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The Trichoptera of Panama X. The Quebrada Rambala drainage, with description of 19 new species of microcaddisflies (Trichoptera: Hydroptilidae)

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The Trichoptera of Panama X. The Quebrada Rambala drainage, with description of 19 new species of microcaddisflies (Trichoptera: Hydroptilidae)

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Abstract. The Quebrada Rambala drainage is found immediately south and south-southeast of the town of Chiriqui Grande and east of Rambala on the Caribbean coast. It is one of two tributaries of the Rio Margarita watershed, a small, lowland drainage with elevations up to 180 m. During the 2014-2017 period, collections of caddisflies (Insecta: Trichoptera), employing both UV-light and Malaise traps, were made at two locations on Quebrada Rambala proper, and four locations on its unnamed tributary, all on a land area of approximately 1 ha. As a result, 127 species of caddisflies were identified, including 59 species of microcaddisflies. A non-parametric estimator of true, or potential, species richness based on rare species present for this watershed is 211 species. Previously, 19 new country records were published from this location. In this paper, we record three additional country records (Hydrobiosidae: *Atopsyche minimajada* Blahnik and Gottschalk; Hydroptilidae: *Leucotrichia rhomba* Thomson and Holzenthal and *Oxyethira* (*Oxytrichia*) *apinolada* Holzenthal and Harris) and describe and illustrate 19 new species of microcaddisflies (*Alistotrichia bernali*, *Cerasmatrichia blahniki*, *Costatrichia santosi*, *Metrichia macdonaldi*, *M. thomsonae*, *M. thurmani*, *M. trebeki*, *Neotrichia carlsoni*, *N. rambala*, *N. serrata*, *N. starki*, *Ochrotrichia birdae*, *O. dewalti*, *O. kondratieffi*, *Oxyethira buenoi*, *Rhyacopsyche holzenthali*, *Tizatetrichia panamensis*, *Zumatrichia flinti*, and *Z. hazelae*). Combined, this one small portion of the Quebrada Rambala has increased Panama's caddisfly fauna by 41 species of microcaddisflies. Additionally, several new species of macrocaddisflies await description. Finally, we add one new genus to Panama's fauna (Hydroptilidae: *Tizatetrichia* Harris, Flint, and Holzenthal). With the publication of these new taxa, Panama's caddisfly fauna now includes 403 species in 15 families and 53 genera. We also suggest that multiple collections over time for all stream orders, employing several collection methods, are required in order to better estimate species richness within a drainage.

Key words. Caddisflies, Chao2, Bocas del Toro, Rio Margarita, *Metrichia trebeki*.

Introduction

Until recently, extensive surveys of adult caddisflies (Insecta: Trichoptera) of Panama have been localized. Wolda (1978) of the Smithsonian Institute for Tropical Studies operated light traps on Barro Colorado Island, near Fortuna Dam, and in the Cerro Punta areas of Panama, representing increasing altitudes, respectively, in order to study fluctuations in abundance of tropical insects. Many of Panama's caddisfly records from before 2012 derived from these collections. Additionally, McElravy et al. (1981, 1982) studied non-seasonal variability of caddisflies near Fortuna Dam, on Barro Colorado Island, and near Miramar on the Caribbean coast for almost three years. Most other collections in Panama were unstructured and, for the most part, resulted from isolated collection events. As a consequence, and as demonstrated by Armitage and Cornejo (2015), most of Panama's 52 major watersheds and administrative units were either poorly collected or, usually, not collected at all.

There have been few collections of caddisflies on the Caribbean (northern) half of the country. In part, this is due to the poorly developed road system there. However, collections from this part of Panama provide the best opportunity of discovering Caribbean and northern South American species of caddisflies heretofore unrecorded.

As of 2014, 243 species of caddisflies were known from Panama. During the last several years, 138 additional records, both new species to science (n = 27) and new country records (n = 111) have been added (Armitage et al. 2015, 2016, 2018; Bueno-Soria and Barba-Alvarez 2015; Harris and Armitage 2015; Muñoz-Quesada and Holzenthal 2015; Armitage and Harris 2018; Thomson and Armitage 2018). The purpose of this paper is to add three new country records and 19 new species to science to Panama's caddisfly fauna, bringing Panama's total caddisfly fauna to 403 species. In addition, we emphasize the need for repetitive collection of all stream orders within a drainage employing multiple collection techniques.

Site Description

The Rio Margarita (note: on some maps, Quebrada Margarita) is a small watershed (~10.3 km maximum length; 180 m maximum elevation) on the Caribbean coast of Panama immediately south and south-southeast of Chiriqui Grande (Fig. 1). It discharges into the Laguna de Chiriquí, a shallow embayment of the Caribbean Sea. The watershed arises in a low, isolated foothill of sediment and andesite which is associated with the Cordillera de Talamanca (Terry 1956). This sector of Panama's Caribbean coast is of recent origin (Middle Quaternary to Holocene) and was formed, in part, by landslides from the Cordillera de Talamanca range covering old, underlying coral formations. During the Flandrian Transgression (Holocene; 7000–6500 years BP), the Caribbean Sea invaded the land which hosts this drainage today (Bergoeing 2015). Subsequent recedence of sea water, on-going neotectonic activity, and fluvial erosion helped to form the current drainage. Lying very near the coast, this rather short watershed divides in its upper half into Quebrada Platanarito to the east and Quebrada Rambala to the south.

The area sampled is on the property of the Rambala Jungle Lodge, which includes a portion of Quebrada Rambala proper and a separate, first order tributary. The landscape is hilly with some small open areas near the Lodge and the first order tributary. With few breaks, the main stream itself is well canopied in the study area. Quebrada Rambala (Fig. 2) is 1.5–5 m wide and contains a range of substrates including some exposed bedrock, very large boulders, smaller boulders, cobble, pebbles, gravel, and coarse sand. The tributary is 0.4–1.0 m wide and contains substrates ranging from small boulders through fine sand, with pockets of fragmented organic matter derived from the surrounding habitat. The tributary flows on an upland area some 10–18 m above the stream bed of Quebrada Rambala, depending on the direction of access. Both streams flow continuously, year-round.

Materials and Methods

Single-night collections were made during 2014–2017, in general using UV light and alcohol traps (Calor and Mariano 2012). Multiple-night collections were made employing a two-meter Malaise trap (Fig. 2). The sample locations were located at 133 m (Quebrada Rambala) and 159 m (tributary to Quebrada Rambala) altitudes. Adults, primarily males, were sorted to family and genus, and then identified to species under a Wild M-5 dissecting scope. When necessary, the abdomens were cleared by soaking in a 4% KOH solution for a 12-hour period, so that reproductive structures could be better observed. The abdomens were then mounted on depression slides in a water-soluble media and drawn to scale at 250× using a Leitz LaborluxS compound microscope. These pencil drawings were then scanned (HP model G4050) and digitally edited and inked using Adobe Photoshop and Illustrator (version CC2015), then electronically formatted into plates. Length of specimens was measured from the top of the head to the tip of forewings and given as a range with two or more specimens. Morphological terms follow those of Marshall (1979).

Jaccard similarity values were calculated by dividing the total number of shared species (stream versus tributary, or UV-light versus Malaise trap) by the total number of species. However, despite being widely used in ecological studies, this measure of species overlap among two or more species assemblages is not reliable when there is a substantial percentage of rare species, as is the case with our data (Wolda 1981; Colwell and Coddington 1994; Plotkin and Muller-Landau 2002). In such situations, there is an underestimation of similarity because of undetected shared species. This is particularly applicable in

this study because we are comparing assemblages in a stream and its tributary, greatly increasing the probability of shared species. Chao et al. (2005) suggested a modification of the Jaccard (and Sørenson) formula to account for this situation. Their modified Jaccard formula consisted of taking the number of shared species for two assemblages and dividing by the result of summing the total species for both assemblages and subtracting the number of shared species.

The true, or potential, species richness of each stream and this portion of the drainage as a whole were estimated using Chao2 (Chao 1984, 1987; Colwell and Coddington 1994) as calculated by EstimateS software (Colwell 2013). Estimators like Chao2 use the number of rare species in a sample to estimate the likelihood of more, undiscovered species that could have been found if the sampling period or sampling area had been expanded. First, the summed frequency values for each species across all temporal samples were generated (Table 1). Then the number of species with single occurrences (Q_1) and double occurrences (Q_2) were each totaled. The estimated, or extrapolated, species richness (S_2) was then calculated by adding the observed number of species (S_{obs}) to the rounded quotient of squared single occurrences divided by twice the number of double occurrences.

$$S_2 = S_{obs} + \frac{Q_1^2}{2Q_2}$$

As more sampling occurs, fewer new single occurrences result in relation to former single occurrences becoming double occurrences or greater, thus causing the species accumulation curve to reach an asymptote.

Holotypes of new species are deposited in the Colección Zoológica Dr. Eustorgio Méndez (COZEM) of the Instituto Conmemorativo Gorgas de Estudio de la Salud (Gorgas Institute). COZEM was recently approved by the Ministerio de Ambiente as an official repository for biological specimens in Panama. Paratypes and all other material will either be deposited with COZEM or placed in the first author's reference collection (SCH; as indicated in the Materials Examined sections) to assist with future identifications.

Table 1. List of Trichoptera from Quebrada Rambala and its tributary. Presence and absence of species are indicated for the mainstem and its tributary as well as for collection method. The frequency of occurrence in samples are also given for the mainstem (n = 11 samples) and the tributary (n = 7 samples).

		Quebrada Rambala		Collection Method		Frequency	
Family	**Species**	**Main**	**Afluente**	**UV light**	**Malaise**	**Main**	**Afluente**
Calamoceratidae	*Phylloicus elegans* Hogue and Denning [in Denning et al., 1983]	x			x	1	0
Ecnomidae	*Austrotinodes* sp.	x			x	2	0
Glossosomatidae	*Mortoniella anakantha* Blahnik and Holzenthal, 2008	x	x	x	x	2	1
	Protoptila chitaria Holzenthal and Blahnik, 2006	x	x	x	x	4	4
	Protoptila n. sp.	x		x	x	3	0
Helicopsychidae	*Helicopsyche tuxtlensis* Bueno-Soria, 1983	x	x	x	x	2	1
	Helicopsyche vergelana Ross 1956	x		x	x	6	0
	Helicopsyche n. sp. (nr *selanderi*)	x			x	4	0
Hydrobiosidae	*Atopsyche minimajada* Blahnik and Gottschalk 1997	x		x		1	0
Hydropsychidae	*Calosopsyche continentalis* Flint and Bueno-Soria, 1987		x	x		0	1
	Centromacronema apicale (Walker, 1852)	x			x	1	0
	Centromacronema sp. 1	x	x	x	x	5	1

Family	Species	Quebrada Rambala		Collection Method		Frequency	
		Main	Afluente	UV light	Malaise	Main	Afluente
Hydropsychidae	*Centromacronema* sp. 2	x			x	5	0
	Centromacronema sp. 3 (nr *auripenne*)	x			x	3	0
	Leptonema albovirens (Walker, 1852)	x	x	x	x	6	3
	Leptonema complexum Mosely, 1933		x	x		0	1
	Leptonema forficulum Mosely, 1933	x		x	x	3	0
	Leptonema rafita Muñoz-Quesada, 1997		x	x		0	1
	Macronema variipene Flint and Bueno-Soria, 1979	x	x	x	x	7	4
	Smicridea bivittata (Hagen, 1861)	x	x	x	x	4	2
	Smicridea filicata Flint and Denning, 1989	x	x	x	x	7	5
	Smicridea gemina Blahnik, 1995	x			x	1	0
	Smicridea lobata (Ulmer, 1909)	x	x	x	x	3	3
	Smicridea matagalpa Flint, 1974	x	x	x	x	1	1
	Smicridea mirama Flint and Denning, 1989	x	x	x	x	2	3
	Smicridea radula Flint, 1974	x		x		1	0
	Smicridea turrialbana Flint, 1974	x			x	1	0
Hydroptilidae	*Alisotrichia asta* Harris and Flint, 2002	x	x	x	x	7	1
	Alisotrichia bernali n. sp.	x			x	4	0
	Alisotrichia cuernita Harris and Flint, 2002	x		x		1	0
	Alisotrichia panamensis Harris and Flint, 2002	x			x	1	0
	Brysopteryx cuchilla Harris and Holzenthal, 1994	x		x	x	2	0
	Cerasmatrichia blahniki n. sp.	x	x	x	x	4	1
	Cerasmatrichia wirthi Flint, 1968	x			x	2	0
	Costatrichia dietrichi Thomson and Armitage, 2018	x			x	1	0
	Costatrichia santosi n. sp.	x	x	x	x	5	1
	Flintiella heredia Harris, Flint, and Holzenthal, 2002	x		x	x	3	0
	Hydroptila flinti Bueno-Soria, 1984	x	x	x	x	6	5
	Hydroptila maza Harris and Holzenthal, 1999	x	x	x	x	6	4
	Hydroptila mexicana Mosely, 1937	x	x	x	x	2	4
	Hydroptila paradenza Harris and Holzenthal, 1999	x			x	1	0
	Hydroptila singri Harris and Holzenthal, 1999		x	x		0	1
	Hydroptila veracruzensis Flint, 1967	x			x	1	0
	Leucotrichia extraordinaria Thomson and Holzenthal, 2015	x			x	7	0
	Leucotrichia fairchildi Flint, 1970	x			x	4	0
	Leucotrichia melleopicta Mosely, 1934	x		x	x	8	0
	Leucotrichia mutica Flint, 1991	x	x	x	x	7	1
	Leucotrichia rhomba Thomson and Holzenthal, 2015	x			x	3	0
	Leucotrichia viridis Flint, 1967	x		x	x	3	0

