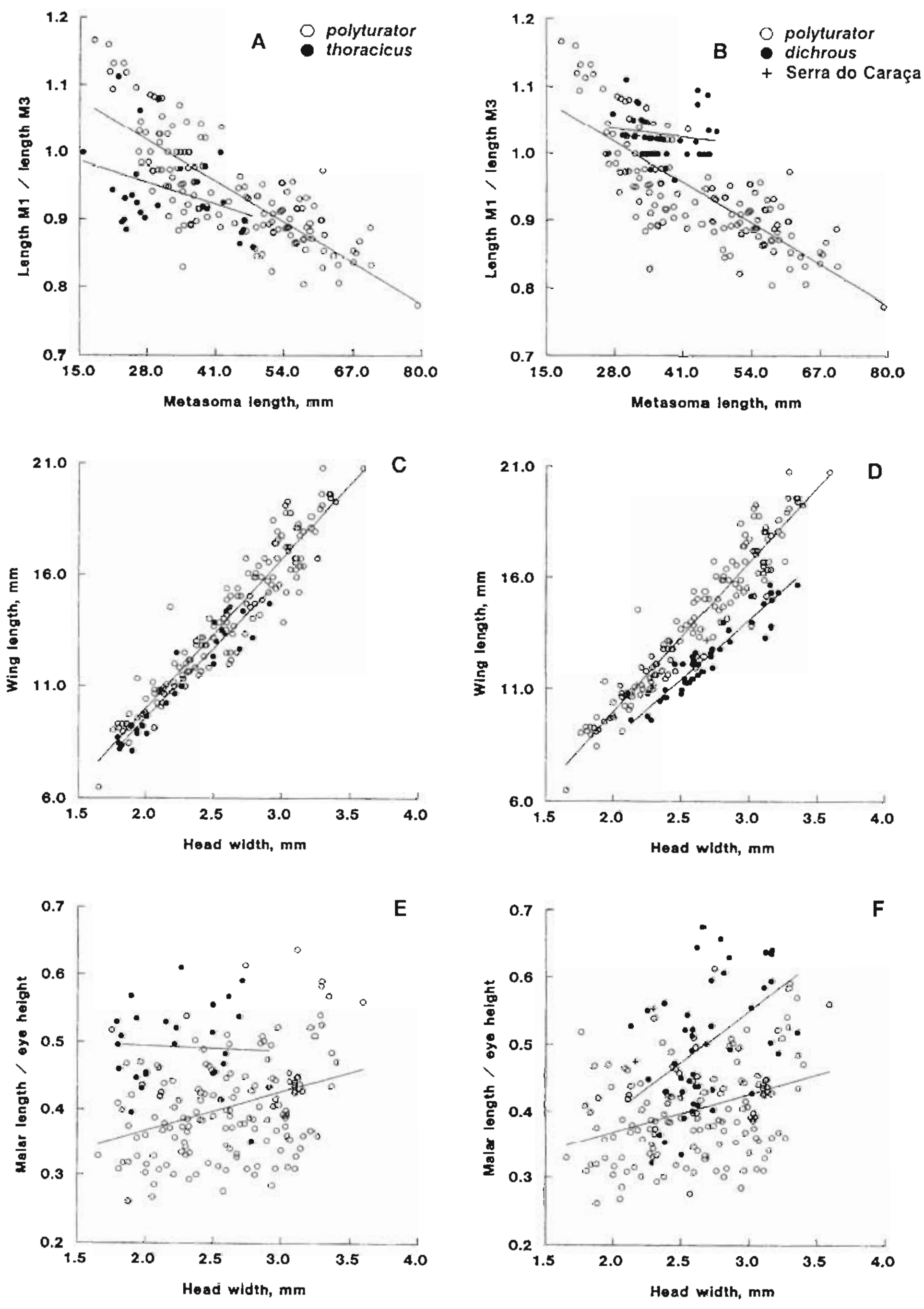


FIG. 5. Comparison of quantitative characters between species of *Pelecinus*. (A, C, E) *P. polyturator* and *P. thoracicus*. (B, D, F) *P. polyturator*, *P. dichrous* and specimens from Serra do Caraça, Minas Gerais, Brazil. Lines are least-squares regressions of data from each species; Serra do Caraça specimens excluded.

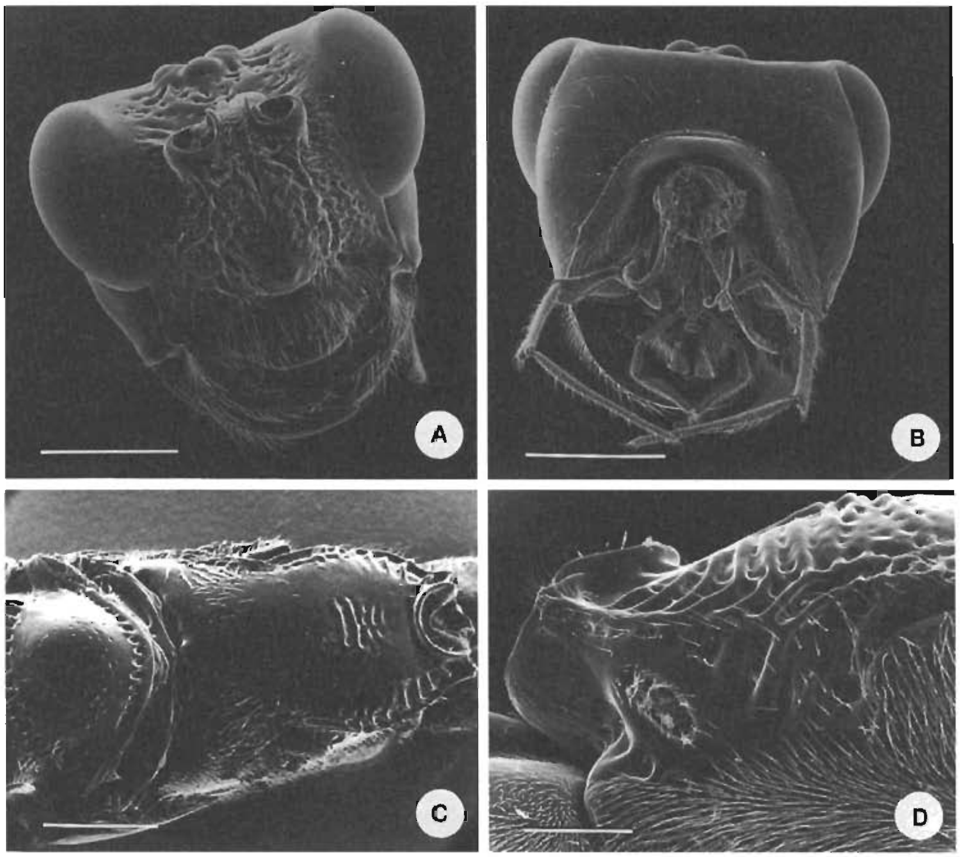


FIG. 6. *Pelecinus polyturator*. (A) Head, anterior view. Scale: 1 mm. (B) Head, posterior view. Scale: 1 mm. (C) Scutellum, metanotum, propodeum, dorsal view. Scale: 1 mm. (D) Posterior portion of propodeum, lateral view. Scale: 0.5 mm.

able to specify the host species as *Phyllophaga anxia* (LeConte). Muesebeck (1979) listed *Phyllophaga futilis* (LeConte) as a host, but no voucher specimen for this record is stored in the USNM. K. Katovich (University of Wisconsin) has recently reared *P. polyturator* from third instar larvae of *Phyllophaga drakei* Kirby and *Phyllophaga rugosa* (Melsheimer) in Wisconsin. A single specimen from Colombia (OSUC 2624, stored in USNM) bears a label stating that it had been reared from *Podischnus agenor* Olivier (Coleoptera: Scarabaeidae, Dynastinae). Clausen (1940) speculated that the true host may be some wood-boring beetle, but this has not been supported. Davis (1919) reported cursory observations of the oviposition behaviour. Hammond (1944) stated that parasitism rates were low, ranging from 1 to 3%.

There is a great deal of size variation in *Pelecinus*. The very few rearing records and the generally large body size suggest that the parasitoid is solitary. Nearctic *Phyllophaga* species have three larval instars, and the life cycle varies from 1 to 4 years (Woodruff and Beck, 1989). The larvae migrate vertically in the soil through the year, being closest to the surface in mid to late summer (Gibb and Reicher, 1993). Some of the size variation of the wasps may result from the range in size of larvae of different species of host. Luginbill and Painter (1953) recorded a size range

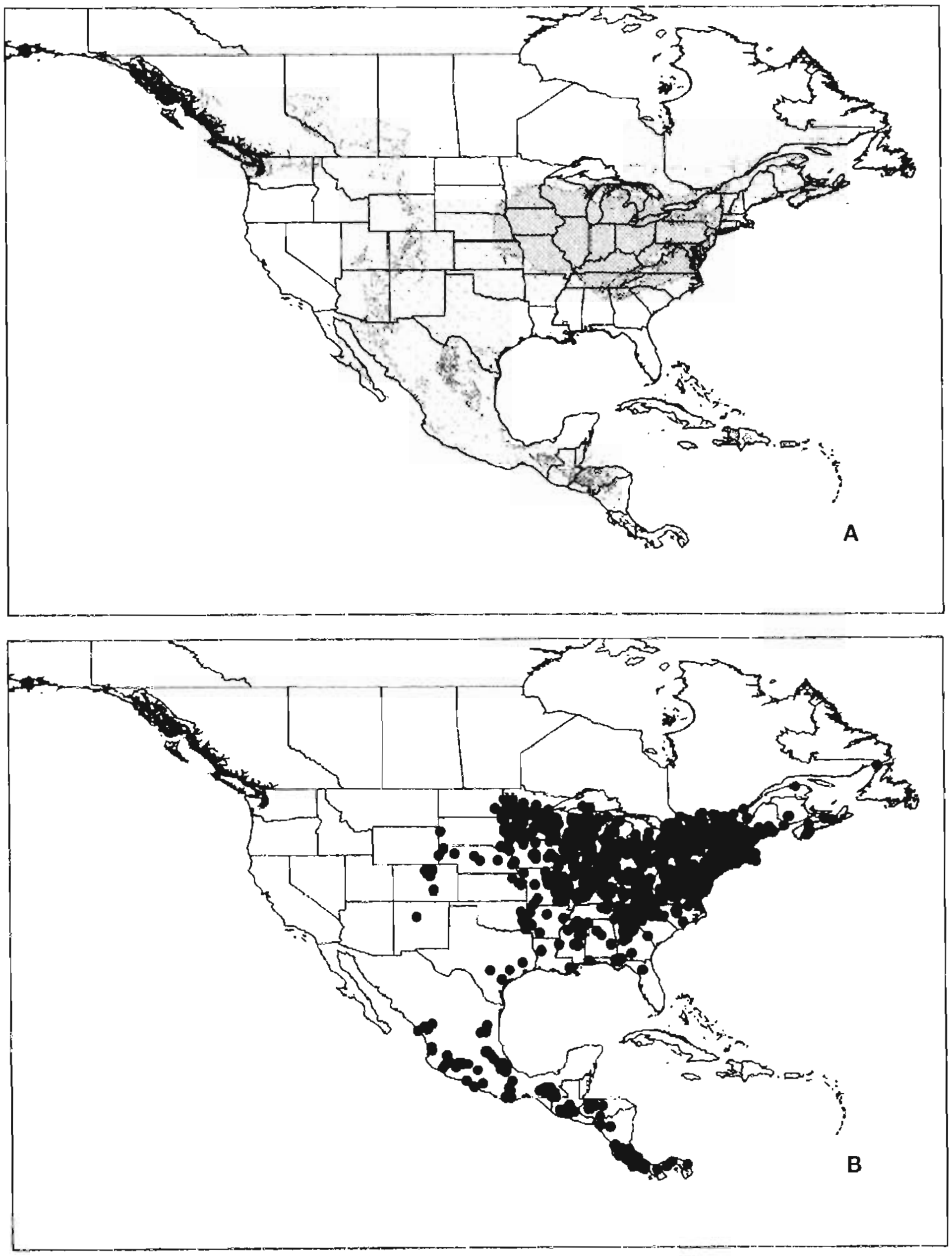


FIG. 7. Distribution of *Pelecinus polyturator* in North America. (A) Climatic model of distribution. Dense hatching: suitable climate; open hatching: marginal climate; unhatched areas: unsuitable climate. (B) Collecting localities.

of adult beetles from 7.25 to 25 mm. The extremes may also be related to whether the wasp develops on a second or third instar host.

Brues (1928) highlighted *Pelecinus polyturator* as an example of the phenomenon of geographic parthenogenesis: tropical populations are bisexual and temperate populations consist only of females. We have analysed the data on the distribution

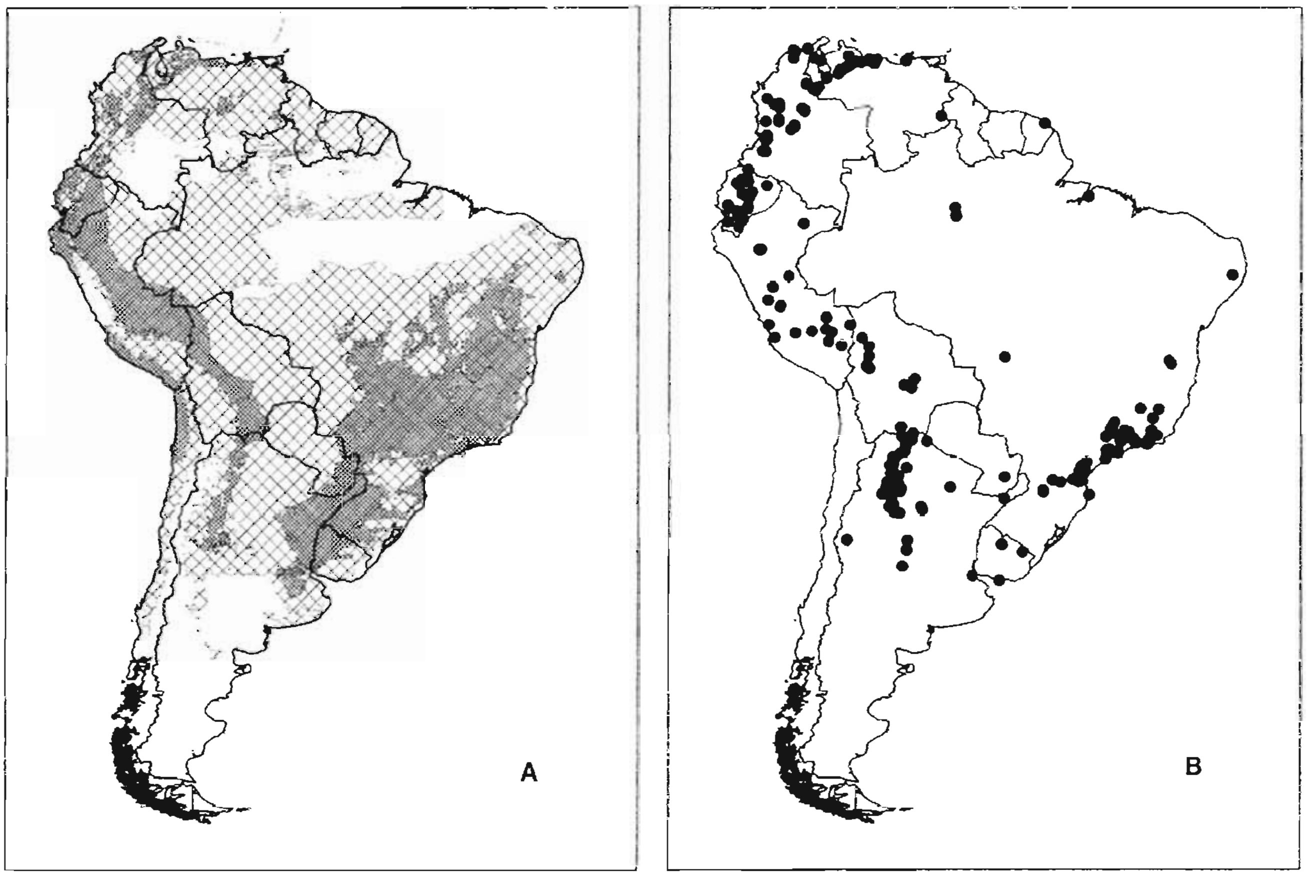


FIG. 8. Distribution of *Pelecinus polyturator* (including *apicalis*) in South America. (A) Climatic model of distribution. Dense hatching: suitable climate; open hatching: marginal climate; unhatched areas: unsuitable climate. (B) Collecting localities.

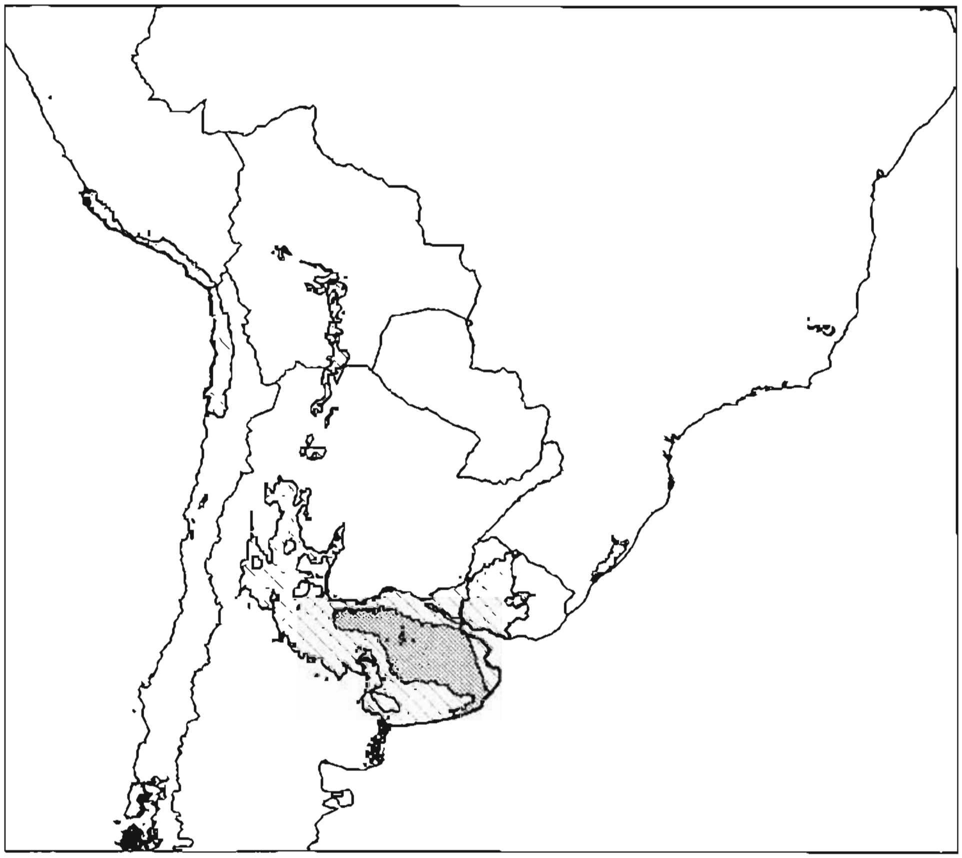

FIG. 9. Climatic model of distribution of *Pelecinus dichrous*. Dense hatching: suitable climate; open hatching: marginal climate; unhatched areas: unsuitable climate.

of sexes separately (Johnson and Musetti, 1998). The populations in the USA and Canada are primarily thelytokous. Males account for approximately 4% of the collected specimens, and we believe that collecting bias has probably inflated this number above the true value. The nearest populations in northern Mexico have males occurring at the same, or higher frequency as in the rest of tropical America.