Family	Species	Quebrada Rambala		Collection Method		Frequency	
		Main	Afluente	UV light	Malaise	Main	Afluente
Hydroptilidae	*Metrichia avon* (Bueno-Soria, 1983)		x	x		0	1
	Metrichia continentalis (Flint, 1972)	x			x	7	0
	Metrichia macdonaldi n. sp.	x		x	x	1	0
	Metrichia penicillata (Flint, 1972)	x		x	x	4	0
	Metrichia picuda Bueno-Soria and Holzenthal, 2003		x	x		0	1
	Metrichia sacculifera (Flint, 1991)	x			x	6	0
	Metrichia thomsoni n. sp.	x			x	3	0
	Metrichia thurmani n. sp.	x		x	x	7	0
	Metrichia triquetra Bueno-Soria and Holzenthal, 2003	x			x	1	0
	Metrichia trebeki n. sp.	x			x	4	0
	Neotrichia carlsoni n. sp.	x	x	x	x	3	1
	Neotrichia rambala n. sp.	x			x	1	0
	Neotrichia serrata n. sp.	x			x	1	0
	Neotrichia starki n. sp.	x			x	1	0
	Neotrichia tatianae Armitage and Harris, 2018	x		x	x	3	0
	Neotrichia unamas Botosaneanu [in Botosaneanu and Alkins-Koo, 1993]	x	x	x	x	10	6
	Ochrotrichia anomala Bueno-Soria and Santiago-Fragoso, 1997		x	x		0	2
	Ochrotrichia birdae n. sp.	x			x	2	0
	Ochrotrichia caimata Flint, 1972	x	x	x	x	6	2
	Ochrotrichia dewalti n. sp.	x		x	x	10	0
	Ochrotrichia flagellata Flint, 1972	x	x	x	x	5	1
	Ochrotrichia kondratieffi n. sp.		x	x		0	1
	Ochrotrichia longispina Bueno-Soria and Holzenthal, 2004	x			x	1	0
	Ochrotrichia moselyi Flint, 1972	x			x	1	0
	Ochrotrichia pacifica Flint, 1972	x	x	x	x	5	2
	Ochrotrichia paraldama Bueno-Soria, 2009	x			x	1	0
	Ochrotrichia tenanga (Mosely, 1937)	x			x	3	0
	Oxyethira (*Dampfitrichia*) *simulatrix* Flint, 1968	x		x		1	0
	Oxyethira (*Loxotrichia*) *janella* Denning, 1948	x			x	1	0
	Oxyethira (*Loxotrichia*) *parazteca* Kelley, 1983	x	x	x	x	1	1
	Oxyethira (*Loxotrichia*) *parce* (Edwards and Arnold, 1961)	x	x	x	x	8	6
	Oxyethira (*Loxotrichia*) *tica* Holzenthal and Harris, 1992		x	x		0	1
	Oxyethira (*Oxytrichia*) *apinolada* Holzenthal and Harris, 1992		x	x		0	1
	Oxyethira (Oxytrichia) *culebra* Holzenthal and Harris, 1992		x	x		0	1
	Oxyethira (unplaced) *buenoi* n. sp.	x	x	x	x	2	2

Family	Species	Quebrada Rambala		Collection Method		Frequency	
		Main	Afluente	UV light	Malaise	Main	Afluente
Hydroptilidae	*Rhyacopsyche holzenthali* n. sp.	x	x	x	x	2	1
	Tizatetrichia panamensis n. sp.	x			x	3	0
	Zumatrichia flinti n. sp.	x	x	x	x	5	1
	Zumatrichia galtena Mosely, 1937	x	x	x	x	3	2
	Zumatrichia hazelae n. sp.		x	x		0	1
	Zumatrichia rhamphoides Flint, 1970		x	x		0	1
	Zumatrichia teribe Harris and Armitage, 2015	x	x	x	x	5	1
Leptoceridae	*Nectopsyche dorsalis* (Banks, 1901)	x		x		2	0
	Nectopsyche gemmoides Flint, 1981	x	x	x	x	5	2
	Oecetis constricta Blahnik and Holzenthal 2014		x	x		0	1
	Oecetis knutsoni Flint, 1981	x	x	x		3	1
	Triaenodes clauseni Holzenthal and Andersen, 2004	x			x	1	0
	Triaenodes delicatus Holzenthal and Andersen, 2004	x	x	x		1	2
	Triaenodes hornitos Holzenthal and Andersen, 2004	x			x	8	0
	Triaenodes woldai Holzenthal and Andersen, 2004	x			x	2	0
	Triplectides flintorum Holzenthal, 1988	x	x	x	x	2	1
Philopotamidae	*Chimarra* (*C.*) *altmani* Blahnik, 1998	x	x	x	x	6	5
	Chimarra (*C.*) *emima* Ross, 1959	x	x	x	x	6	3
	Chimarra (*C.*) *flinti* Bueno-Soria, 1985	x		x	x	4	0
	Chimarra (*C.*) *limon* Blahnik, 1998	x			x	1	0
	Chimarra (*C.*) *munozi* Blahnik and Holzenthal, 1992	x			x	2	0
	Chimarra (*C.*) *peineta* Blahnik and Holzenthal, 1992	x		x	x	6	0
	Chimarra (*C.*) *pollex* Blahnik and Holzenthal, 1992	x	x	x	x	8	2
	Chimarra (*C.*) *spangleri* Bueno-Soria, 1985	x	x	x	x	8	3
	Chimarra (*C.*) *woldai* Blahnik, 1998	x			x	1	0
	Chimarra (*C.*) *xus* Blahnik, 1998	x			x	1	0
	Chimarra (*Curgia*) *aureopunctata* Flint, 1967		x	x		0	1
	Chimarra (*Curgia*) *centralis* Ross, 1959		x	x		0	1
	Chimarra (*Curgia*) *costaricensis* Flint, 1998	x			x	1	0
	Chimarra (*Curgia*) *pablito* Flint, 1998	x	x	x	x	4	1
	Chimarra (*Curgia*) *persimilis* Banks, 1920	x	x	x	x	1	2
	Chimarra (*Curgia*) *sarophora* Flint, 1998	x	x	x		1	2
	Chimarra (*Otarrha*) *rossi* Bueno-Soria, 1985	x	x	x	x	9	3
	Wormaldia eberhardi Muñoz-Quesada and Holzenthal, 2015		x	x		0	1
	Wormaldia gallardoi Muñoz-Quesada and Holzenthal, 2015	x	x	x	x	2	2
	Wormaldia monsonorum Muñoz-Quesada and Holzenthal, 2015	x	x	x	x	7	1

Family	Species	Quebrada Rambala		Collection Method		Frequency	
		Main	Afluente	UV light	Malaise	Main	Afluente
Philopotamidae	*Wormaldia planae* Ross and King [in Ross, 1956]	x	x	x	x	10	4
Polycentropodidae	*Polyplectropus insularis* Chamorro and Holzenthal, 2010	x			x	3	0
Xiphocentronidae	*Machairocentron* sp.	x			x	3	0
	Xiphocentron (*Sphagocenton*) *evandrus* Schmid, 1982	x	x	x	x	3	1
	Xiphocentron (*Sphagocentron*) *julus* Schmid, 1982	x			x	4	0
	Xiphocentron sp. 1 (nr *numanus*)	x		x		2	0
	Xiphocentron sp. 2	x		x	x	1	0
	Total species = 127 No. of species:	**110**	**63**	**84**	**101**		

Results

During the period 2014–2017, 127 species of caddisflies were identified from all sample locations (Table 1). Of these, 110 species were recorded from Quebrada Rambala and 63 species were recorded from its first-order tributary. The Jaccard similarity values using the two methods outlined above were essentially the same, so the Chao et al. values are reported here. The percent Jaccard similarity value for these two streams was 44.2%. In terms of collection methods, UV-light traps captured 84 of the total 127 species. Malaise traps accounted for 101 species. The percent Jaccard similarity value for these two collection methods was 45.6%

The Chao2 estimate for species richness of Quebrada Rambala (n = 110 species) was 142 species. The Chao2 estimate for species richness of Quebrada Rambala's tributary (n = 63) was 114 species. Combined estimate of species richness for the studied portion of the Quebrada Rambala drainage was 211 species.

Hydroptilidae were the dominant family in the species assemblage of this drainage, accounting for 59 species (46.5% of total taxa identified). There were 49 species identified from Quebrada Rambala and 31 species recorded from its tributary. For this dominant family of caddisflies, Jaccard similarity values indicated a 35.6% similarity between the two streams and a 47.5% similarity between collection methods.

Employing a recent catalog of Neotropical Trichoptera (Holzenthal and Calor 2017), we present the regional affinities of the Quebrada Rambala species assemblage in Fig. 3. Country affinities (Central America and those countries adjacent) are presented in Fig. 4. The number and percentage of endemics (n = 33 species; 26%) are similar to that of other Panamanian watersheds surveyed. The greatest regional affinity is with other Central American countries, followed by South America, Mexico, and the Caribbean. As expected, Panama has the greatest country affinity with Costa Rica with which it shares a border to its WNW.

Nineteen species new to science (Table 1) were found in samples collected over a 2.5-year period. Six of the new species were collected only in Quebrada Rambala, two new species only in the tributary, and 11 new species in both streams. Three new country records are also noted: the hydrobiosid *Atopsyche minimajada* Blahnik and Gottschalk, and the hydroptilids *Leucotrichia rhomba* Thomson and Holzenthal and *Oxyethira* (*Oxytrichia*) *apinolada* Holzenthal and Harris. Adding these three species to the 19 new country records previously published brings the total new country records from the Quebrada Rambala drainage in this paper to 22. Adding the 19 new species described here to this subtotal results in 41 new taxa to Panama's caddisfly fauna from this study. Finally, we record one additional new genus for Panama, *Tizatetrichia* Harris, Flint, and Holzenthal.

New species

Alisotrichia bernali Harris and Armitage, new species

Fig. 5

Diagnosis. *Alisotrichia bernali* appears to be most similar to *A. lobata* Flint and *A. circinata* Flint, both of which have abdominal segment VIII narrowing distally to an acute point and a tubular, thin phallus. The new species differs in that the acute apex of segment VIII is bifid and the phallus apex is widened. In *A. mathisi* Harris and Flint there are a pair of spines at the apex of segment VIII which resemble the structure of segment VIII in the new species, but the dorsal view of *A. mathisi* shows clearly that these are spines and not a bifid apical portion of the segment.

Male. Length 1.7 mm. Antenna 18 segments, scape slightly enlarged, remaining segments spatulate. Abdominal segment VI annular, with bifid, ventromesal process posteriorly. Segment VII thin ventrally, widening dorsally; emarginate posteriorly in dorsal view. Segment VIII elongate and narrowing distally to bifid apex, ventrally thin, narrowing anteriorly: dorsally and ventrally truncate, deeply incised posteriorly forming lateral bifid processes, mesally with pair of rounded humps; ventrally elongate with mesal humps posteriorly and bifid laterally. Segment IX entirely enclosed within VIII, anteriorly sharply narrowed into elongate, thin apodeme which extends into segment V, posteriorly divided into dorsal process bearing elongate, thickened seta, and a ventral process which is narrow and projects ventrad to an acute apex; ventrally with narrow anterior apodemes, posteriorly squarish, with sclerotized, slightly produced lateral margins, and truncate distally; dorsally narrow laterally with posterior inner lobes bearing elongate thickened seta, mesally with pair of thin sclerites. Segment X shelf-like in lateral view, rounded distally; in dorsal view generally rectanguloid, tapering to truncate apex. Phallus thin and tubular, widening basally, distally abruptly widening to oval, spatulate apex.

Female. Unknown.

Type material. Holotype, male—Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91543°N and 82.15527°W, 120 m, Malaise trap, February 6–12, 2017, E. Carlson.

Etymology. With respect and sadness, we name this species after Dr. Juan Bernal Vega of the University of Chiriqui (UNACHI) who passed away very recently while on a field trip. He will be deeply missed.

Cerasmatrichia blahniki Harris and Armitage, new species

Fig. 6

Diagnosis. *Cerasmatrichia blahniki* is very similar to *C. wirthi* (Flint) from Dominica and Venezuela, as well as *C. adunca* (Flint) from Colombia in the overall appearance of the male genitalia. The new species is most easily separated by the presence of a large sternal process from abdominal segment VII, which is absent in the two closely related species.

Male. Length 2.3–2.8 mm. Antenna pale with 37 segments, scape round about twice length and thickness of 2nd segment. Maxillary palpus with 3rd segment darkened and bearing specialized setae. Legs tan in alcohol, foretibia spine reduced. Wings unmodified and dark brown in alcohol. Abdominal segment VII annular, with prominent ventromesal process. Segment VIII with deep mesal incision, cluster of stout spines posteroventrally; in ventral and dorsal views annular with mesal notch posteriorly on sternum, cluster of stout setae laterally. Segment IX thin, narrowing anteriorly and dorsally; ventrally reduced posteriorly anteriorly deeply incised; dorsum a narrow shelf. Segment X shelf-like, tapering distally to upturned, acute process; tergum divided into pair of elongate lobes, tapering apically, with numerous folds basally. Inferior appendage in lateral view narrow, turning ventrad, distally narrowing to sharp apex, basally with oval, setose lobe; ventrally narrow over length, apex curving inward to acute point, basal lobes narrow and diverging. Subgenital plate in lateral view shorter than inferior appendages, downturned apically to sharp point, subapical ventral notch; triangular in ventral view with mesal notch. Phallus with tubular basal portion, apical portion cylindrical with narrow curving internal rod

(ejaculatory duct), dorsally with apical portion divided at midlength, ejaculatory duct protruding mesally.

Female. Unknown.

Type material. Holotype, male—Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91627°N and 82.15469°W, 120 m, Malaise trap, March 28, 2015, E. Carlson. **Paratypes.** ibid., March 31–April 11, 2015, 1 male, ibid., February 6–12, 2017, 1 male; ibid., December 21–31, 2016, 4 males; tributary of Quebrada Rambala, Rambala Jungle Lodge, 3.7 km SSE Rambala, 8.91627°N and 82.15469°W, 134 m, November 29, 2014, E. Carlson, 1 male (SCH).

Etymology. We take great pleasure in naming this species for our colleague Dr. Roger Blahnik for his friendship and professional expertise in verifying adult Trichoptera from Panama, and for his dedication to Trichoptera systematics in the Neotropics and beyond.