In the northern and southern ends of its range, adult *Pelecinus* appear on the wing in late summer and early autumn (figure 2). The flight periods of males and females broadly overlap (Johnson and Musetti, 1998). In the tropics, specimens may be encountered throughout the year.

Mason (1984) described the extensive modifications of the female metasoma and how it may be employed to reach host larvae. The distribution of the wasp may be limited by soil characteristics, either directly, by affecting its ability of penetrate the soil, or indirectly, by limiting the habitat for appropriate host larvae. The extremely long metasoma, useful for probing for hosts, creates problems for copulation; the mating behaviour has been recently described by Aguiar (1997).

### *Higher classification and relationships*

*Pelecinus* is most commonly placed in the superfamily Proctotrupoidea (=Serphoidea, Oxyura). This has been a poorly defined taxon based on the

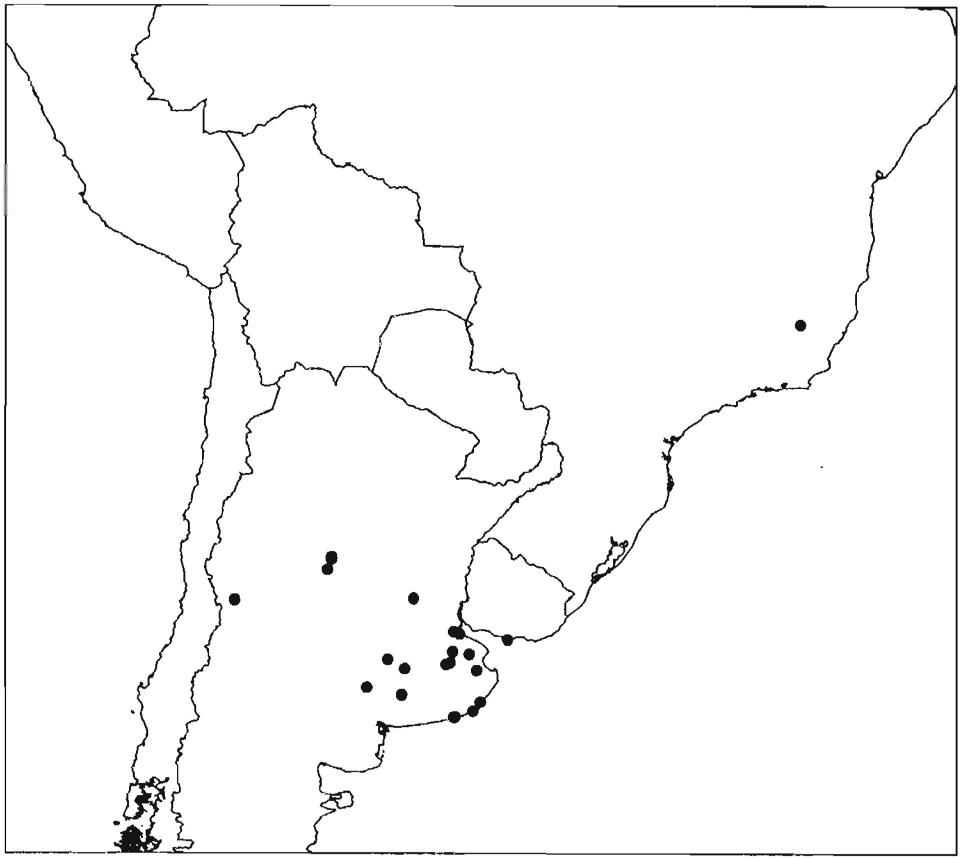

FIG. 10. Collecting localities of *Pelecinus dichrous.*

possession of a triangular pronotum (in lateral view) that reaches the tegula and an apically inserted ovipositor that is retracted into the metasoma when at rest. The former character is shared with many other taxa and the latter has numerous and prominent exceptions. The content of the Proctotrupoidea has varied through the years, and the tendency now is to recognize monophyletic groups of families and to set them aside in their own superfamily. Thus, the Megaspilidae and Ceraphronidae now comprise the Ceraphronoidea; the Bethylidae, Embolemidae and Sclerogibbidae were removed many years ago to the Chrysidoidea; and the Platygastridae and Scelionidae are classified together in the Platygastroidea (see e.g. Naumann, 1990). The remaining extant families—Austroniidae, Diapriidae, Heloridae, Monomachidae, Pelecinidae, Proctotrupidae, Renyxidae, Roproniidae and Vanhorniidae, along with the fossil Jurapriidae and Mesoserphidae—constitute the proctotrupoids. Handlirsch (1933) contended that pelecinids could not be placed in either the Aculeata or the Terebrantia (today, this is seen as a false dichotomy), although they share characters with both, and therefore they should be best placed in their own superfamily, the Pelecinoidea. This suggestion has been followed only by a few authors (e.g. De Santis, 1967; Muesebeck, 1979).

The purported similarity with aculeates was based upon the structure of the ovipositor. Oeser (1961) reviewed the literature and published a detailed analysis of

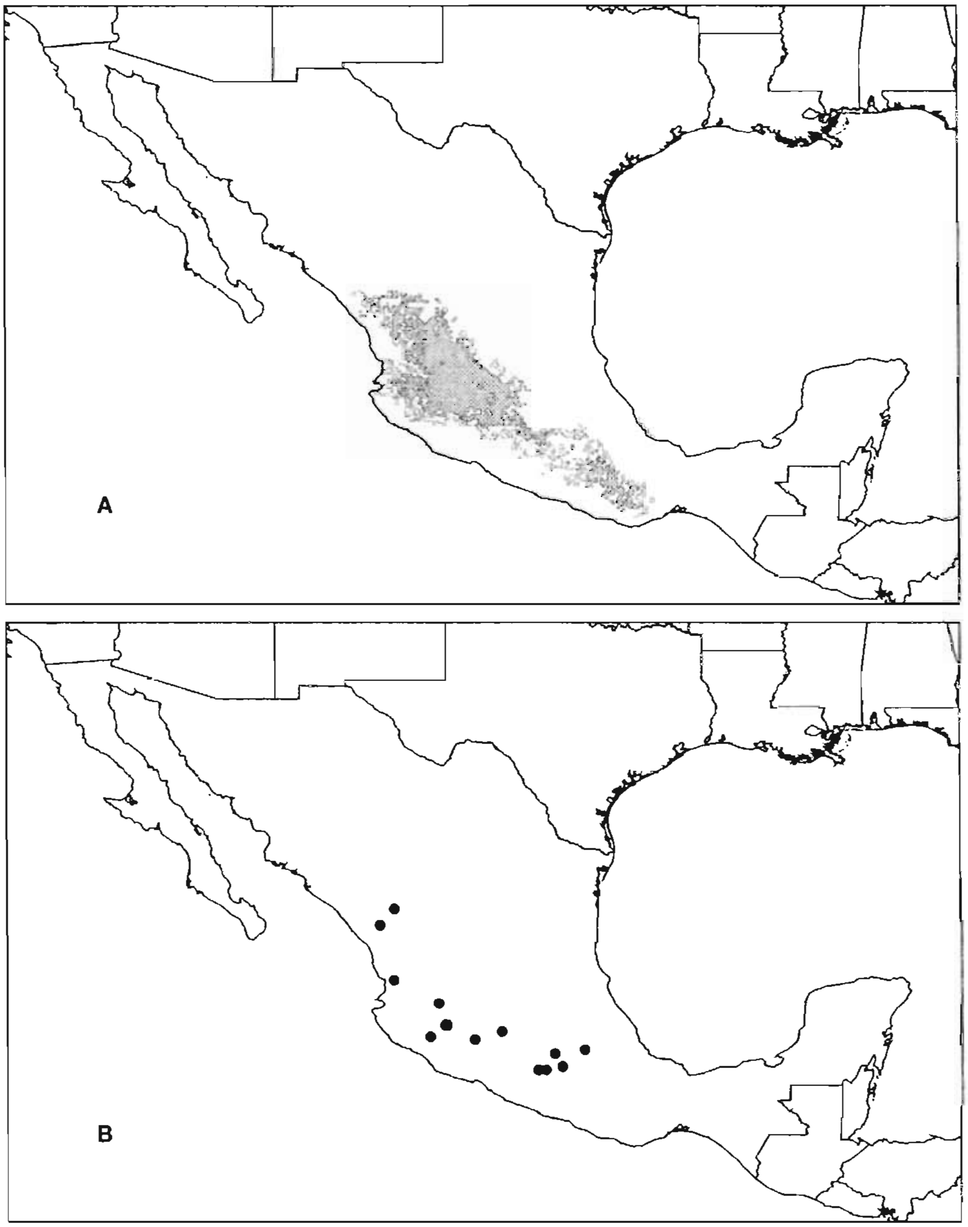


FIG. 11. Distribution of *Pelecinus thoracicus*. (A) Climatic model of distribution. Dense hatching: suitable climate; open hatching: marginal climate; unhatched areas: unsuitable climate. (B) Collecting localities.

the anatomy of the female genitalia. He conclusively demonstrated that the ovipositor of *Pelecinus* is neither reduced (Handlirsch, 1933) nor absent (Schulz, 1904), and that the features claimed to be shared with aculeates are either misinterpreted (the invagination of the ovipositor) or not unique to the aculeates (the fusion of the second gonapophyses). The absence of a furcula, basal articulation, and posterior incision in the second gonocoxae clearly demonstrate that pelecinids are not aculeates.