Costatrichia santosi Harris and Armitage, new species

Fig. 7

Diagnosis. *Costatrichia santosi* appears to be most similar to a cluster of species, including *C. devestiva* Thomson and Armitage, *C. dietrichi* Thomson and Armitage, *C. falsa* Santos, Takiya and Nessimian, and *C. zopilote* Holzental and Harris, all of which have stout spines projecting from posterior processes on abdominal segment VIII. These species are separated by the location of these processes, the number of spines and their thicknesses. Santos et al. (2016) suggested that *C. falsa* and *C. zopilote* should be transferred to the genus *Leuotrichia* based on similarities in the male reproductive structures and molecular data for *C. falsa*, but also mentions that such a move may be premature pending more analyses of all Leucotrichiini genera. Pending more studies of the Leucotrichiini, we are leaving the species mentioned above in *Costatrichia*, while acknowledging the closeness of the species in the cluster above. The new species appears closest to *C. dietrichi* and *C. devestiva* based on the pair of spines from segment VIII, but in *C. dietrichi* these spines originate from one process, and of the spines in *C. devestiva*, only the dorsal most originates from a posterior process. Like *C. falsa* and *C. dietrichi*, the phallus of *C. santosi* has a pair of thickened spines apically, but the posterior spines of segment VIII in *C. falsa* are more similar to those of *C. zopilote*, one of which is much longer than those seen in *C. zopilote*.

Male. Length 2.1–2.4 mm. Head unmodified, with 3 ocelli, antennae with 18 segments, scape and first flagellar segment elongate, color brown in alcohol. Abdominal segment VII annular with acute, ventromesal process, anteriorly with sclerotized ridge. Segment VIII with posterior margin divided into a pair of elongate lateral processes , each bearing a long, thickened seta, dorsomesal process longer than ventromesal, with elongate seta thinner than that on the ventromesal process, short spine at base of insertion, anteriorly with numerous sharp spines, ventromesal process short with elongate seta thickening apically, narrow, acute process posteroventrally; in dorsal and ventral views, segment elongate with setal-bearing processes lateral in position, outer process much longer than inner process. Segment IX with anterolateral margin rounded, posterolateral margin shallowly concave with dorsal and ventral sclerites, posterolateral process bearing several apical setae; in dorsal view anterior margin concave, posterior margin with dorsal sclerite knoblike, anterior and posterior margins shallowly incised; in ventral view posterior margin incised mesally and laterally. Tergum X square, with dorsal posterior lobe; dorsally with lateral margins sclerotized, posteriorly triangular. Inferior appendage square, with narrow, setal-bearing process posteriorly; in ventral view sinuate on margins, setal-bearing processes laterad. Phallus apex in dorsal view with pair of thin, elongate sclerites distally which taper anteriorly; in lateral view apical sclerite dorsal in position and crescent-shaped, basal supports thin and lacking basal loop.

Female. Unknown.

Type material. Holotype, male—Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91627°N and 82.15469°W, 120 m, Malaise trap, February 6–12, 2017, E. Carlson. **Paratypes**. Same information as holotype, 7 males; ibid., but December 21–31, 2016, 2 males; ibid., November 15–20, 2016, 1 male; ibid., March 31–April 11, 4 males; ibid.,

October 7–9, 2016, 2 males; ibid., tributary to Quebrada Rambala, 134 m, January 22, 2015, E. Carlson, 4 males (SCH).

Etymology. We take great pleasure in naming this species for our colleague Allan Paulo Moreira Santos for his many contributions to the study of Neotropical microcaddisflies.

Metrichia macdonaldi Harris and Armitage, new species

Fig. 8

Diagnosis. *Metrichia macdonaldi* is placed in the nigritta group of Flint (1972) on the basis of the thick setal patches arising between the fifth and sixth abdominal segments and the pair of stout subapical hooks on the phallus. The new species has rectanguloid inferior appendages somewhat similar to that of *M. longitudinis* Bueno-Soria and *M. pernambucana* Souza and Santos, however the setal patches, and structure of the phallus, are much different in the new species.

Male. Length 2.6–2.9 mm. Head without modification. Antennae with 19 segments, middle segments slightly widening and flattened. Body and unmodified wings brown in alcohol. Abdominal segments with thick setal patches between segments V and VI, those on V much thicker than those of VI. Segments VII and VIII annular. Segment IX triangular in lateral view, anterior portion within segment VIII, posterior margin rounded dorsally; in ventral and dorsal views annular. Preanal appendage (cercus) thin in lateral view, apex rounded; in dorsal view short and lobate; dorsolateral hook narrow, widening to hatchet-like apex, posteriorly with several sclerotized processes; in dorsal view narrow over length, to widened, curved apex. Segment X membranous and rectangular laterally; in dorsal view thin and triangular, apex truncate. Inferior appendages in lateral view rectanguloid, narrowing anteriorly to rounded apex; in dorsal and ventral views wide basally, gradually narrowing anteriorly to rounded apex, series of peg-like setae on inner margins. Phallus widening basally and apically, apex in dorsal view with pair of spines subapically, inner spine short and stout, outer spine elongate and sharply curving at midlength, pair of short, stout spines basally; in lateral view two subapical spines evident, lowermost one straight, and upper one curving to acute upturned spike; ejaculatory duct thin extending anteriorly beyond curving spine.

Female. Unknown.

Type material. Holotype, male—Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91627°N and 82.15469°W, 120 m, Malaise trap February 6–12, 2017, E. Carlson.

Etymology. We take great pleasure in naming this species for John R. MacDonald of the Mississippi Entomological Museum, Mississippi State University, for his dedicated study of the Lepidoptera of Panama and for assisting us with the collection of Trichoptera and Plecoptera specimens.

Metrichia thomsonae Harris and Armitage, new species

Fig. 9

Diagnosis. *Metrichia thomsonae* is placed in the campana group of Flint (1972) based on the presence of small dorsal pouches between abdominal segments VI and VII with closet similarity to that of *M. lacuna* (Bueno-Soria) and *M. kocka* Olah and Johanson in the lateral appearance of the inferior appendage. It differs from *M. lacuna* in the spinal apex of the phallus which is more similar to that of *M. kocka*. However, the phallus of the new species has a midlength process which is not present in *M. kocka*.

Male. Length 2.6–2.8 mm. Head without modification. Antennae simple with 19 segments. Body and unmodified wings brown in alcohol. Abdominal segments VI and VII with small round pouches dorsally; segment VII annular, with small ventromesal process. Segment VIII in lateral view wide dorsally, tapering ventrally; deeply incised ventrally. Segment IX triangular in lateral view, anterior portion within segments VII and VIII, posterior margin truncate. Preanal appendage (cercus) narrow in lateral view, tapering to rounded apex; in dorsal view narrow and angled inward, tapering

to rounded apex; dorsolateral hook elongate in lateral view, narrow over length, gradually curving downward to acute apex; in dorsal view narrow over length, curving outward, subapical lateral point. Segment X membranous and triangular laterally; in dorsal view short and truncate posteriorly. Inferior appendages in lateral view quadrate, apical margin concave mesally, cluster of stout setae on inner posteroventral margin; in dorsal and ventral views rectanguloid, inner margins tapering distally to broad rounded apex, stout spines on inner posterior margin. Phallus tubular, elongate lateral process at midlength, apex bulbous in dorsal view with pair of apical spines, inner spine about half-length of outer spine, ejaculatory duct extending posteriorly between spines; in lateral view apical spines curving and diverging.

Female. Unknown.

Type material. Holotype, male—Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91627°N and 82.15469°W, 120 m, Malaise trap, March 31–April 11, 2015 E. Carlson (COZEM). **Paratypes.** Same data as for the holotype, 1 male (SCH).

Etymology. We take great pleasure in naming this species for our colleague Dr. Robin E. Thomson, Curator of the University of Minnesota Insect Collection, for her work on Neotropical microcaddisflies, including those in Panama.

Metrichia thurmani Harris and Armitage, new species

Fig. 10

Diagnosis. *Metrichia thurmani* is placed in the aberrans group of Flint (1972) as it lacks abdominal modifications and the phallus has a pair of subapical spines and an elongate tubule. The new species has a similar appearance to that of *M. enigmatica* Bueno-Soria and Santiago-Fragoso in the lateral shape of the inferior appendages and the structure of the phallus, but *M. enigmatica* displays abdominal modifications which are absent in the new species.

Male. Length 2.3–2.6 mm. Head without modification. Antennae simple with 20 segments. Body and wings brown in alcohol, forewing with diagonal white band at midlength. Abdominal segments lacking any hair brushes or setal pouches. Segment VII annular, with small ventromesal process. Segment VIII annular in lateral view widening posteromesally, deeply incised ventrally. Segment IX triangular in lateral view, anterior portion within segments VII and VIII, posterior margin rounded. Preanal appendage (cercus) rectanguloid in lateral view, rounded distally; in dorsal view ovate, margins irregular distally; dorsolateral hook shorter than segment X, curving downward to acute apex in lateral view; in dorsal view narrow over length, subapical lateral point. Segment X membranous and triangular laterally; in dorsal view triangular, apex rounded and setose. Inferior appendages in lateral view wide basally, gradually narrowing over length to acute apex; in dorsal and ventral views wide basally, sharply narrowing near midlength on inner surfaces. Phallus widening basally and apically, apex bulbous in dorsal view with pair of spines subapically, inner spine short and stout, outer spine elongate and sinuate, ejaculatory duct enclosed within thin tubule extending slightly beyond outer spine; in lateral view, tubule elongate and narrow, lower apical spine short, upper apical spine thin and sinuate.

Female. Unknown.

Type material. male—Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91627°N and 82.15469°W, 120 m, Malaise trap, E. Carlson, March 31–April 11, 2015. **Paratypes.** ibid., 2 males; ibid., October 7–9, 2016, 2 males; ibid., November 15–20, 2016, 2 males; ibid., February 6–12, 2017, 2 males; ibid., December 21–31, 2016, 1 male; tributary of Quebrada Rambala, Rambala Jungle Lodge, 3.7 km SSE Rambala, 134 m, 8.91627°N and 82.15649°W, August 9, 2014, E. Carlson, 1 male (SCH).

Etymology. We take great pleasure in naming this species for Albert A. Thurman of Phoenix, AZ for introducing lay entomologists to the insects of Panama, and for assisting us with the collection of Trichoptera and Plecoptera specimens.

***Metrichia trebeki* Harris and Armitage, new species**
Fig. 11

Diagnosis. *Metrichia trebeki* is most similar to *M. madre* Flint and Bueno-Soria from Peru on the basis of the single, short phallic spine and the triangular shape of the inferior appendage. However, the new species is distinguished by the lack of a toothed mesolateral margin on the inferior appendage, the cerci being thin and elongate in dorsal view, and the phallus having an elongate lateral process at midlength.

Male. Length 1.8 mm. Head without modification. Antennae simple with 18 segments. Body and wings brown in alcohol, forewing with numerous bands of white hairs. Abdominal segments without modifications. Segments VII and VIII annular, without ventromesal process. Segment IX triangular in lateral view, anterior portion within segment VIII, posterior margin rounded dorsally, laterally widening posteroventrally. Preanal appendage (cercus) rectanguloid in lateral view, rounded distally; in dorsal view thin and elongate, distally rounded; dorsolateral hook elongate, curving downward to blunt apex in lateral view; in dorsal view narrow over length, curving distally to acute point. Segment X shelf-like laterally, narrowing posteroventrally; in dorsal view round and setose, apex with thin, sclerotized band. Inferior appendages in lateral view triangular, basally elongate and thin to rounded apex, dorsally rounded, inner surface with band of sclerotized teeth; in dorsal and ventral views wide basally, sharply narrowing near midlength on outer surface to acute apex, tooth-like band on dorsal surface near base. Phallus long and thin, wide basally, with elongate lateral process near midlength, apical portion short and bulbous, narrow sinuate spine basally, ejaculatory duct extending slightly beyond phallic apex; in lateral view, basal spine projecting above tubular portion.

Female. Unknown.

Type material. Holotype, male—Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91627°N and 82.15469°W, 120 m, Malaise trap, June 12–15, 2017, E. Carlson.

Etymology. We take great pleasure in naming this species for Alex Trebek, the longtime host of the television show Jeopardy!, which the authors have enjoyed for many years.

***Neotrichia carlsoni* Harris and Armitage, new species**
Fig. 12

Diagnosis. *Neotrichia carlsoni* is a member of the collata group of Keth et al. (2015) based on the paired apical rods of the phallus, the prominent dorsal projection of the subgenital plate and the lateral extension of segment IX. The new species is most similar to *N. hiaspa* (Mosely), which is also known from the Bocas del Toro Province in Panama, based on the thin dorsal spike from segment IX, the thin, elongate inferior appendages, and the bifid phallus apex. It differs from *N. hiaspa* in the configuration of the subgenital plate, the shorter dorsal spike from segment IX, the longer inferior appendages, and the elongate phallic apex.

Male. Length 1.7–1.9 mm, 18 antennal segments, brown in alcohol. Abdominal segment VIII annular. Segment IX complete dorsolaterally, bearing elongate, thin dorsal spike, which is shorter than segment X, mesal process strongly curved dorsally and nearly parallel-sided, anteriorly narrowing to elongate process; dorsally fused posteriorly with segment X, narrow spikes laterally, posterior extension curving mesad to acute apex; in ventral view deeply incised on posterior margin, shallowly incised anteriorly. Tergite X rounded distally, basally fused with segment IX; in lateral view tapering posteriorly to rounded apex. Subgenital plate in lateral view wide basally, tapering distally to rounded lobe bearing stout setae, subapical ventral process with acute apex; in ventral view tapering distally to bifid apex bearing pair of stout setae, ventral process tapering sharply. Bracteoles lobate, nearly parallel-sided to rounded apex, in dorsal and ventral views rectanguloid. Inferior appendages thin and tapering distally, slightly upturned beyond midlength, extending beyond segment X; in ventral view elongate and thin, slightly curving mesally, small finger-like process basally. Phallus tubular in lateral view, constricted

at mid-length and bearing thin paramere encircling shaft, apex with pair of unequal sclerotized rods, ejaculatory duct ending subapically.

Female. Unknown.

Type material. Holotype, male—Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91627°N and 82.15469°W, 120 m, Malaise trap, December 21–31, 2016, E. Carlson, 1 male. **Paratypes.** ibid., February 6–12, 2017, 1 male; tributary of Quebrada Rambala, Rambala Jungle Lodge, 134 m, August 9, 2014, E. Carlson, 1 male; ibid., 2nd footbridge, near Rambala Jungle Lodge, March 28, 2015, 1 male. **Chiriqui Province**, Rio Caldera Boquete, Wilson Bridge road to Lucero, 8.74228°N and 82.42160°W, November 18, 2013, B. and T. Armitage, 1 male (SCH).

Etymology. We take great pleasure to name this species for Eric Carlson, owner and operator of Rambala Jungle Lodge, who collected this species and many other interesting caddisflies in the Quebrada Rambala watershed.

Note. As the new species is similar to *N. hiaspa*, we have provided new drawings (Fig. 13) of a specimen found in Panama. Comparing this specimen to material from Mexico provided by Dr. Joaquin Bueno and the drawings of the holotype in Keth et al. (2015), we found considerable variation in the apical spines of the phallus and in the configuration of the inferior appendages, particularly in the ventral aspect. Material examined: Mexico, Chiapas, Cascada de Misolha, May 18, 1981, J. Bueno and H. Velasco, 1 male; Panama, Bocas del Toro Province, Quebrada Canaza @ pipeline road, May 18, 1985, R. Flowers, 1 male.

Neotrichia rambala Harris and Armitage, new species

Fig. 14

Diagnosis. *Neotrichia rambala* appears to be a member of the collata group of Keth et al. (2015) based on the prominent projection from the subgenital plate and the elongate segment X. The new species is most similar to *N. lacertina* Botosaneanu, with some resemblance to *N. elongata* Flint, *N. biuncifera* Flint, and *N. kurta* Olah and Johanson, all of which have elongate inferior appendages and a prominent process from the subgenital plate. With *N. lacertina*, the new species shares the characteristics of the phallus ending in a single spine and the subgenital plate having a lobate, spinose base. However, the new species differs in the elongate ventral process of the subgenital plate and the bilobed apex of the tenth tergite.

Male. Length 1.8 mm, 18 antennal segments, brown in alcohol. Abdominal segment VIII annular. Segment IX incomplete dorsolaterally, tapering anteriorly, posteriorly truncate; ventrally deeply incised anteriorly and posteriorly. Segment X elongate in lateral aspect, tapering distally to acute apex; dorsally rectanguloid, incised posteriorly, anteriorly fused with segment IX. Subgenital plate complex in lateral view, narrow basally, widening at mid-length, elongate subapical ventral process with acute apex, venter divided into curved toothed process adjacent to ventral projection and lobe bearing stout spike; in ventral view ovoid, truncate distally, with mesal process flanked by setae, basally with pair of lobes tipped with stout spike. Bracteoles lobate, widening gradually to rounded apex; in dorsal and ventral views linear. Inferior appendages wide basally, tapering distally, series of short spines on dorsal margin; in ventral view fused basally, thin and rectanguloid over length, rounded apically, numerous short spines subapically. Phallus elongate and thin in dorsal view, constricted at mid-length and bearing short paramere encircling shaft, apically tubular, narrowing to acute sclerotized apex, ejaculatory duct protruding apically and lightly sclerotized.

Female. Unknown.

Type material. Holotype, male—Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91543°N and 82.15527°W, Malaise trap, November 15–20, 2016, E. Carlson. **Paratype.** ibid., except February 6–12, 2017, 1 male (SCH).

Etymology. Named for *Quebrada Rambala* where the species was collected.

***Neotrichia serrata* Harris and Armitage, new species**
Fig. 15

Diagnosis. *Neotrichia serrata* is a member of the canixa group of Keth et al. (2015) based on the posterior horns from tergum X, forked bracteoles, bifid inferior appendages, and the forked phallic apex. The new species is most similar to *N. canixa, N. unamas,* and *N. xicana*, on the basis of the apicolateral processes from segment IX. It is most easily separated from these species by the serrate structure of the rods from segment IX.

Male. Length 1.6 mm, 18 antennal segments, brown in alcohol. Abdominal segment VIII annular. Segment IX incomplete dorsolaterally with setal-bearing lobe; anteriorly rounded, posteriorly bearing elongate, thin process, which is serrate on dorsal margin; ventrally with deep mesal incision on posterior and anterior margins. Tergite X narrow, with pair of symmetrical, sclerotized horns distally, basally fused with segment IX; in lateral view distal horn long and thin. Subgenital plate in lateral view wide basally, tapering distally to acute, downturned apex; in ventral view narrow with pair of stout, lateral setae apically. Bracteoles slender and bifid, dorsal and ventral branches similar in length, each terminating in elongate seta. Inferior appendages thin and tapering distally; in ventral view bifid, outer processes wide basally, tapering distally to rounded apices which are turned inward, inner processes fused basally and narrow over length, shorter than outer processes. Phallus tubular, constricted at mid-length and bearing thin paramere encircling shaft, apex divided into pair of short curving processes, ejaculatory duct protruding apically.

Female. Unknown.

Type material. Holotype, male—Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91543°N and 82.15527°W, 120 m, Malaise trap, February 6–12, 2017, E. Carlson.

Etymology. From the Latin, *serratus* meaning serrate, referring to the serrate structure of the rods from segment IX.

***Neotrichia starki* Harris and Armitage, new species**
Fig. 16

Diagnosis. *Neotrichia starki* belongs to a large cluster of Neotropical species with a characteristic elongate process from segment IX, including *N. delgadeza* Harris and Davenport, *N. napoensis* Harris and Davenport, *N. tompa* Olah and Johanson, and *N. filifera* Flint. The new species is readily identified by the structure of the inferior appendages and the greatly reduced tenth tergum.

Male. Length 1.3 mm, 18 antennal segments, brown in alcohol. Abdominal segment VIII annular. Segment IX rounded anteriorly, sinuate posteriorly with submesal triangular projection, notched dorsally giving rise to elongate sinuate rod; in ventral view narrow posteriorly with short lateral processes, incised anteriorly; in dorsal view narrow with pair of elongate sinuate rods. Segment X in lateral view short and wide; dorsally short and inconspicuous, truncate mesally and membranous. Subgenital plate in lateral view triangular, wide basally, gradually tapering to acute apex, which bears a stout seta; in dorsal view wide basally, abruptly narrowing distally to truncate apex, pair of setae laterally. Bracteoles elongate, widening posteriorly to rounded apex. Inferior appendages nearly parallel-sided basally, narrowing distally to rounded apex; in ventral view rectanguloid, basally incised along inner margin. Phallus in dorsal view linear, widening basally and apically, thin paramere encircling shaft at midlength, ejaculatory duct protruding subapically.

Female. Unknown.

Type material. Holotype, male—Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91543°N and 82.15527°W, 120 m, Malaise trap, February 6–12, 2017, E. Carlson.

Etymology. We take great pleasure in naming this species for our colleague Dr. Bill P. Stark, Department of Biology, Mississippi College, in recognition of his lifetime of work on aquatic insects in the Neotropics.

Ochrotrichia birdae Harris and Armitage, new species

Fig. 17

Diagnosis. This species is very similar to *Ochrotrichia flagellata* which was described from Panama by Flint in 1972. The new species differs from *O. flagellate* most notably in the structure of the phallus apex; in *O. flagellata* the phallus ends in a spiral process which is absent in *O. birdae*. There are several other differences seen in the new species; the dorsal extension of segment VIII is more pronounced and the apical portion of segment X is straight as opposed to upturned, both features as seen in lateral view. Also, in *O. flagellata* the inferior appendages are shorter than the tenth segment

Male. Length 2.4-2.6 mm, 27 antennal segments, brown in alcohol. Abdominal segment VII annular, without short posteroventral process. Segment VIII in lateral view with lobe-like dorsal extension; ventrally square; dorsally deeply incised forming elongate lateral lobes posteriorly, anteriorly rounded. Segment IX reduced dorsally to narrow band. Segment X in lateral view tapering distally to narrow, acute apex; dorsally wide basally gradually tapering distally to rounded apex. Inferior appendages rectanguloid in lateral view, abruptly widening apically, numerous peglike setae on inner posterior margin and subbasally, extending distally beyond segment X; in ventral view wide basally curving on inner margin to rounded apex, numerous peglike setae on apical mesal margins. Phallus elongate, wide basally, narrowing at midlength, apical portion about same length as basal, very thin and narrowing distally.

Female. Unknown.

Type material. Holotype, male—Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91627°N and 82.15469°W, 120 m, Malaise trap, December 21–31, 2016, E. Carlson. **Paratype.** ibid., November 15–20, 2016, 1 male (SCH).

Etymology. Named for Suzanne Bird Boyden, colleague of the first author at Clarion University, in recognition of her contributions to ecology, and instilling an appreciation of nature in our students.

Note. As the new species is similar to *O. flagellata*, which we have also collected collected in Bocas del Toro Province, Panama, we have provided new drawings (Fig. 18) of the species from these Panamanian specimens. Material examined: Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91627°N and 82.15469°W, Malaise trap, March 31–April 11, 2015, E. Carlson, 4 males; ibid., November 15–20, 2016, 1 male; ibid., February 6–12, 2017, 2 males, tributary of Quebrada Rambala, Rambala Jungle Lodge, 134 m, November 29, 2014, E. Carlson, 1 male.

Ochrotrichia dewalti Harris and Armitage, new species

Fig. 19

Diagnosis. This species is similar to a number of species in the aldama group of Flint (1972) on the basis of the simple, divided tenth tergum, notably *O. paraldama* Bueno-Soria, *O. citra* Bueno-Soria and Holzenthal, *O. compacta* Bueno-Soria and Holzenthal, and *O.* jolandae Bueno-Soria and Holzenthal, with closest similarity to *O. dulcea* Bueno-Soria and Holzenthal and *O. bicaudata* Bueno-Soria and Santiago-Fragoso. As with the latter two species, *O. dewalti* has the left side process of the tenth tergum wide and curving distally, and the right side process elongate and thin. The new species is separated from these two species and other members of the aldama group by the rhomboidal shape of the inferior appendages in lateral view and the concave inner margins of these structures in dorsal and ventral views, which bears a pronounced inner spike subapically.

Male. Length 2.3–2.7 mm, 31 antennal segments, first segment twice length of second, brown in alcohol. Abdominal segment VII annular, with short posteroventral process. Segment VIII narrow in lateral view, tapering ventrally; in dorsal view narrow, concave on posterior margin. Segment IX rectangular in lateral view, incomplete dorsally, sinuate posteriorly, tapering anteriorly; annular ventrally, medially

truncate anteriorly, posteriorly with concave margin; dorsally narrow. Tergum X divided into two elongate processes, left side process narrow basally, widening below stout curving apex, right process thin and gradually narrowing to acute apex; in lateral view, outer process angulate below downward turning apex, inner process narrow, curving upward to acute apex. Inferior appendages parallel-sided in lateral view, apex rounded and tapering ventrad, numerous peglike setae on inner posterior margin; in dorsal and ventral views wide basally curving on inner margin to subapical acute spine, then tapering to rounded apex, numerous peglike setae on apical mesal margins. Phallus thin and elongate, subapically with pair of small lateral hooks on outer margin, pair of thin lobes mesally.

Female. Unknown.

Type material. Holotype, male—Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91627°N and 82.15469°W, 120 m, Malaise trap, March 31–April 11, 2015, E. Carlson. **Paratypes.** ibid., 50 males; ibid., Malaise trap, March 28, 2015, 8 males (SCH); ibid., December 21–31, 2016, 38 males; ibid., October 7–9, 2016, 40 males; ibid., November 15–20, 2016, 1 male; ibid., February 6–12, 2017, 25 males; tributary of Quebrada Rambala, Rambala Jungle Lodge, 134 m, August 9, 2014, E. Carlson, 1 male; ibid., above small falls, March 28, 2015, 52 males.

Etymology. We take great pleasure in naming this species for our colleague Dr. R. Edward DeWalt, aquatic entomologist with the Illinois Natural History Survey, in recognition of his lifetime of work on aquatic insects.

***Ochrotrichia kondratieffi* Harris and Armitage, new species**
Fig. 20

Diagnosis. Based on the divided tenth tergum, this species is placed in the *O. aldama* group of Flint (1972), with some similarity to *O. avis* Bueno-Soria and Holzenthal, *O. bicaudata* Bueno-Soria and Santiago-Fragoso, and *O. quebrada* Bueno-Soria and Holzenthal. The new species is separated on the basis of the spinose left side of the tenth tergum, which has a basal process, and the thin, elongate right side of the tergum.

Male. Length 2.0 mm, antennae broken, brown in alcohol. Abdominal segment VII and VIII annular, the former with short posteroventral process. Segment IX in lateral view posteriorly sinuate, tapering anterodorsally; square ventrally, rounded anteriorly, sinuate posteriorly; dorsally incomplete. Tergum X divided into three processes, two of which are elongate, right side process narrow over length, twisting inward subapically, left process widening subapically, apex divided into several sharp spines, base of left side with thin process tapering apically; in lateral view, upper process, thin and elongate, lower process thicker with bifid apex. Inferior appendages in lateral view thin and elongate, widening near midlength, apex rounded, numerous peglike setae on inner posterior and ventral margin; in dorsal and ventral views narrow, gradually tapering to acute apex, numerous peglike setae on mesal margins. Phallus thin and elongate, apically with pair of small lobes.

Female. Unknown.

Type material. Holotype, male—Panama, Bocas del Toro Province, tributary of Quebrada Rambala at 2nd footbridge, Rambala Jungle Lodge, 8.91627°N and 82.15469°W, 134 m, March 28, 2015, E. Carlson.

Etymology. We take great pleasure in naming this species for our colleague Dr. Boris C. Kondratieff, Director of the C.P. Gillette Museum of Arthropod Diversity, Colorado State University, in recognition of his lifetime of work on aquatic insects in the Neotropics.