Königsmann (1978) suggested that Pelecinidae and Monomachidae may be sister groups within the Apocrita. This was based on the overall aspect of the metasoma: elongate in the females, apically clavate in the males. Rasnitsyn (1980), in contrast, suggested that Pelecinidae should be grouped together with Proctotrupidae and Vanhorniidae on the basis of the annular shape of the pronotum (connected ventrally via fusion with the postspiracular sclerites) and their parasitism of larval Coleoptera. He further suggested that Proctotrupidae and Pelecinidae share an apomorphic character in the displacement of the first (=mesothoracic) spiracle anteriorly on to the pronotum. Dowton *et al.* (1997) have recently published results of analyses of mitochondrial 16S RNA sequence data of apocritan wasps. The relationships of the Pelecinidae are highly unstable: under different methods of analysis *Pelecinus* is recovered as the sister group to Proctotrupidae + Vanhorniidae, the sister group to most Proctotrupomorpha (i.e. the Platygastroidea, Proctotrupoidea *sensu lato* and Chalcidoidea, but excluding Cynipoidea), and as the sister-group to Platygastroidea.

Two fossil taxa have been associated with the Pelecinidae (Johnson, 1998). *Pelecinopteron* Brues was described from specimens in Baltic amber, but presently is known only from a single male metasoma preserved in Paleocene amber from Sakhalin Island. The genus *Iscopinus* is based upon a single Cretaceous fossil; Johnson (1998) treated this as a family of uncertain position within the Apocrita.

*Taxonomic problems*

*Wing colour.* The many specific names that have been applied to *Pelecinus* reflect the variability in size, structure and colour found among individuals. Within the genus, fore wing length ranges from 6.5 to 20.8 mm, with the total length of females (excluding the antennae) varying from approximately 20 to 90 mm. The colour of the legs, the presence and extent of the whitish annulus on the antennae, and the colour of the male hind tarsi vary considerably. The extent to which surface sculpture is expressed is roughly correlated with the size of a specimen. Larger females also tend to have the vertex sunken, the compound eyes large and bulging, and the metasoma particularly elongate. The fore wings of most specimens show some infuscation, especially apically and along the costal margin (figure 3A). One of the most extreme variants in wing coloration was first recognized and described by Roman (1910) as the variety *apicalis*.

*Pelecinus polyturator* var. *apicalis* is a shining black wasp, similar in body colour to the typical *P. polyturator*. It is striking in that the apex of the fore wing (actually the apical fifth) is abruptly and strongly infuscate, nearly black (figure 3B–D). The basal edge of this darkened area is roughly perpendicular to the longitudinal axis of the wing, with the posterior edge slightly more apical. The leading edge of the wing, between the stigma and the darkened tip has only a narrow band of infuscation behind the costal vein. This band, of varying width, is present in all specimens of *Pelecinus*. Otherwise, the fore wing membrane is clear. These gracile creatures range widely in size, with fore wing lengths from 10.8 to 19.7 mm, and are primarily found in the central Andean countries of Peru, Ecuador and Bolivia. We also have a series of 20 specimens from the vicinity of Manaus (Reservas Campinas and Ducke). These Amazonian examples have the infuscation paler, more brown in colour, with the posterior edge more irregular and oblique (figure 3C).

Some degree of wing infuscation is a common phenomenon throughout the range of *Pelecinus*. Some specimens (examples from Costa Rica, Venezuela, Brazil and Bolivia) have the entire wings slightly and uniformly darkened. A stronger colour pattern approaching that of *apicalis* is found in specimens from the Brazilian state of Mato Grosso (figure 3E) and from Central America (actually from Colombia north to Veracruz, Mexico; figure 3F). These have a general darkening of the wing apex that starts less abruptly than in *apicalis*, and the coloured area extends around the wing tip along the trailing edge at least as far as the cubital vein. The darkened area in front of the stigma also is much broader, a feature common in males from throughout the range of *Pelecinus* (figure 3G, H). In the area occupied by *apicalis* (generally 1°N to 17°S), the typical form of *polyturator* is also found in almost equal numbers. In fact, specimens of both forms have been collected at the same place and time (e.g. Tingo María, Peru). These sympatric forms are clearly distinguishable on the basis of wing colour; nothing that we would describe as an intermediate form has been found.

At a late stage in this study we discovered two specimens from Colombia (OSUC 17465, OSUC 17466 in BMNH) in which the wing infuscation is extremely oblique. The posterior edge of the dark field is displaced far toward the tip of the wing and does not reach $Rs_2$.

Our search for morphological characters that might correlate with this difference in wing pattern produced only one candidate structure. The posterolateral portion of the propodeum in typical *polyturator* has a series of arcuate wrinkles or rugae extending from the propodeal spiracle to the articulation with the metasoma (figure 6C, D). When viewed at a particular angle, these rugae appear to coalesce to form a longitudinal ridge on either side of the body. In fact, this ridge is not a single structure itself, but a composite feature. The propodeum of *apicalis*, in contrast, usually has a well-defined carina running posteriorly from the spiracle. It is sometimes crenulate above, but appears at all angles of view to be a single, continuous line. Propodeal carinae similar to those of *apicalis* can be found in some extralimital specimens from Argentina and Brazil. These are small individuals in which much of the propodeal sculpture is lacking. The specimens from the Manaus area that we originally associated with *apicalis*, in contrast, have the propodeal carina poorly developed and the sclerite seems very similar to typical *polyturator*.

We applied the BIOCLIM protocols to determine whether the known collecting localities of *apicalis* define a potential geographical distribution that might be distinguishable from that of the typical *polyturator*. In fact, the regions of appropriate climatic regime for the two wing-colour forms greatly overlap (figure 4). These climatic envelopes also include substantial areas in which no specimens are known. Some of these certainly reflect lack of collecting effort, but this cannot be the entire story. Only typical *Pelecinus polyturator* are known from the well-collected Rancho Grande area (Venezuela); *apicalis* certainly is not found there even though the climate appears to be appropriate.

The available data do not provide an unequivocal indication of the appropriate taxonomic status of the name *apicalis*. It may be only a well-defined variant of *polyturator*: both forms are sympatric, fly at the same time, and occur in similar climatic regimes. The size range and mean size of specimens is nearly identical in the area of overlap. Although no intermediates have been found in the area of sympatry, specimens in Colombia to the north and in Mato Grosso to the south-east have strongly infuscate wing tips of two different patterns. One of those Brazilian specimens also has a propodeal carina that strongly resembles *apicalis*.

A second interpretation would be to recognize *apicalis* as a separate species. It is clearly distinguishable from *polyturator* within its geographical range, and that distribution is fairly well circumscribed. We know of no intermediate forms in this area. Accommodation of the Colombian specimens with the strong oblique pattern of wing tip infuscation would require a fairly generous definition of the species limits or they may represent yet a third species. None of these possible species would be based on characters other than colour and geographic distribution.

In struggling with this question, we reconsidered the facts at hand. In the Andean region there are two distinctive phenotypes, typical *polyturator*, with the wings generally infuscate and *apicalis*, with the strongly darkened wing tips. In the central Amazon Basin (Manaus) we have numerous specimens of a single form that is quite similar to *apicalis*, yet the colour and shape of the patch on the wing tip is noticeably different. The other three Amazonian specimens from Belém and specimens peripheral to Amazônia (La Gran Sabana, Venezuela; Caruaru, Pernambuco), initially appeared to be typical *polyturator*. On closer examination, though, the Belém specimens have the faintest indication of the apical darkening of the wing that is found in material from Manaus. The specimens from Venezuela and Belém, and small individuals from Caruaru have beautifully developed propodeal carinae. As a result, we conclude that we cannot unambiguously define *apicalis* since its distinctive characters seem to become more strongly expressed as one proceeds westward through the Amazon Basin. We also cannot support the recognition of *apicalis* as a subspecies because it is sympatric in the Andes with the typical form. Our best interpretation of this situation is that *apicalis* may represent a case of circular overlap.

*Body colour.* The typical *Pelecinus* specimen is shining black in colour, with some variation in the colour of the legs and antennae. A number of more distinctive colour 'variants' have been observed and described as separate species under the names *P. dichrous* Perty, *P. rufus* Klug, *P. thoracicus* Klug, *P. guerinii* De Romand, *P. annulatus* Klug and *P. brunneipes* Patton. The last name was proposed to apply to a small Nearctic specimen (from Tennessee) with lighter-coloured legs (Patton, 1894). Brues (1928) treated the name as a subspecies of *P. polyturator*, but little can be said in support of its recognition at any level. The other colour forms appear more substantial, varying in the hues of the head, mesosoma, and metasoma. The names were applied to specimens from throughout the Neotropics: Mexico, Colombia (Santa Fé de Bogotá), Brazil and Montevideo (presumably Uruguay). Schletterer (1890) swept all these names aside, claiming to find a continuous series of colour variants with intermediates between those that had been formally recognized. In making this assertion it seems that he treated all colour variants together without regard to their geographic origin. We believe there is more substance to this issue than did Schletterer.

We are not concerned here with colour variation that is found in apparently teneral specimens or the fading that occurs in very old material. Small wasps typically have more brown colour in the legs than is found in the large specimens. The colour variants we have observed fall into two geographically distinct categories.

*South America.* Three female specimens from the Serra do Caraça in Minas Gerais, Brazil were collected at 1380 m elevation in November of 1960 and 1961 (MZSP). The wasps are relatively small and slender (fore wing length 11.19–13.22 mm). The first metasomatic segment is entirely black; the following segments are dark reddish brown. The mesosoma, legs, and, to a lesser extent, the lower portion of the head are distinctly brownish red in colour.