***Oxyethira buenoi Harris and Armitage, new* species**
Fig. 21

Diagnosis. *Oxyethira buenoi* is most similar to *Oxyethira quinquaginta* Kelley and *O. sierruca* Holzenthal and Harris on the basis of the many segmented antennae, the vestigial inferior appendages and

the asymmetrical arms of the subgenital plate. The new species is separated by the acute tapering of abdominal segment VIII and the configurations of the subgenital plate and the phallus.

Male. Length 2.6 mm. 43 antennal segments, brown in alcohol. Abdominal segment VII tapering ventrad in lateral view, elongate ventral process. Segment VIII in lateral view elongate, posteriorly tapering to acute apex; in dorsal and ventral views deeply convex posteriorly, laterally tapering to angled apices, truncate anteriorly. Segment IX retracted into segments VI, VII, and VIII, in lateral view tapering anteriorly, posteriorly truncate; in dorsal and ventral views, rounded anteriorly, posteriorly reduced to a thin band. Segment X and inferior appendages vestigial. Subgenital plate reduced to a narrow band in lateral view, with pair of asymmetrical posterior arms, ventral arm thick, with acute apical point, dorsal arm thin and upturned distally; in dorsal view, left arm widening distally with margin slightly concave, with lateral sclerotized spot; right arm nearly uniform in width, boot-shaped apically. Phallus in dorsal view widening distally and divided into pair of elongate rods, right rod sinuate, tapering apically, left rod straight, tapering distally; in lateral view inner rod curving upward to rounded apex, outer rod nearly parallel-sided and tapering to acute, slightly upturned apex.

Female. Unknown.

Type material. Holotype, male—Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91627°N and 82.15469°W, 120 m, Malaise trap, February 6–12, 2017, E. Carlson. **Paratypes.** ibid., 1 male; ibid., December 21–31, 2016, 1 male; ibid., unnamed tributary, above small waterfall, 134 m, January 22, 2015, 3 males; ibid., above main lodge, March 28, 2015, B. Armitage, 1 male (SCH).

Etymology. We take great pleasure in naming this species for our colleague Dr. Joaquín Bueno-Soria, Universidad Nacional Autónoma de México, in recognition of his lifetime of work on Trichoptera in Mexico and Panama.

Rhyacopsyche holzenthali Harris and Armitage, new species

Fig. 22

Diagnosis. *Rhyacopsyche holzenthali* appears most closely related to *R. andina* Flint, *R. intraspira* Wasmund and Holzenthal, *R. mexicana* (Flint), and *R. torulosa* Flint in the shape of inferior appendages in lateral view. However, in these species the dorsum of segment IX is deeply divided, which is the new species is entire.

Male. Length 2.7–2.9 mm. 39 antennal segments, tufts of hair between and behind the scapes, brown in alcohol with wings mottled with white hairs. Abdominal segment VIII annular. Segment IX produced dorsally into shelf-like lobe, tapering distally and bearing row of dark, peg-like setae ventrally, truncate lobe mesally; in dorsal view truncate posteriorly with small notch mesally, cluster of dark peg-like setae on margin, anteriorly deeply incised, truncate mesally. Tergum X narrow and shelf-like, retracted within segment IX posteriorly, anteriorly articulating with subgenital plate, which is round distally and ventrally, and bears several stout setae from venter. Inferior appendages narrow basally, dorsal margin expanded at midlength, then abruptly narrowing to finger-like apex which bears an elongate dorsal spine; in dorsal and ventral views, nearly parallel-sided until narrowing apically and curving along the outer margin. Phallus in dorsal view tubular, thin membranous sheath subapically, both central and lateral processes linear.

Female. Unknown.

Type material. Holotype, male—Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.7 km SSE Rambala, 8.91627°N and 82.15469°W, 120 m, Malaise trap, February 6–12, 2017, E. Carlson. **Paratypes.** ibid., 1 male; ibid., March 31–April 11, 2015, 1 male; ibid., March 28, 2015, 1 male; ibid., tributary of Quebrada Rambala, 134 m, September 29, 2015, 1 male (SCH).

Etymology. We take great pleasure in naming this species for our colleague Ralph Holzenthal, who has contributed much to our knowledge of neotropical caddisflies and, along with Anne Wasmund, recently revised the genus *Rhyacopsyche*.

***Tizatetrichia panamensis* Harris and Armitage, new species**
Fig. 23

Diagnosis. This new species is difficult to place, as it lacks one of the characters used by Harris et al. 2002, to designate the genus, that of the venter of segment X being well-developed and bearing heavy spines. However, the inferior appendages are longer than segment X and thin, and the subgenital plate is reduced, which is characteristic of the genus. This is the second species to be placed in *Tizatetrichia*, and it is possible that these are aberrant members of the closely related genus *Bredinia*. However, both *T. costaricensis* and the new species lack the elongate thickened seta from the posterior of the inferior appendage which is typical for *Bredinia*. The structure of the phallus in the new species is also more similar to that seen in *T. costaricensis*, being deeply divided posteriorly, and lacking a medial, protruding ejaculatory duct which is typical of *Bredinia*. We have collected a third species belonging to this genus which strengthens our argument, but females for *Tizatetrichia* remain unknown and could provide additional information when discovered.

Male. Length 1.3–1.5 mm. Head, wings and 18 segmented antennae typical for genus, as are the legs and thoracic segments, brown in alcohol. Abdominal segments VII annular with pair of posterolateral apodemes. Segment VIII annular, incised ventrally on posterior margin. Segment IX rectanguloid in lateral view, rounded ventrally and tapering dorsally, anteriorly narrowing to elongate apodemes which extend into segment VI; ventrally with mesal notch; dorsally deeply incised on posterior margin, laterally with sclerotized margins. Segment X reduced laterally to thin lobe, with dorsal notch posteriorly; dorsally membranous with posterior incision. Inferior appendages in lateral view narrow, tapering distally and bearing stout spike; in ventral view, thin and elongate, rectanguloid posteriorly, fused basally and bearing numerous short spines, apically with short, stout spike Subgential plate not noticeable and seemingly represented by a flat plate which is incised posteriorly. Phallus tubular, in dorsal view divided apically into pair of long, narrow processes each tipped with numerous spines, long lateral spine subapically, mesally with cluster of short spikes and lateral processes; in lateral view ending in several long, spiny processes, mesally with narrow sclerite just posterior to cluster of sharp spikes.

Female. Unknown.

Type material. Holotype, male—Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91543°N and 82.15527°W, 120 m, Malaise trap, February 6–12, 2017, E. Carlson. **Paratypes.** ibid., November 15–20, 2016, 1 male (SCH).

Etymology. Named for the country of Panama, whence the species is described.

***Zumatrichia flinti* Harris and Armitage, new species**
Fig. 24

Diagnosis. *Zumatrichia flinti* is placed in the galtena group of Flint (1970) based on the presence of a basodorsal process from the inferior appendages. The new species, along with *Z. diamphidia* Flint and *Z. attenuata* Flint, has a tripartite inferior appendage and appears to be most similar to *Z. attenuata*. *Zumatrichia flinti* differs in the shape of the basodorsal process of the inferior appendage, which is apically straight in *Z. flinti*, but sharply angled in *Z. attenuata*. As well, the subapical process from the basodorsal process projects dorsally in *Z. attenuata* and ventrally in *Zumatrichia flinti*.

Male. Length 3.0–3.2 mm. Head without modification, antennae 18 segmented with enlarged scape, body and unmodified wings brown in alcohol. Abdominal segment VII annular with posteroventral mesal process. Segment VIII in lateral view truncate posteroventrally, tapering dorsally; in dorsal view narrow, concave posteromesally; ventrally with wide mesal incision on posterior margin. Segment IX generally quadrate in lateral view, narrowing anteriorly, posterior margin with thin lobe, laterally with elongate setal-bearing process; dorsally emarginate anteriorly and posteriorly, posterior margins sclerotized. Segment X rectanguloid in lateral aspect; in dorsal view square, with posterior margin tapered. Inferior appendages tripartite, dorsalmost process angled basally then thin and elongate, subapically with ventral process, medial process thin and acute distally, ventralmost portion rectangular, rounded distally; in

ventral view this ventralmost process is truncate posteriorly with numerous setae, small medial notch. Penile sheath with subapical point in lateral view; phallus with medial ring-like process, basally with pair of thin basal spines, apically divided into three rods, dorsalmost shelflike and shorter than lower pair, medial rod thin and spinelike, ventralmost rod narrow to upturned apex; in dorsal view, phallus apex with elongate central rod with three short basal spines.

Female. Unknown.

Type material. Holotype, male—Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91627°N and 82.15469°W, 120 m, Malaise trap, February 6–12, 2017. **Paratype.** tributary to Quebrada Rambala, above waterfall, 134 m, March 28, 2015, B. Armitage, 1 male (SCH).

Etymology. We take great pleasure in naming this species for our colleague Dr. Oliver S. Flint, Jr., Smithsonian Institution, in recognition of his lifetime of work on the Trichoptera of the Neotropics.

Zumatrichia hazelae Harris and Armitage, new species

Fig. 25

Diagnosis. *Zumatrichia hazelae* is placed in the galtena group of Flint (1970) based on the presence of a basodorsal process from the inferior appendages similar to that of *Z. kerekeda* Olah and Flint and *Z. kisgula* Olah and Flint. However, unlike these two species, *Z. hazelae* has the basal portion of the inferior appendage short and ovate, similar to that seen in *Z. teribe* Harris and Armitage.

Male. Length 2.7–2.9 mm. Head without modification, a broken with enlarged scape bearing large circular process, body and unmodified wings brown in alcohol. Abdominal segment VII annular with serrate posteroventral mesal process. Segment VIII in lateral view truncate posteroventrally, tapering dorsally; in dorsal view narrow, emarginated posterolaterally; ventrally with narrow mesal incision on posterior margin. Segment IX generally square in lateral view, narrowing anteriorly, posterior margin with thin lobe, laterally with elongate setal-bearing process; dorsally emarginate anteriorly and posteriorly, posterior margins sclerotized. Segment X rectanguloid in lateral aspect; in dorsal view square, with posterior margin tapered. Inferior appendages with elongate, thin basodorsal process, subapically with setal-bearing dorsal lobe, main body an enlarged lobe, which in ventral view is deeply incised posteriorly with numerous setae on margin. Penile sheath with subapical point in lateral view; phallus with medial ring-like process, apically enlarged and platelike, internally with elongate dorsal spine and numerous anterobasal spines; in dorsal aspect, a pair of deeply divided mesal spines, two pair of posterior spines, one mesal, one lateral.

Female. Unknown.

Type material. Holotype, male—Panama, Bocas del Toro Province, tributary of Quebrada Rambala, Rambala Jungle Lodge, 3.7 km SSE Rambala, 8.91627°N and 82.15469°W, 134 m, November 29, 2014, E. Carlson. **Paratype.** ibid., 1 male (SCH).

Etymology. Named for the mother of the first author, Hazel I. Harris, in honor of her 90th birthday.

New drawings

In some instances, we had difficulty in placing names on species. In part, this was due to incomplete drawings, or that the drawings were done in a different style than that of ours. With that in mind, we have taken this opportunity to redraw several species occurring in Panama.

Leucotrichia extraordinaria Bueno-Soria

Fig. 26

We found the specimens from Panama to have a shorter posterolateral extension of segment VII than that seen in the original drawings. As well, this extension lacks a stout spine at the apex, seen in the

original description. In ventral view, this extension of segment VII was notably shorter and narrower that that seen in the original drawings.

Material examined. Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91627°N and 82.15469°W, 120 m, Malaise trap, December 21–31, 2016, E. Carlson, 13 males; ibid., February 6–12, 2017, 6 males; ibid., November 15–20, 2016, 18 males; ibid., October 7–9, 2016, 59 males; ibid., March 31–April 11, 2015, 3 males (SCH).

Leucotrichia mutica Flint

Fig. 27

We found *Leucotrichia mutica* to be similar to that of *L. melleopicta* Mosely. The structure of the inferior appendages, which appeared to be fused ventrally and the details of the phallus seemed to vary from the figures in Thomson and Holzenthal (2015). We found *L. mutica* to be most easily recognized by the setose basal loop of the phallus. Thomson and Holzenthal (2015) mentions in their revision that the posterior portion of the phallus is missing from *L. mutica*, and that the description was based on a unique holotype. The species was fairly common in our collections from Quebrada Rambala.

Material examined. Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91627°N and 82.15469°W, 120 m, Malaise trap, February 6–12, 2017, E. Carlson, 6 males; ibid., December 21–31, 6 males; ibid., March 31–April 11, 2015, 2 males; ibid., October 7–9, 2016, 17 males; ibid., March 28, 2015, 1 male; tributary of Quebrada Rambala, 2nd footbridge, Rambala Jungle Lodge, 134 m, March 28, 2015, E. Carlson, 2 males.

Notes. As *Leucotrichia mutica* is similar to *L. melleopicta*, we have taken the opportunity to provide new drawings of *L. melleopicta* (Fig. 28) from material collected in Quebrada Rambala at the following sites: near Rambala Jungle Lodge, 3.74 km Rambala, 8.91627°N and 82.15469°W, Malaise trap, October 7–9, 2016, E. Carlson, 38 males; ibid., December 21–31, 2016, 66 males; ibid., February 6–12, 2017, 55 males, ibid., November 15–20, 36 males; ibid., March 31–April 11, 2015, 50 males.

Leucotrichia rhomba Thomson and Holzenthal

Fig. 29

The structure of the phallus appeared to be somewhat different in the Panamanian specimens we examined in comparison to the Costa Rican holotype described by Thomson and Holzenthal (2015). As we have collected this species for the first time in Panama, we have taken this opportunity to provide new drawings of the species.

Material examined. See below under New Country Records.

Metrichia sacculifera (Flint)

Fig. 30

Metrichia sacculifera (Flint) has previously been reported from Dpto. Antioquia in Colombia by Flint 1991. The specimens from Quebrada Rambala, appear to be identical in nearly all respects to the description in Flint (1991). The phallus of the Panamanian specimens appear to be the mirror image of the specimens from Colombia, but this could be a result of the phallus rotating The abdominal pouches in the specimens from Panama match the description of those from Colombia, but they were not drawn in the original description. We have taken the opportunity to redraw this species based on the material from Quebrada Rambala.

Material examined. Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91627°N and 82.15469°W, 120 m, Malaise trap, March 31–April 11, 2015, E. Carlson, 4 males; ibid., October 7–9, 2016, 41 males; ibid., November 15–20, 2016, 36 males; ibid., February 6–12, 2017, 10 males; ibid., November 15–20, 2016, 36 males.

***Ochrotrichia paraldama* Bueno-Soria**
Fig. 31

We had some difficulty in identifying this species. In the original drawings in Bueno-Soria (2009), the tenth tergum appears to have the left side process overlapping the right side process, but in the specimens we have seen, the left side overlaps the right. As well, the left process terminates in an acute spine, which is adjacent to a clump of dense setae.

Material examined. Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 3.74 km SSE Rambala, 8.91627°N and 82.15469°W, 120 m, Malaise trap, February 6–12, 2017, E. Carlson, 1 male.

New Country Records

The following three species were identified from the Quebrada Rambala watershed and were determined to be new country records for Panama.

Hydrobiosidae

***Atopsyche minimajada* Blahnik and Gottschalk**

Material examined. Panama, Bocas del Toro Province, tributary of Quebrada Rambala, Rambala Jungle Lodge, 8.91543°N and 82.15527°W, 134 m, UV light, July 29, 2014, B. Armitage, 1 male (COZEM).

Hydroptilidae

***Leucotrichia rhomba* Thomson and Holzenthal**

Material examined. Panama, Bocas del Toro Province, Quebrada Rambala, near Rambala Jungle Lodge, 8.91627°N and 82.15469°W, Malaise trap, 120 m, November 15-20, 2016, E. Carlson, 1 male; ibid., June 12–15, 2017, 1 male; ibid., June 28-30, 2017, 1 male (SCH).

***Oxyethira* (*Oxytrichia*) *apinolada* Holzenthal and Harris**

Material examined. Panama, Bocas del Toro Province, tributary of Quebrada Rambala, above small falls, Rambala Jungle Lodge, 8.91543°N and 82.15527°W, 134 m, UV light, March 28, 2015, B. and T. Armitage, 1 male.

Discussion

Quebrada Rambala versus its tributary

The fact that Quebrada Rambala's tributary has fewer species than the mainstem is not unexpected. First order streams, in general, have less substrate area, fewer niches, and lower population sizes compared to the second order streams into which they flow. However, it should be noted that 53 of the 63 species identified from the tributary were also found in the mainstem. This is, perhaps, another way to look at differences, if any, between two different sized, associated streams. In the third part of the Discussion section, we will add other reasons why these two streams are not as different as the Jaccard's value implies.

UV light traps versus Malaise traps

The species identified from UV light traps versus Malaise traps were quite distinct. They shared 58 out of the 127 species collected, and they did not share 69 species. Although this difference possibly could be reduced, as described in the next section, it remains clear that employing both collection methods yields a better estimate of species richness than either method alone. One of the deficiencies in this study was that only UV light traps were employed for the tributary.

Estimates of true species richness

Sampling limitations inherent in almost every biological survey cause species to be missed that are present, but not detected (Chao et al. 2017). Thus, true species richness (identified plus undetected species) is invariably underestimated. Nonparametric estimators for reduction of undersampling bias have become increasingly favored because they make no assumptions about the underlying probability distribution of the supporting species incidence or abundance data. Further, incidence (presence/absence) data is preferred over abundance data in order to avoid the sometimes major error terms which accompany abundance estimates due to sampling problems. Not discussed here are contributions of cryptic species, if any.

In order to estimate these undetected species for incidence data, species that are frequently encountered offer little or no insight. However, species that are detected (or undetected) in only a few samples contain almost all of the information about undetected species richness (Gotelli and Chao 2013). Thus, as stated in the Methods section, most of these nonparametric estimators (e.g., Chao2) are based on rare species, particularly those whose frequency is one (one time in only one sample) or two occurrences (one time in two different samples) for all samples in a sampling area or temporal period.

The Chao2 estimator, in general, provides a nonparametric lower bound of species richness (Chao 1987) if the sample size is not sufficiently large and/or the detection probability of very unique and undetected species in samples is unequal. However, if the sample size is large and the rare species have an equal detection probability, then Chao2 becomes an unbiased point estimator for true species richness. Another consideration involves the relatedness of the assemblages. Two assemblages in different watersheds or separated by great distances would not necessarily have a large proportion of shared species. However, in our case, one assemblage occupies a tributary of the other stream assemblage's waterbody, and it would be expected that the proportion of shared species is larger than normal. The high number of rare species whose summed frequency values are one or two for Quebrada Rambala (n = 47) and its tributary (n = 48) across all respective samples taken, provide ample opportunities for increasing numbers of shared species. If we continued sampling these same locations for an extended period of time, we would expect higher similarity values between the two drainages, both from increased matching of known rare species as well as matched, undetected species. In summary, the similarity values for these two assemblages are likely underestimates.

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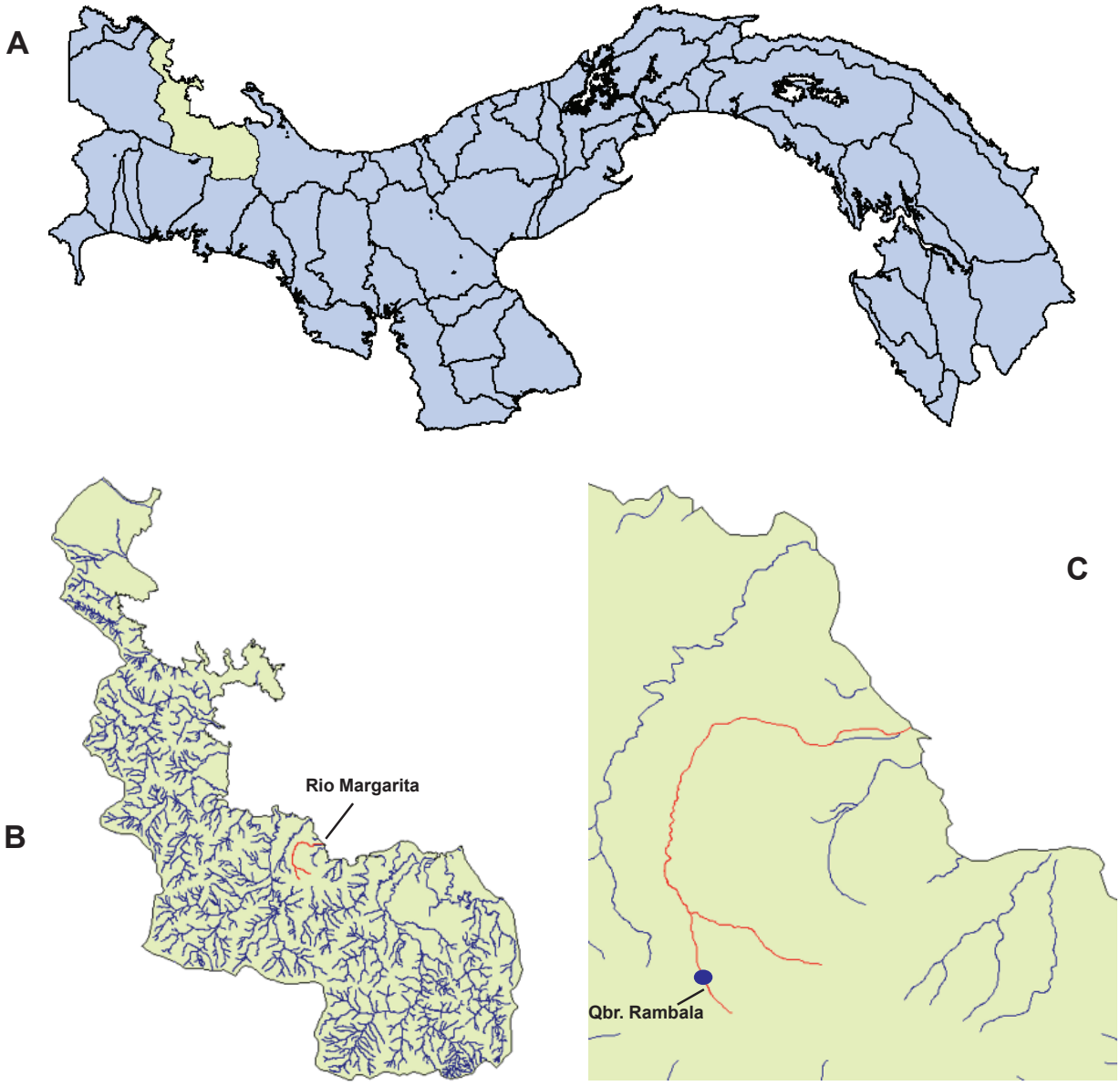

Figure 1. Location of Quebrada Rambala. A. Map of Panama with Cuenca 093 shaded in green. B. Map of Cuenca 093 with hydrography overlay – Rio Margarita in red. C. Close up of the Chiriquí Grande area with the sample location on Quebrada Rambala indicated.

Figure 2. Photograph of Quebrada Rambala at the site where a Malaise trap was employed.

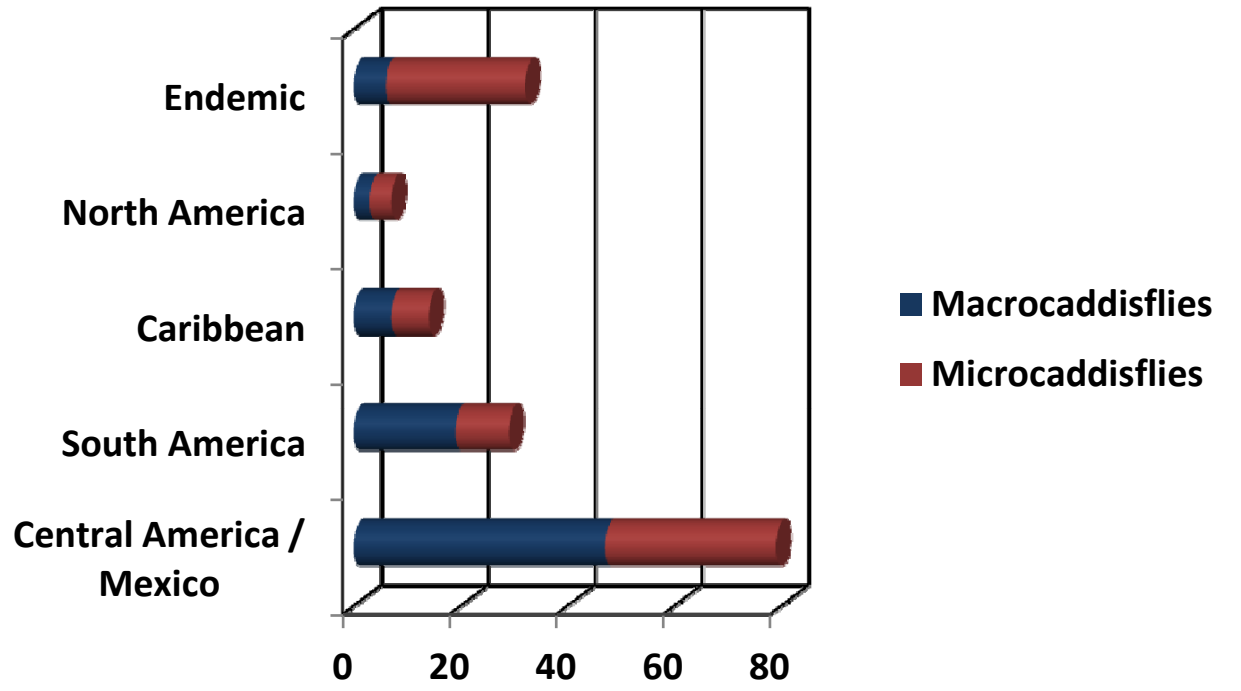

Figure 3. Regional affinities for the caddisfly species collected in the Quebrada Rambala drainage. Colors are used to differentiate between the relative contributions of microcaddisflies (Hydroptilidae) and the macrocaddisflies (all other families).

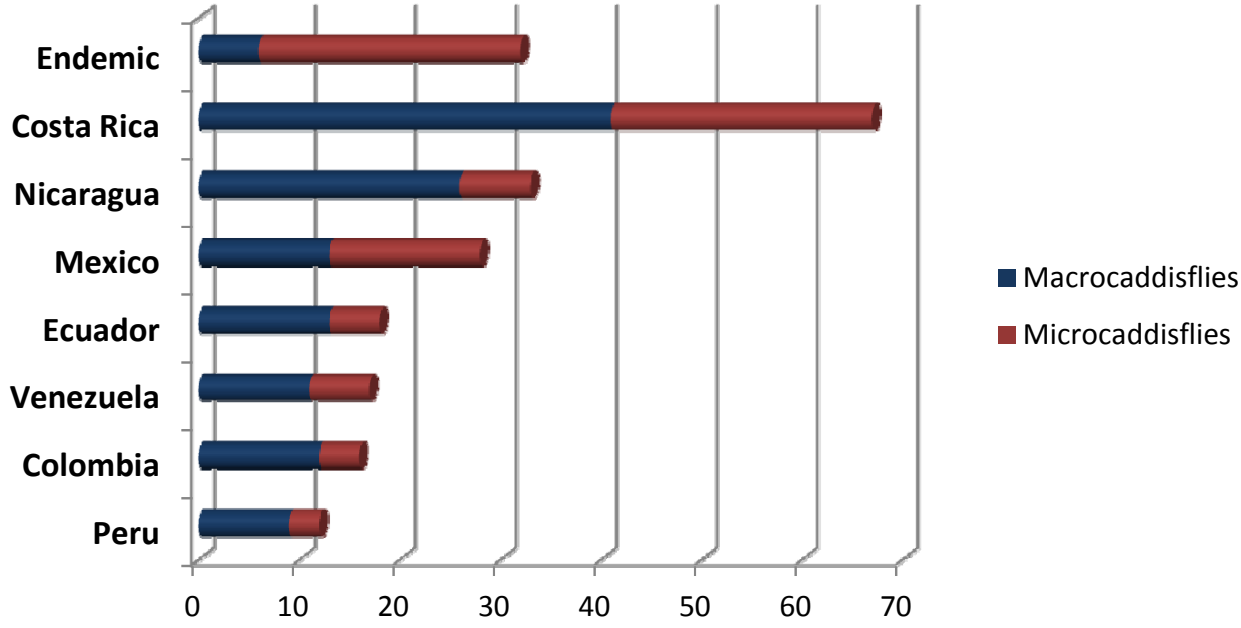

Figure 4. Country affinities for the caddisfly species collected in the Quebrada Rambala drainage. Colors are used to differentiate between the relative contributions of microcaddisflies (Hydroptilidae) and the macrocaddisflies (all other families).