A larger series of large and robust *Pelecinus* with a notable dark reddish body colour were collected from the provinces of Buenos Aires, Catamarca, Santa Fé, Córdoba and Mendoza in Argentina, and single specimens from Uruguay (Montevideo) and Paraguay (no further locality data). The extent and intensity of the colour varies and is most strongly evident in the mesosoma. The metasoma is generally darker, and the first segment is almost black. A reddish hue is also apparent on the head. The males are black, with only a slight indication of red in the metasoma of one individual. In all specimens the wings have only the costal cell and the narrow band along the costal margin beyond the stigma infuscate; otherwise the wing membrane is notably clear.

*North America.* From the Mexican states of Puebla, Michoacán and Jalisco a number of very small and distinctive specimens have been collected. The females have the first metasomatic segment black, but the rest of the body is light brown or tan colour. Males also have the mesosoma and first metasomatic segment the same light colour, but the head and apex of the metasoma in males are black and the hind tibiae usually are darkened apically. The wings of females are clear, the venation light brown. Males have the wings more generally, but only slightly, infuscate.

From Michoacán, Jalisco, Durango and Sinaloa (Mexico): female specimens, larger than those just described, in which the head and mesosoma are black; the legs, including the coxae, are light brown; the first, fifth and sixth metasomatic segments are entirely black; but the second, third and fourth segments are light brown through nearly their entire length, with only the apex black. The metasomatic colour gives the appearance that these individual segments are banded. Males are entirely black with the exception of the legs: these are largely light brown in colour, with the hind tibiae strongly darkened. The wings in both males and females are slightly darkened throughout their length.

Finally, from the states of Guerrero, Morelos, Michoacán, Jalisco and Nayarit of Mexico there is a short series of female specimens with black head; light brown to reddish mesosoma; light brown legs; and the same banded pattern of metasomatic coloration as in the previous form, except that the pattern continues on to segment five. Two male specimens have a black head; brown mesosoma and legs; and a dark brown to black metasoma. All but two of the specimens with this pattern of body colour have the wings strongly darkened, especially the tips (reminiscent of *apicalis*).

We have had difficulty in interpreting the older literature and matching the colour described with those we see in the specimens before us. De Romand (1840a) described *P. guerinii* from a female specimen in which the head, mesosoma and basal metasomatic segment were black, and the remainder of the metasoma entirely yellowish brown. He did not specify the provenance of the specimen, we have not seen any that matches this description.

Three nominal species of colour variants come from South America and may correspond to the material from Serra do Caraça, Uruguay, Paraguay and Argentina. Klug (1841) described *P. annulatus* on the basis of a male specimen from Montevideo. He emphasized that the mesosoma is reddish brown, the head and metasoma black, the legs brown, but with the hind tibiae black. *Pelecinus dichrous* Perty also hails from Montevideo. In this species the head under the eyes, the mandibles and the pronotum are blood-red; the legs darker red. The specimens from the original description are generally small, the male 20 mm in length (5–8½ lines), the females 40 mm (15–22 lines) (the conversion from Klug's lines provided in the redescription by De Romand). The original description of *Pelecinus rufus* Klug refers to a male and female from Brazil, notable because of their shining brown colour. Klug (1841) described the head as much darker than the body. The male has the apex of the abdomen dark; the base of the female metasoma is black.

*Pelecinus thoracicus* Klug is the only colour variant described from North America. This description matches well the small light brown specimens, with the added benefit that the name was based on specimens from Mexico.

The colour pattern variants we found range from the subtle to the dramatic. On that basis alone, we were reluctant to recognize distinct species. Therefore, we sought to find corroborating morphological or biological evidence that might lend support to hypotheses of specific differences.

*South America.* The reddish Argentine specimens actually attracted our attention initially not because of the colour, but because of their more solid habitus. The head and mesosoma are robust, the metasoma, wings and antennae seem rather short for the overall size of the specimens. We measured the length and width of the head, length of the fore wing, and lengths of the individual metasomatic segments for these specimens and compared these values with those for typical *polyturator*.

The heads of these red Argentine specimens also seemed to be more square than in *polyturator*, with relatively smaller eyes, and with the vertex flat, level with the upper edge of the eyes. One measure of the relative length of the eyes is the ratio of malar length to eye height (eye height + malar length = head length). Figure 5F compares this ratio as a function of head width. The ratio is substantially higher in the Argentine specimens (mean = 0.50) than in *polyturator* (mean = 0.40, upper 95% confidence limit = 0.412). As one measure of the relative lengths of metasomatic segments, we compare the ratio of the length of the first segment to the length of the third segment with the combined lengths of all metasomatic segments. *Pelecinus polyturator* demonstrates a significant allometric pattern, with the third segment becoming increasingly elongate in larger specimens (figure 5B). The Argentine specimens, although from a more restricted range of sizes, show no change in the ratio of sizes of these two segments. Therefore, larger specimens appear to have a shorter metasoma in comparison with *polyturator* of the same size. Finally, it seemed that the red Argentine specimens have relatively short wings for such large insects. Figure 5D compares fore wing length with head width and demonstrates that typical *polyturator* have longer wings for a given head width.

Typical *Pelecinus* polyturator exhibits a great range in the development and expression of sculptural characters, and it is difficult to find any morphological variant that is not approximated in some specimens. The red South American specimens are exceptional, however, in the degree to which the lateral propodeal carinae are expanded into a high flange, especially in large females. The propodeal carina begins posteriorly as a series of diagonal ridges that merge anteriorly.

The specimens from the Serra do Caraça are quite distinctive in colour. However, from the same locality, collected in the months from January to April (some collected by the same people) we have a series of specimens with the body entirely black. Our initial assumption was that the two sets of specimens are probably conspecific and the difference in colour was somehow related to the difference in collecting dates. Our attempts to find morphological characters to distinguish the red Brazilian material from the red Argentine specimens were fruitless, and conversely, the red and black Brazilian specimens are easily separable on the basis of propodeal sculpture. Because of their small size, the allometric effects described above are not immediately apparent. Despite the great distance separating the Brazilian specimens from the populations in Argentina and Uruguay, we conclude that they are conspecific (the single specimen from Paraguay has no specific locality data).

When the BIOCLIM protocols were used to identify climatic envelopes for the red specimens and typical South American *polyturator* a fair degree of complementarity was revealed (compare figure 8 with figures 9 and 10). Because all recorded localities for specimens by definition will fall within the climatic envelopes, this suggests that the two forms are largely allopatric. The 'suitable' climatic envelope for the red specimens is a relatively small area in eastern to central Argentina, an arid region with little arboreal vegetation (Cabrera and Willink, 1980). This contrasts sharply with the moist forest habitat of the Yungas and the Mata Atlântica in which *polyturator* is common. The red *Pelecinus* may actually be found in moister microenvironments (e.g. along permanent water) rather than the open habitats. Focused field work would greatly contribute towards the resolution of this question. Adding the Brazilian specimens to the analysis, surprisingly, did not add an extensive area of suitable climate to the distribution estimate. The disjunctions in the distribution of specimens and the areas of suitable climate identified should not necessarily lead to the conclusion that this species is truly absent from intervening areas. Only further collections can lead to a more definitive estimate of distribution.

The laconic descriptions of all three species *dichrous*, *rufus* and *annulatus* could reasonably refer to this red species. The first, *Pelecinus dichrous* Perty, accurately characterizes the colour and has priority for application to this species (**new status**); *P. rufus* Klug and *P. annulatus* Klug should be considered to be junior synonyms (**new synonyms**).

*North America.* The frontal aspect of the head of the western Mexican specimens seemed similar to that observed in *P. dichrous*, i.e. that the head is more rectangular, the eyes smaller and the vertex flatter. Figure 5E illustrates the ratio of malar length/eye height as a function of head width for these Mexican specimens (solid circles) in comparison with *polyturator* (open circles). Overall, this ratio is larger in the Mexican colour forms (mean $=0.487$, SD $=0.067$) than in *polyturator* (mean $=0.401$, SD $=0.076$), and if one assumes for the sake of argument that these samples are random, then the two populations differ significantly ($t=5.75$). The assumptions necessary for such a statistical test clearly are not met, however, and we interpret the comparison as suggestive, but not definitive.

One striking difference was found in the structure of the lower portion of the occipital carina. In *polyturator* (and *dichrous*) the carina extends as a distinct, simple ridge connecting the posterior mandibular articulations, and the genae are only sparsely setose (figure 6B). The carina is clearly visible in lateral view. In contrast, the occipital carina in the Mexican 'red' material is much more variable. In the smallest specimens there is a substantial area, largely smooth, with some scattered punctures and setae, that separates widely the lower extremes of the occipital carina from the mandibles. The carina ends on the posterior surface of the head, at a level slightly below the lower edge of the compound eye. In most specimens with the banded metasoma, the carina ends in a fairly dense field of punctures. At some angles of view, the alignment of the raised edges of the punctures and the orientation of the setae may give the impression of an irregular ridge that extends to the mandibular articulation. The course of the carina is further obscured by the dense setae in this area, particularly in males. The sharp, raised occipital carina ends at a level at or slightly below the level of the lower edge of the eyes. In a few specimens the carina does appear actually to reach the mandibles, but it is irregular and surrounded by deep punctures.

From one point of view, the last colour form described above (black head, red mesosoma, banded metasoma) could be considered an intermediate connecting the other Mexican forms. Two female specimens (specimen ID numbers OSUC 7249 and OSUC 7248) with red mesosoma and banded metasoma combine further features. They have the reddish brown mesosoma, but the wings are quite hyaline, and the head is dark brown to black in the upper half, reddish brown below. The occipital carina appears very similar to the banded forms just described, but lacks the dense field of punctures. In other words, these specimens have a combination of characters that makes it impossible to consistently distinguish among the colour forms. We therefore treat them as a single species. Klug's description of *P. thoracicus* unmistakably describes the smallest colour variant that has a reddish head, mesosoma and metasoma.