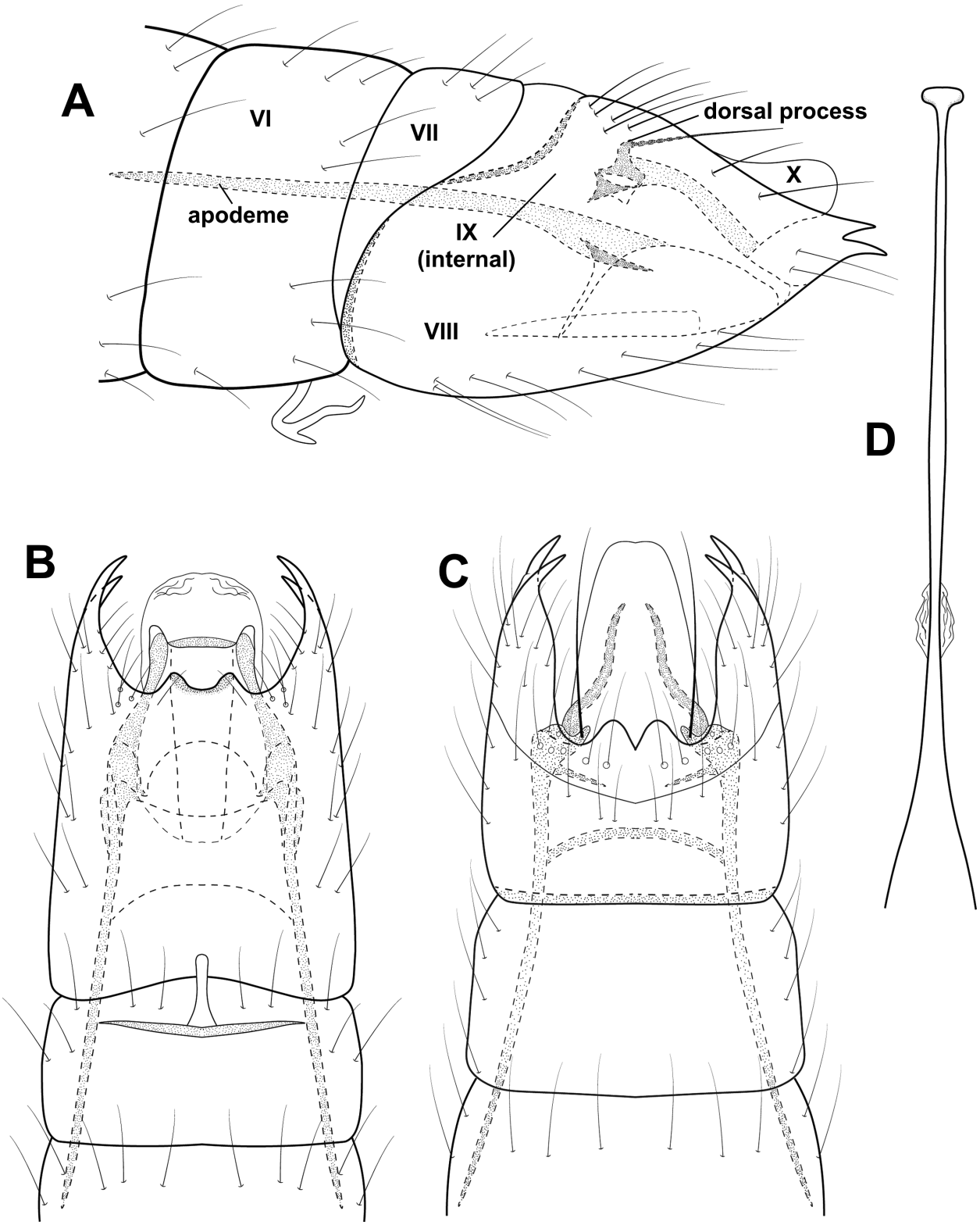

Figure 5. *Alisotrichia bernali*, sp. n., Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, dorsal view.

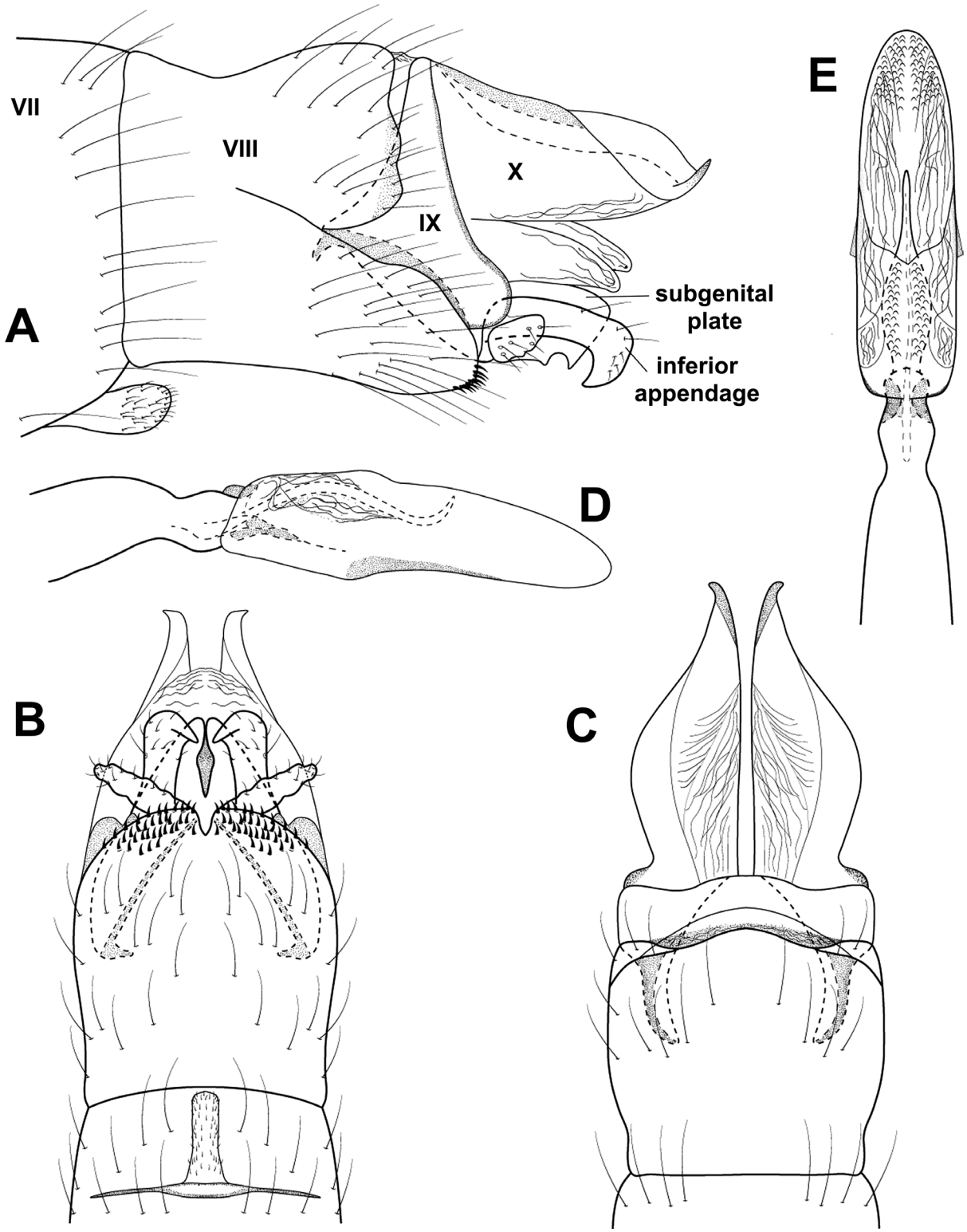

Figure 6. *Cerasmatrichia blahniki*, sp. n., Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, lateral view. **E)** Phallus, dorsal view.

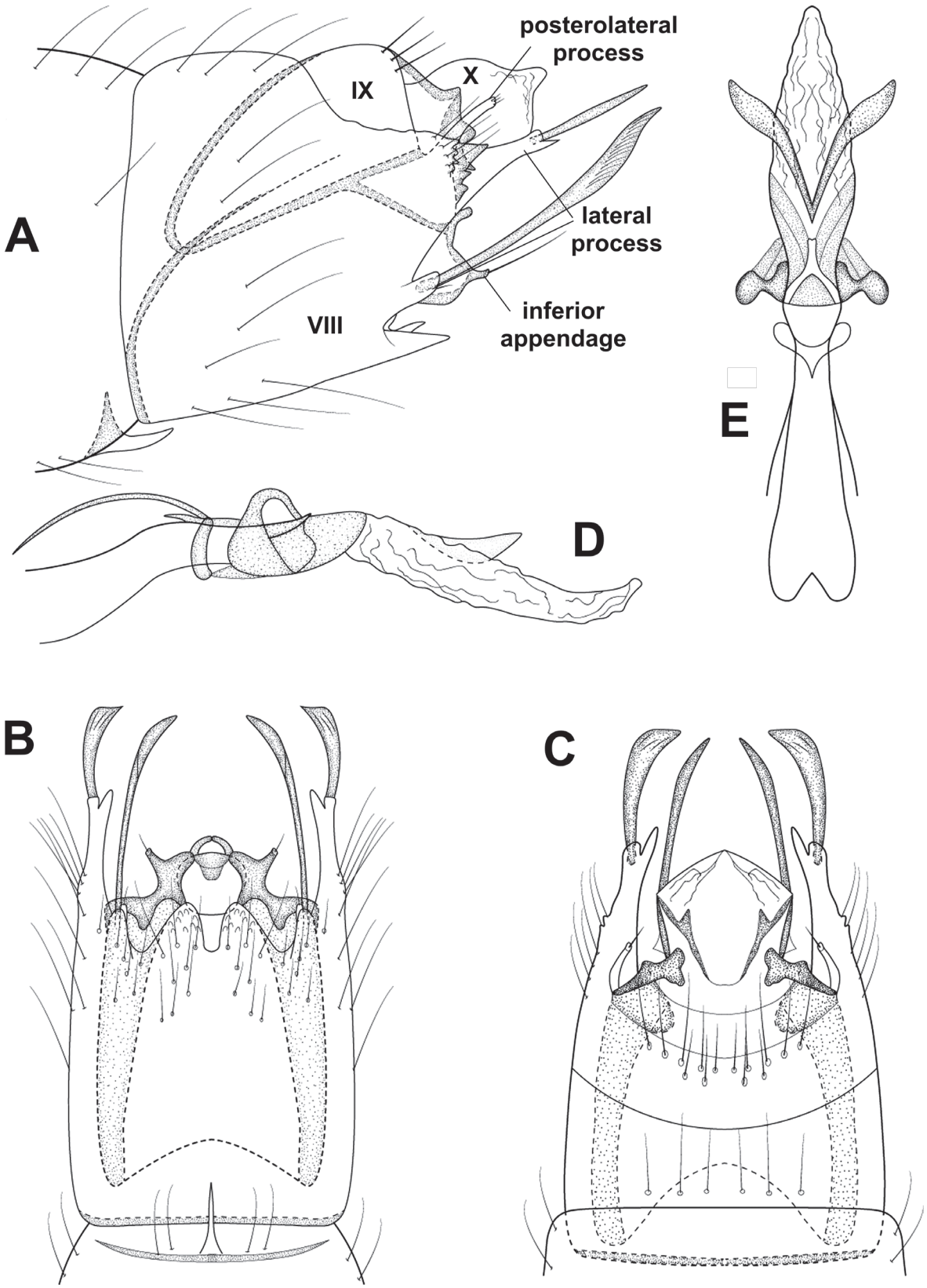

Figure 7. *Costatrichia santosi*, sp. n., Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, lateral view. **E)** Phallus, dorsal view.