The climatic analysis of *thoracicus* defines an envelope in central Mexico generally west of the Sierra Madre Occidental (figure 11). The entire range is overlapped by areas classified as marginal for *polyturator*. In fact, typical *polyturator* has been collected throughout the region, and in those eight states *polyturator* specimens outnumber *thoracicus* by 91 to 56. The two species appear to be broadly sympatric in western Mexico, although the areas classified as suitable do not overlap.

## *Pelecinus* Latreille

*Pelecinus* Latreille, 1800: 155. Type: *Ichneumon polycerator* Fabricius (= *Ichneumon polyturator* Drury), designated by Latreille (1810)

*Episceuastes* Gistel, 1848: x. Type: *Ichneumon polycerator* Fabricius, by substitution of *Episceuastes* for *Pelecinus* Latreille, unnecessary replacement name

(For full synonymy see Johnson, 1992)

*Head* (figure 6A, B). Inner orbits weakly convergent ventrally, nearly parallel; maxillary palp 5-segmented; labial palp 3-segmented; mandibles bidentate, broadly overlapping, basal half with dense, long setae, basal tooth distinctly smaller; ocelli in equilateral triangle, POL > OOL; occipital carina strongly raised medially; frons medially developed into a roughly triangular elevation; malar sulcus well-developed; clypeus convex, strongly punctured, covered with long setae, anterior margin weakly sinuate; antennae filiform, arising high above clypeus, 14-segmented in both sexes, predominantly dark brown; female antenna with A9, A10, and sometimes A8 lighter in colour (the annulus), varying from light brown to yellowish white; A1 short, excavated basally on outer margin, A2 globular, A3–A14 elongate, cylindrical; segments of male flagellum slightly shorter basally and apically; basal segments of female flagellum distinctly more elongate, becoming shorter distally; ratios of length to width of male antennomeres (A1, A2, ... A14): 1.6, 0.9, 8.0, 11.8, 13.0, 13.2, 12.8, 13.1, 12.1, 12.1, 11.6, 11.5, 10.0, 9.7; ratios of length to width of female antennomeres (A1, A2, ... A14): 2.9, 1.0, 11.9, 20.8, 17.1, 15.3, 13.2, 12.0, 10.6, 9.9, 8.5, 8.3, 6.7, 7.8.

*Mesosoma* (figure 6C, 6D). Pronotum annular, seen from above with a distinct trapezoidal section on dorsal midline, anterior to this the pronotum drops off vertically to form a short collar connecting head and mesosoma, epomia strongly developed laterally, first thoracic spiracle displaced anteriorly to arise on lateral portion of pronotum on a small fusiform area; notauli well-developed, crenulate, confluent posteriorly; mesoscutum and scutellum separated by a broad, deeply crenulate furrow; axillae narrow; scutellum strongly arched; metanotum narrow, dorsellum weakly developed; propodeum elongate, usually with median longitudinal smooth area, between this and spiracles quite variable sculptured, laterally more or less densely setose; sternaulus weakly developed; mesopleural scrobe weakly concave, smooth; tibial spur formula 1-2-2; hind tibia of female swollen apically (figure 1A–C), densely setose medially, with a crescent-shaped cleft in basal third; hind tibia of male only gradually widened apically (figure 1D), densely covered with fine setae; hind tarsus of both sexes with basal segment strongly shortened; hind tarsi of male usually lighter in colour to varying degrees, beginning with segment 2, extending apically as far as segment 5, colour varying from light brown or yellowish brown to white, basal segment strongly darkened, brown or black; fore wing (figure 3) with only two tubular veins, C and Sc + R in base of wing; costal cell open, strongly infuscate; stigma narrow, elongate; Rs apically with two divergent branches, usually called $Rs_1$, $Rs_2$; medial cell trapezoidal; M extending from apical margin of wing through at least distal half of wing, fading before reaching medial cell; cells $1R_1$ and $2R_1$ indicated in some specimens; Cu extends throughout wing; 2cu-a arises opposite or distal to m-cu; apex of wing usually with some degree of infuscation, often more strongly expressed in males; hind wing without any tubular veins, with only broad infuscation along costal margin; the wings are carried in a fully supinated position and not folded over the dorsum at rest, alert wasps hold the wings above the mesosoma, at rest they may be lowered and held on either side of the body.

*Metasoma*. Female metasoma (figure 1A–C) extremely elongate, with six clearly divided functional segments; tergum and sternum of first metasomatic segment independent, tergum broadly overlapping sternum, with pair of functional spiracles; terga of metasomatic segments 2–5 encircling segment, fused along midline ventrally to form a tube; sterna of segments 2–5 divided into basal and apical portions, forming specialized articulations between segments that allow lateral flexion (Mason, 1984); apical apparent segment composed of sternum of metasomatic segment 6 and terga of segments 6–8; cerci present, medially approximated; ovipositor short, largely hidden within apical apparent segment. Male metasoma (figure 1D) composed of seven terga and sterna, only six visible externally; basal segment elongate, metasoma apically expanded, more or less clavate; terga and sterna strongly attached to each other and to adjacent segments; male genitalia with unsegmented parameres; cuspis absent; digitus with numerous small digital teeth, these arranged in two or more rows near apex of digitus.

*Diagnosis*. *Pelecinus* can only be confused with the Monomachidae from the Neotropics. The fore wing of monomachids (macropterous forms, a brachypterous species known from Chile where *Pelecinus* is not known to occur) has numerous tubular veins and, usually, a closed radial cell; the hind wing has numerous veins; the hind tibia of the female gradually increases in diameter distally and is not grossly enlarged; and the basal tarsomere of the hind tarsus is longer than the second.

*Species list*. Included here are all names that have been assigned to the genus *Pelecinus*. Indented names are synonyms of the name that they subtend. Specific, subspecific and varietal names are treated equally.

*dichrous* Perty, 1833 **new status**
  *annulatus* Klug, 1841 **new synonym**
  *rufus* Klug, 1841 **new synonym**
*fuscator* Perty, 1833: transferred to *Monomachus* (Monomachidae) by Klug (1841)
*polyturator* (Drury, 1773)
  *apicalis* Roman, 1910
  *brunneipes* Patton, 1894

*clavator* Latreille, 1817
*duponchelii* De Romand, 1842
*guerinii* De Romand, 1840a
*libellula* (Christ, 1791)
*peruvianus* Brèthes, 1920
*polycerator* (Fabricius, 1777)
*spinolae* De Romand, 1842
*tibiator* Perty, 1833
*thoracicus* Klug, 1841 **new status**

## Key to species of *Pelecinus*

1 Males (figure 1D): metasoma short, strongly expanded apically, hind tibiae gradually expanded apically; segments 2–5 of hind tarsi usually lighter in colour than basitarsus and tibia, white to light brown . . . . . . . . . . . . 2
– Females (figure 1A-C): metasoma extremely elongate, beyond first segment uniformly cylindrical; hind tibiae strongly expanded; hind tarsomeres dark . . . 3

2 (1) Legs, except hind tibiae, light brown to reddish brown; mesosoma often distinctly brown to reddish brown . . . . . . . . . . . *P. thoracicus* Klug
– Legs dark brown to black; head, mesosoma and metasoma always dark brown to black . . . . . . . . . *P. polyturator* (Drury) and *P. dichrous* Perty

3 (1) Head, mesosoma and metasoma entirely shining black (widespread in the New World) . . . . . . . . . . . . . . . . *P. polyturator* (Drury)
– Metasoma or mesosoma with reddish coloration (some *dichrous* overall rather dark in colour) . . . . . . . . . . . . . . . . . . . . 4

4 (3) Mesosoma dark reddish brown to black in colour, concolorous with first metasomatic segment . . . . . . . . . . . . . . . . . . . . 5
– Mesosoma light brown in colour, contrasting distinctly with black base of first metasomatic segment . . . . . . . . . . . . *P. thoracicus* Klug

5 (4) Legs and base of metasomatic segments 2–4 light brown, contrasting strongly with head, mesosoma, and first metasomatic segment; occipital carina either abbreviated ventrally or indistinctly ending in a field of punctures and setae *P. thoracicus* Klug
– Legs and metasomatic segments 2–5 dark reddish brown, concolorous with head and mesosoma; occipital carina reaching posterior mandibular articulations as a distinct raised line . . . . . . . . . . . . . . *P. dichrous* Perty

### *Pelecinus polyturator* (Drury)
(figures 1A, 3, 6–8)

*Ichneumon polyturator* Drury, 1773: 77, 92, ♀. Location of type material unknown
*Ichneumon polycerator* Fabricius, 1777: 245. Synonymized by Klug (1841), and implicitly by Latreille (1805). Location of type material unknown
*Ichneumon libellula* Christ, 1791: 352. Synonymized by Klug (1841). Location of type material unknown
*Pelecinus clavator* Latreille, 1817: 377. Synonymized by Klug (1841). Location of type material unknown
*Pelecinus tibiator* Perty, 1833: 131. Synonymized by Klug (1841). Type not found in Zoologische Staatssammlung, Munich (Diller, 1990)
*Pelecinus guerinii* De Romand, 1840a: 2, plate 49, figure 2, ♀. Synonymized by Schletterer (1890). Location of type material unknown
*Pelecinus duponchelii* De Romand, 1842: 1, plate 86, figure 1, ♂, ♀. Synonymized by Schletterer (1890). Location of type material unknown
*Pelecinus spinolae* De Romand, 1842: 2, plate 86, figure 2, ♂. Synonymized by Schletterer (1890). Location of type material unknown

*Pelecinus brunneipes* Patton, 1894: 896, ♀. Synonymized by Brues (1928). Location of type material unknown
*Pelecinus polyturator* var. *apicalis* Roman, 1910: 196, ♀. Holotype (examined) in NHRS
*Pelecinus polyturator* v. *peruvianus* Brèthes, 1920: 49, ♀. Holotype (examined) in MACN
(For full synonymy see Johnson, 1992)

*Female. Colour.* Body usually shining black, head and mesosoma sometimes dark brown or, rarely, distinctly reddish brown; mandibles black to brown, teeth often lighter in colour; coxae dark brown to black, legs otherwise dark, usually dark brown to black with apices of segments brown; wing colour variable, usually at least faintly coloured throughout, varying from pale yellowish to greyish cast; apex of fore wing variably infuscate, sometimes apical one-fifth of fore wing with sharply defined infuscation, ranging in colour from brown to black, or edges of the darkened area fading into wing membrane, sometimes more strongly developed and extending from stigma, around apex of wing, to or beyond apex of Cu.

*Head.* Eyes large, often appearing bulging in frontal view; vertex, especially in large specimens, concave, sunken below upper level of compound eyes, varying from smooth to coarsely punctate; frons, clypeus, base of mandibles with quite variable number of long setae; frons and clypeus strongly, irregularly rugulose, sculpture very variable; occiput and gena sparsely setose; occipital carina completely encircling head, extending to posterior mandibular articulations, carina clearly visible in lateral view; head length/head width 0.59–0.81 (mean = 0.67, SD = 0.028, $N$ = 153); head length 1.08–2.43 mm (mean = 1.76, SD = 0.349); head width 1.65–3.60 mm (mean = 2.61, SD = 0.449); malar length/eye height 0.26–0.64 (mean = 0.40, SD = 0.074).

*Mesosoma.* Posterior angles of pronotum near tegula varying in sculpture and setation, ranging from strongly punctate or wrinkled to very finely punctate; scutellum smooth or with shallowly incised punctures, crenulae along posterior margin varying from small uniform punctures to deep impressions, longest medially; dorsellum defined above by small row of punctures or elongate crenulae; mesepisternum below mesopleural scrobe with sparse to moderately dense setae; sculpture of disk of propodeum variable, usually with strong transverse rugulae, these often interrupted by smooth area medially, in smaller specimens rugulae abbreviated to some extent, smooth area more extensive; lateral area between propodeal spiracle and articulation of metasoma with series of arcuate rugulae, these, when seen from above, appearing to coalesce to define a ridge delimiting the dorsal and lateral surfaces of the propodeum; ventrolateral portion of propodeum behind hind coxa with deep circular to oval pit filled with setae; stem of Rs beyond 2r-rs quite variable in length, sometimes nearly pointlike; $Rs_2$ sometimes reaching edge of wing; M usually cannot be traced to intersection with cell 1M; fore wing length 6.53–20.85 mm (mean = 14.10, SD = 3.165, $N$ = 152).

*Metasoma.* Length 17.80–79.15 mm (mean = 43.64, SD = 13.221, $N$ = 149); length of first segment 4.15–14.58 mm (mean = 8.76, SD = 2.376); length of second segment 3.31–16.95 mm (mean = 8.67, SD = 2.851); length of third segment 3.56–18.81 mm (mean = 9.48, SD = 3.114); length of fourth segment 3.05–15.09 mm (mean = 7.91, SD = 2.552); length of fifth segment 2.63–10.68 mm (mean = 6.36, SD = 1.868); length of apparent sixth segment (true metasomatic segments 6–9) 1.10–3.56 mm (mean = 2.47, SD = 0.579); length of first segment/length of third segment 0.78–1.17 (mean = 0.94, SD = 0.078).

*Male.* Head length/head width 0.60–0.90 (mean = 0.68, SD = 0.035, $N$ = 99); head length 0.97–2.02 mm (mean = 1.59, SD = 0.263); head width 1.54–3.00 mm (mean = 2.33, SD = 0.340); malar length/eye height 0.19–0.56 (mean = 0.32, SD = 0.068); wing length 7.3–16.5 mm (mean = 12.4, SD = 1.46).

*Diagnosis.* Head and body shining black; occipital carina completely encircling head, reaching mandibles; wing variously infuscated, in extreme cases with apical darkened area spreading from stigma around wing tip as far as Cu along posterior margin.

*Known hosts.* *Phyllophaga anxia* (LeConte), *P. inversa* (Horn), *P. drakei* Kirby, *P. rugosa* (Melsheimer) (Coleoptera: Scarabaeidae, Melolonthinae); *Podischnus agenor* Olivier (Coleoptera: Scarabaeidae, Dynastinae).

*Material examined.* 1546 ♂, 6028 ♀ from (figures 7B and 8B): **Canada**: 38 ♂, 336 ♀ from New Brunswick, Nova Scotia, Ontario, Prince Edward Island, Québec (AEIC, BMNH, CASC, CMNH, CNCI, CUIC, DENH, DFEC, IMLA, INHS, MNHN, MSUC, NHRS, PSUC, PURC, QBUM, RMNH, ROME, TKPC, UMMZ, UMRM, USNM, VPIC, ZSMC). **USA**: 107 ♂, 3245 ♀ from North Dakota, South Dakota, Nebraska, Colorado, New Mexico and all states east (AEIC, AMNH, ANSP, BMNH, BMSC, CASC, CIDA, CMNH, CNCI, CSUC, CUIC, CUMZ, DEIC, DENH, DFEC, DNHC, EDNC, EMEC, EMUS, ESUW, FMNH, FSCA, INHS, IRCW, KSUC, LACM, LUCI, MCPM, MCZC, MEMU, MHNG, MLPA, MNHN, MSUC, MTEC, MZSP, NCSU, NDSU, NHMW, NHRS, NYSM, OSEC, OSUC, PKLC, PMNH, PSUC, PURC, QBUM, RMNH, ROME, RUIC, RWFC, SDSU, SEMC, SIUC, TAMU, UADE, UAIC, UCCC, UCDC, UCMC, UCMS, UCRC, UDCC, UGCA, ULKY, UMDE, UMEC, UMIC, UMMZ, UMRM, UMSP, UNSM, USNM, UVCC, VPIC, WFBM, WSUC, WVUC, ZSMC). **Mexico**: 144 ♂, 297 ♀ from Chiapas, Colima, Durango, Guerrero, Hidalgo, Jalisco, Michoacán, Nayarit, Oaxaca, Puebla, San Luís Potosí, Sinaloa, Tamaulipas, Veracruz (AEIC, ANSP, BMNH, CASC, CIDA, CNCI, CUIC, EBCC, EMEC, EMUS, FSCA, INHS, KSUC, LACM, MAIC, MCZC, MHNG, MNHN, MSUC, NHMW, NHRS, OSUC, PKLC, PMNH, PURC, RMNH, ROME, SEMC, TAMU, UAIC, UCDC, UCRC, UGCA, UMMZ, UMSP, UNAM, USNM, UVCC). **Guatemala**: 19 ♀ from Alta Verapaz, Baja Verapaz, El Progreso, Sacatepéquez, Sololá, Zacapa (BMNH, CASC, CNCI, SEMC, UGCA, UMMZ, USNM). **Honduras**: 15 ♂, 85 ♀ from Cortés, Francisco Morazán, Olancho, Santa Bárbara, Yoro (EAPZ, FSCA, MEMU, UGCA). **Nicaragua**: 2 ♂, 15 ♀ from Chontales, Jinotega, Matagalpa (BMNH, CASC, SEAN, TAMU). **Costa Rica**: 387 ♂, 476 ♀ from Alajuela, Cartago, Guanacaste, Heredia, Limón, Puntarenas, San José ( AEIC, BMNH, CASC, CNCI, DEIC, DFEC, EMEC, EMUS, FIOC, FSCA, INBC, INHS, LACM, MNHN, NHMW, NHRS, PMNH, PURC, ROME, SEMC, TAMU, UCDC, UCMC, UMSP, UNSM, USNM, ZSMC). **Panama**: 15 ♂, 94 ♀ from Chiriquí, Darién, Panamá, Veraguas (AEIC, AMNH, ANSP, BMNH, CASC, CNCI, EMUS, INPA, LACM, MNHN, RMNH, SEMC, STRI, TAMU, UMRM, UNSM, USNM). **Colombia**: 59 ♂, 93 ♀ from Antioquia, Bogotá, Boyacá, Caldas, Caquetá, Cauca, Cundinamarca, Huila, Magdalena, Nariño, Norte de Santander, Risaralda, Santander, Valle del Cauca (AEIC, AMNH, ANSP, BMNH, CASC, CMNH, FSCA, IMLA, INHS, IZAV, MCZC, MNHN, NCSU, NHRS, SEMC, UADE, UCDC, UMMZ, UMCB, USNM). **Venezuela**: 98 ♂, 169 ♀ from Aragua, Barinas, Bolívar, Carabobo, Distrito Federal, Lara, Miranda, Táchira, Trujillo, Yaracuy (AEIC, AMNH, BMNH, CASC, CNCI, FSCA, IZAV, MAIC, NHRS, OSUC, QBUM, RSMC, UMMZ, UMSP, USNM, ZSMC). **French Guiana**: 1 ♀ from Cayenne (MNHN). **Ecuador**: 55 ♂, 93 ♀ from Azuay, Bolívar, Cañar, Carchi, Cotopaxi, El Oro, Guayas, Morona-Santiago, Napo, Pastaza, Pichincha, Tungurahua, Zamora-Chinchipe (AEIC, AMNH, ANSP, BMNH, CASC, CMNH, CNCI, EMEC, EMUS, IMLA, LACM, MNHN, NHRS, OSUC, PSUC, QCAZ, UMRM, USNM, WFBM, WSUC). **Peru**: 65 ♂, 208 ♀ from Amazonas, Cuzco, Huánuco, Junín, Lima, Loreto, Madre de Dios, Puno, San Martín (AEIC, AMNH, BMNH, BMSC, CASC, CNCI, CUIC, DEIC, EMUS, FSCA, IMLA, INHS, MCZC, MZSP, NHRS, SEMC, USNM, ZSMC). **Bolivia**: 17 ♂, 87 ♀ from Cochabamba, El Beni, La Paz, Santa Cruz, Tarija (AEIC, AMNH, BMNH, CMNH, CNCI, CUIC, EMUS, FSCA, IMLA, MCZC, MZSP, NHMW, NHRS, USNM, ZMHU, ZSMC). **Paraguay**: 6 ♀ from Caaguazú (CNCI, MCZC). **Brazil**: 136 ♂, 524 ♀ from Alagoas, Amazonas, Bahia, Goiás, Mato Grosso, Minas Gerais, Pará, Paraná, Pernambuco, Rio de Janeiro, Santa Catarina, São Paulo, Rio Grande do Sul (AEIC, AMNH, ANSP, BMNH, CASC, CMNH, CNCI, CUIC, DEIC, FIOC, FSCA, IMLA, INPA, MCZC, MHNG, MNHN, MZSP, NHMW, NHRS, PMNH, QBUM, SEMC, UCCC, UCDC, UMSP, USNM, ZSMC). **Uruguay**: 1 ♂, 6 ♀ from Cerro Largo, Montevideo, Tacuarembó (AMNH, MNHN). **Argentina**: 405 ♂, 298 ♀ from Buenos Aires, Catamarca, Chaco, Córdoba, Jujuy, Misiones, Salta, San Juan, Santiago del Estero, Tucumán (AEIC, AMNH, BMNH, CNCI, CUIC, FIOC, FSCA, IMLA, LACM, MCZC, MLPA, MNHN, MZSP, UCDC, USNM). Other indeterminate localities (e.g. North America, South America): 11 ♀.

### *Pelecinus dichrous* Perty, new status
(figures 1C, 9, 10)

*Pelecinus dichrous* Perty, 1833: 131. Holotype missing from Zoologische Staatssammlung, Munich (Diller, 1990)
*Pelecinus annulatus* Klug, 1841: 384, ♂. Location of type material unknown. **New synonym.**
*Pelecinus rufus* Klug, 1841: 384, ♂, ♀. Location of type material unknown. **New synonym.**
(For full synonymy see Johnson, 1992)

Differs from *P. polyturator* in the following characteristics:

*Female.* Entire body with reddish brown hue, sometimes quite dark; wings hyaline, without apical infuscation; eyes appearing relatively small, head quadrate; vertex flat, not sunken below level of eyes; head length/head width 0.65–0.73 (mean = 0.69, SD = 0.017, $N$ = 49); head length 1.45–2.27 mm (mean = 1.86, SD = 0.228); head width 2.14–3.36 mm (mean = 2.68, SD = 0.305); malar length/eye height 0.32–0.69 (mean = 0.50, SD = 0.092); lateral carinae of propodeum often strongly developed, forming a wide flange above propodeal spiracle, strongly arcuate near metasoma; ventrolateral propodeal pit with ventral margin strongly margined below, upper portion at most weakly differentiated from propodeum; metasoma and wings relatively short for body size; wing length 9.66–15.76 mm (mean = 12.47, SD = 1.672); metasoma length 26.78–47.29 mm (mean = 36.56, SD = 5.490, $N$ = 46); length of first segment 5.59–10.34 mm (mean = 7.84, SD = 1.211); length of second segment 5.09–8.98 mm (mean = 7.12, SD = 1.104); length of third segment 5.59–10.00 mm (mean = 7.64, SD = 1.200); length of fourth segment 4.58–8.31 mm (mean = 6.26, SD = 0.965); length of fifth segment 4.07–7.29 mm (mean = 5.50 SD = 0.760); length of apparent sixth segment (true metasomatic segments 6–9) 1.86–3.05 mm (mean = 2.20, SD = 0.295); length of first segment/length of third segment 0.96–1.11 (mean = 1.03, SD = 0.033).

*Male.* Head length/head width 0.73–0.76 (mean = 0.74, SD = 0.015, $N$ = 3); head length 1.65–1.93 mm (mean = 1.81, SD = 0.151); head width 2.17–2.63 mm (mean = 2.45, SD = 0.248); malar length/eye height 0.37–0.55 (mean = 0.46, SD = 0.089); fore wing length 10.34–12.21 mm (mean = 11.58, SD = 1.076).

*Diagnosis.* The reddish hue of the entire body, the relatively short wings, short metasoma, and robust mesosoma of *P. dichrous* distinguish it from the more elongate, black *P. polyturator*.

*Material examined.* 4 ♂, 53 ♀ (figures 9 and 10) from: **Argentina**: 4 ♂, 48 ♀ Buenos Aires, Catamarca, Córdoba, Mendoza, Santa Fé (AMNH, BMNH, IMLA, MACN, MLPA, USNM, ZSMC). **Brazil**: 3 ♀ from Minas Gerais (MZSP). **Paraguay**: 1 ♀ (MACN). **Uruguay**: 1 ♀ from Montevideo (MNHG).

*Discussion.* We have found no characters that conclusively associate the four male specimens with females of *P. dichrous*. The original description of Perty states that males have the same red colour on the body as the females. Three of our specimens are entirely black; the metasoma of the fourth has some red colour. We have associated them with the name *dichrous* by virtue of their collecting localities: in this region we have seen no females of the typical *polyturator*, and on the basis of the shape of the propodeal pit and pattern of wing infuscation.

### *Pelecinus thoracicus* Klug, new status

(figures 1B, 1D, 11)

*Pelecinus thoracicus* Klug, 1841: 384, ♂. Type not seen
(For full synonymy see Johnson, 1992)

Differs from *P. polyturator* in the following characteristics:

*Female. Colour.* Body with more or less extensive reddish to yellowish brown coloration; three colour patterns usually recognizable: (1) head, mesosoma, metasomatic segments 2–5 entirely light brown, first and last apparent segment of metasoma dark brown to black; (2) head, mesosoma, first, fifth and apparent sixth segment of metasoma black, metasomatic segments 2–4 with extensive brown colour basally, apex of each segment dark brown to black; (3) head, first, fifth and apparent sixth segment of metasoma dark brown to black, mesosoma yellowish to reddish brown, metasomatic segments 2–4 as in second pattern described above. Legs brown to reddish brown, including coxae; wings quite variable in colour, ranging from clear to strongly infuscate throughout.

*Head.* Occipital carina abbreviated ventrally, not extending to mandibular articulations; area between mandible and occipital carina punctate, sometimes densely setose; occiput, gena, frons, mandibles sometimes densely setose; head length/head width 0.62–0.71 (mean = 0.66, SD = 0.020, $N = 28$); head length 0.99–2.01 mm (mean = 1.48, SD = 0.264); head width 1.49–2.92 mm (mean = 2.24, SD = 0.379); malar length/eye height 0.34–0.61 (mean = 0.49, SD = 0.067).

*Mesosoma.* Mesepisternum below mesopleural scrobe densely setose; propodeum posteriorly with irregular rugulae between spiracle and articulation of metasoma; ventrolateral pit on propodeum deep, sometimes quite large, strongly margined below; fore wing length 6.61–14.75 mm (mean = 11.09, SD = 2.455).

*Metasoma.* Length 15.68–48.14 mm (mean = 32.64, SD = 9.455); length of first segment 3.22–9.32 mm (mean = 6.54, SD = 1.837); length of second segment 2.80–9.66 mm (mean = 6.37, SD = 2.021); length of third segment 3.22–10.85 mm (mean = 6.99, SD = 2.140); length of fourth segment 2.79–8.81 mm (mean = 5.81, SD = 1.711); length of fifth segment 2.54–7.46 mm (mean = 5.10, SD = 1.379); length of apparent sixth segment (true metasomatic segments 6–9) 1.10–2.54 mm (mean = 1.84, SD = 0.465); length of first segment/length of third segment 0.86–1.11 (mean = 0.94, SD = 0.063).

*Male.* Corresponding colour patterns in male for those described above for females: (1) head black, mesosoma and base of metasoma brown, apex of metasoma dark brown to black; (2) body entirely black; (3) head black, otherwise one specimen very similar to first pattern above, second specimen dark brown throughout; hind tibia darkened through most of its length, legs otherwise reddish brown as in female; head length/head width 0.63–0.70 (mean = 0.67, SD = 0.020, $N = 28$); head length 0.97–1.70 mm (mean = 1.32, SD = 0.241); head width 1.50–2.47 (mean = 1.97, SD = 0.341); malar length/eye height 0.25–0.49 (mean = 0.35, SD = 0.069); fore wing length 7.03–14.07 mm (mean = 10.30, SD = 2.374, $N = 27$).

*Diagnosis.* *Pelecinus thoracicus* may be recognized by the combination of the extensive reddish brown colour of the legs (except the hind tibiae of the males), the reddish colour of at least the apex of the metasomatic segments 2–4, and the ventrally abbreviated occipital carina.

*Material examined.* 28 ♀, 28 ♂ (figure 11) from: **Mexico**: Durango, Guerrero, Jalisco, Michoacán, Morelos, Nayarit, Puebla, Sinaloa (AMNH, CUIC, EBCC, EMEC, MCZC, MSUC, SEMC, TAMU, UGCA, UMMZ, USNM, ZSMC).

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