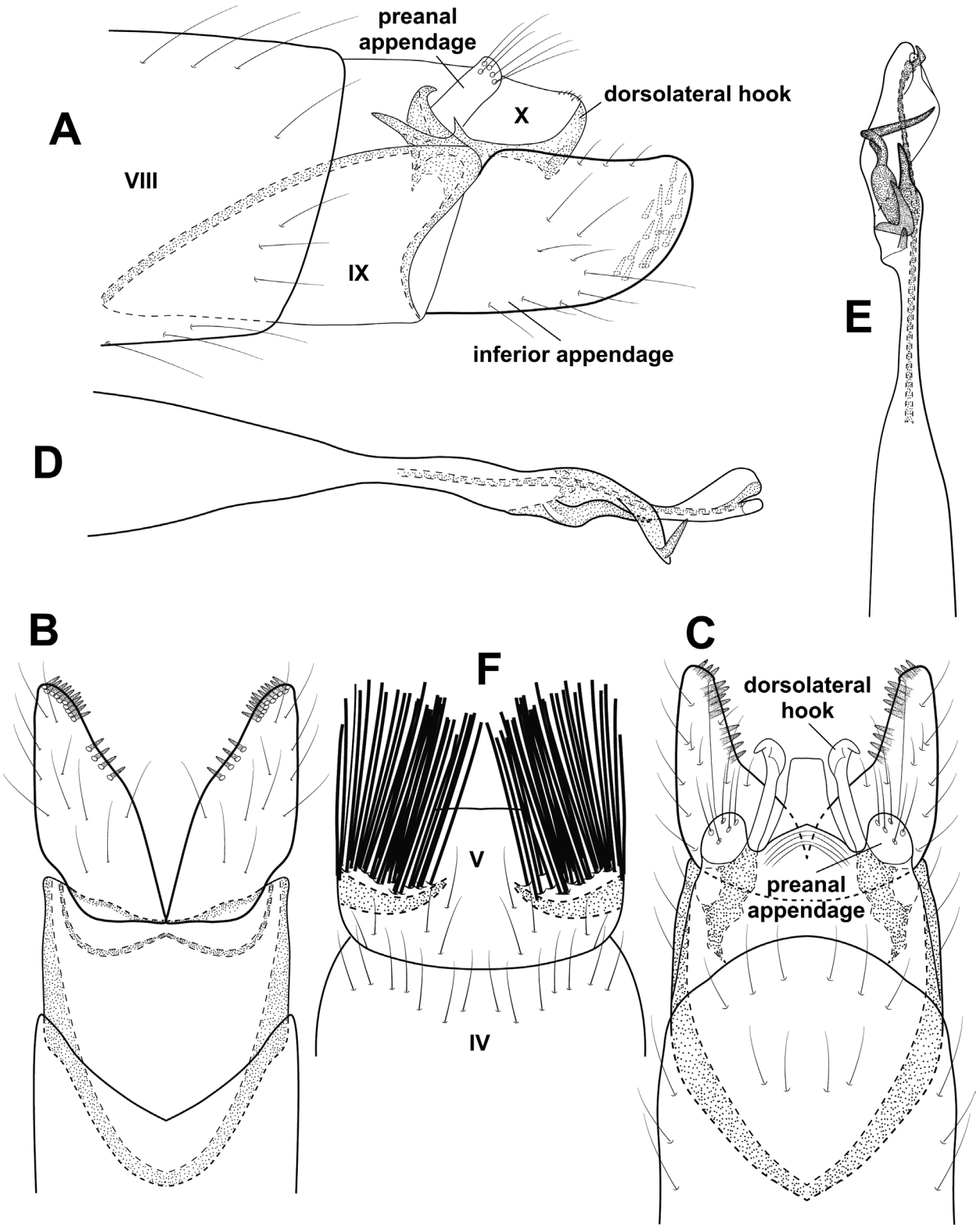

Figure 8. *Metrichia macdonaldi*, sp. n., Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, lateral view. **E)** Phallus, dorsal view. **F)** Abdominal segments IV, V, and VI, dorsal view.

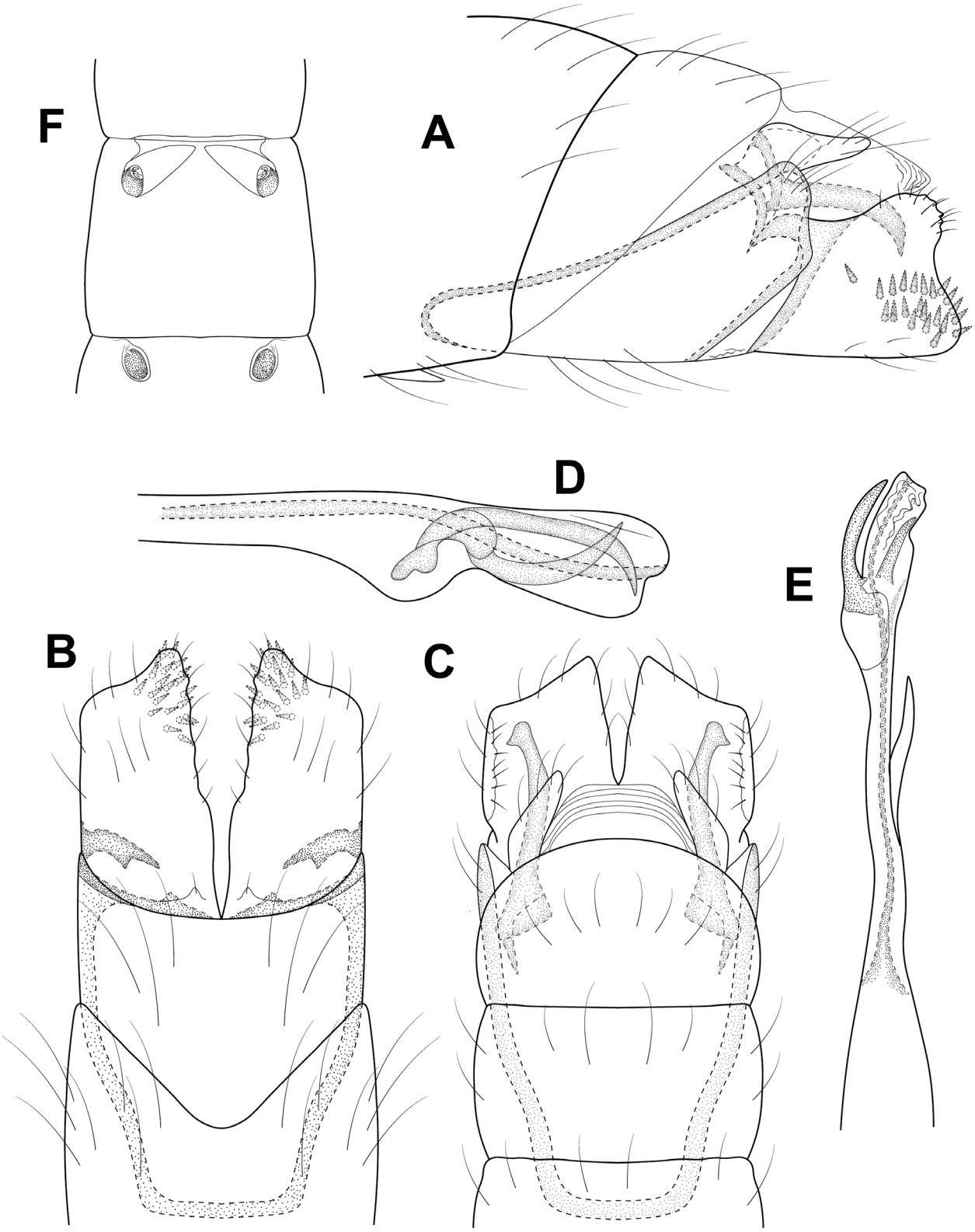

Figure 9. *Metrichia thomsonae*, sp. n., Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus apex, lateral view. **E)** Phallus, dorsal view. **F)** Abdominal segments VI, VII, and VIII, dorsal view.

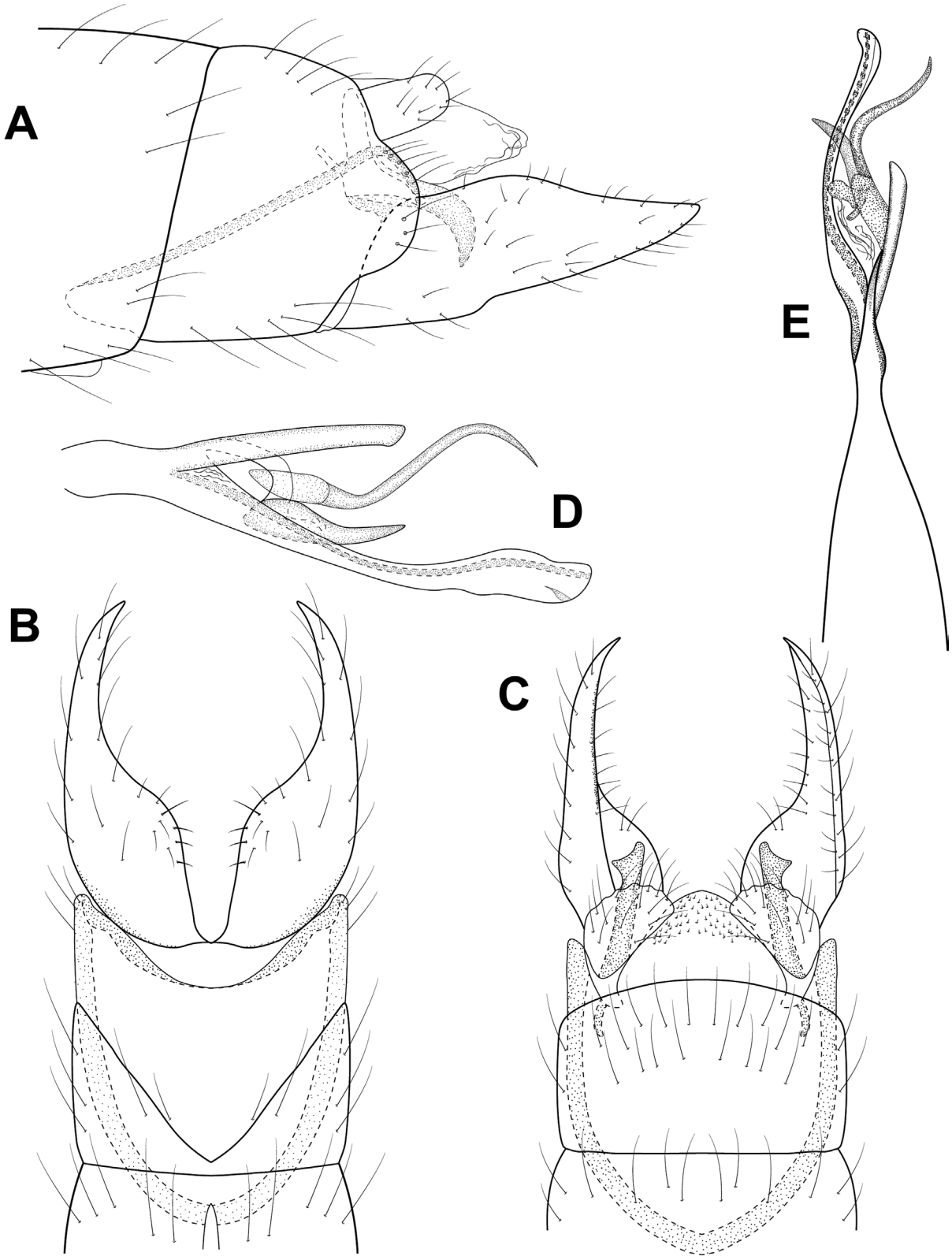

Figure 10. *Metrichia thurmani*, sp. n., Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus apex, lateral view. **E)** Phallus, dorsal view.

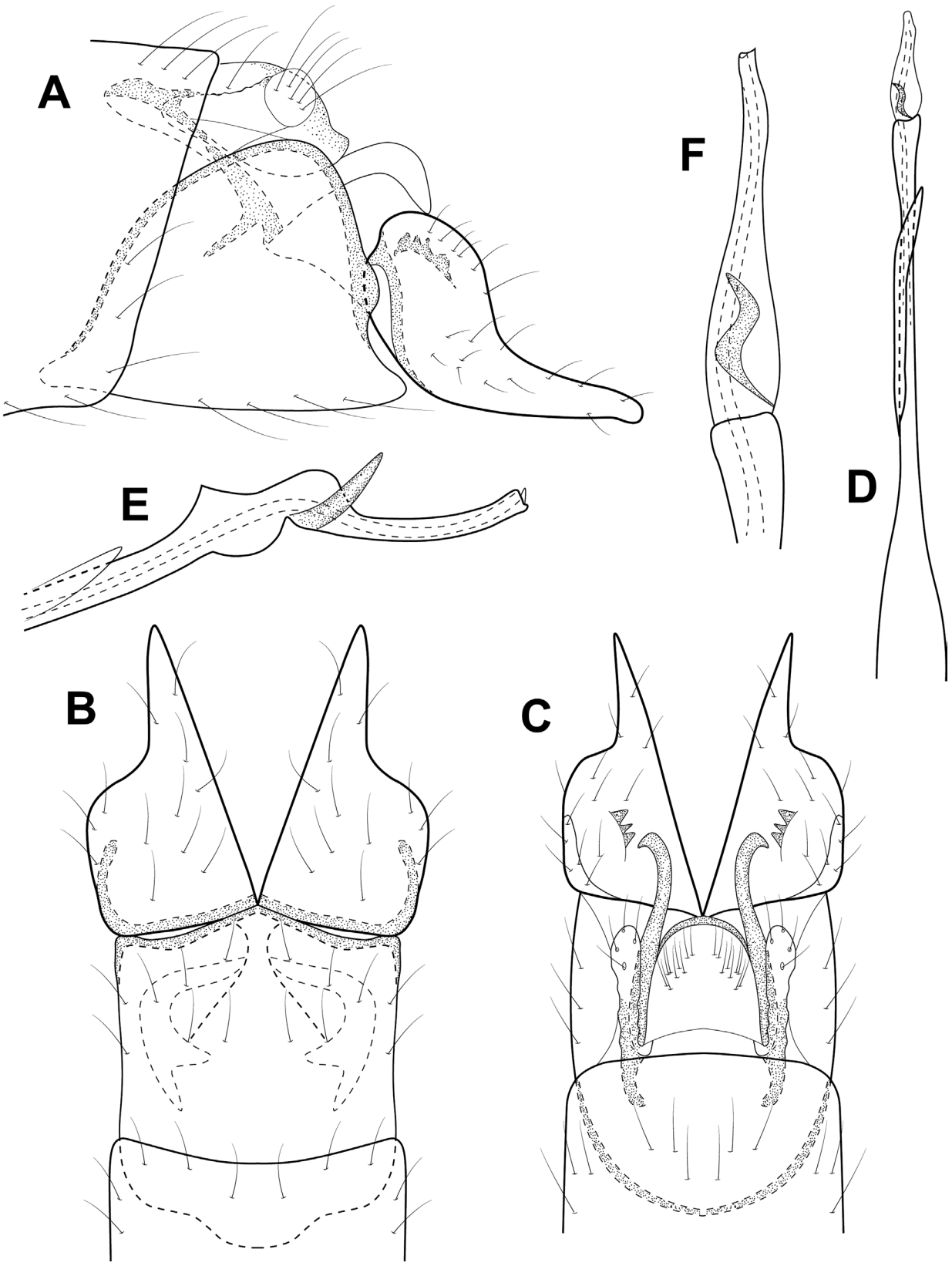

Figure 11. *Metrichia trebeki*, sp. n., Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, dorsal view. **E)** Phallus apex, lateral view. **F)** Phallus apex, dorsal view.

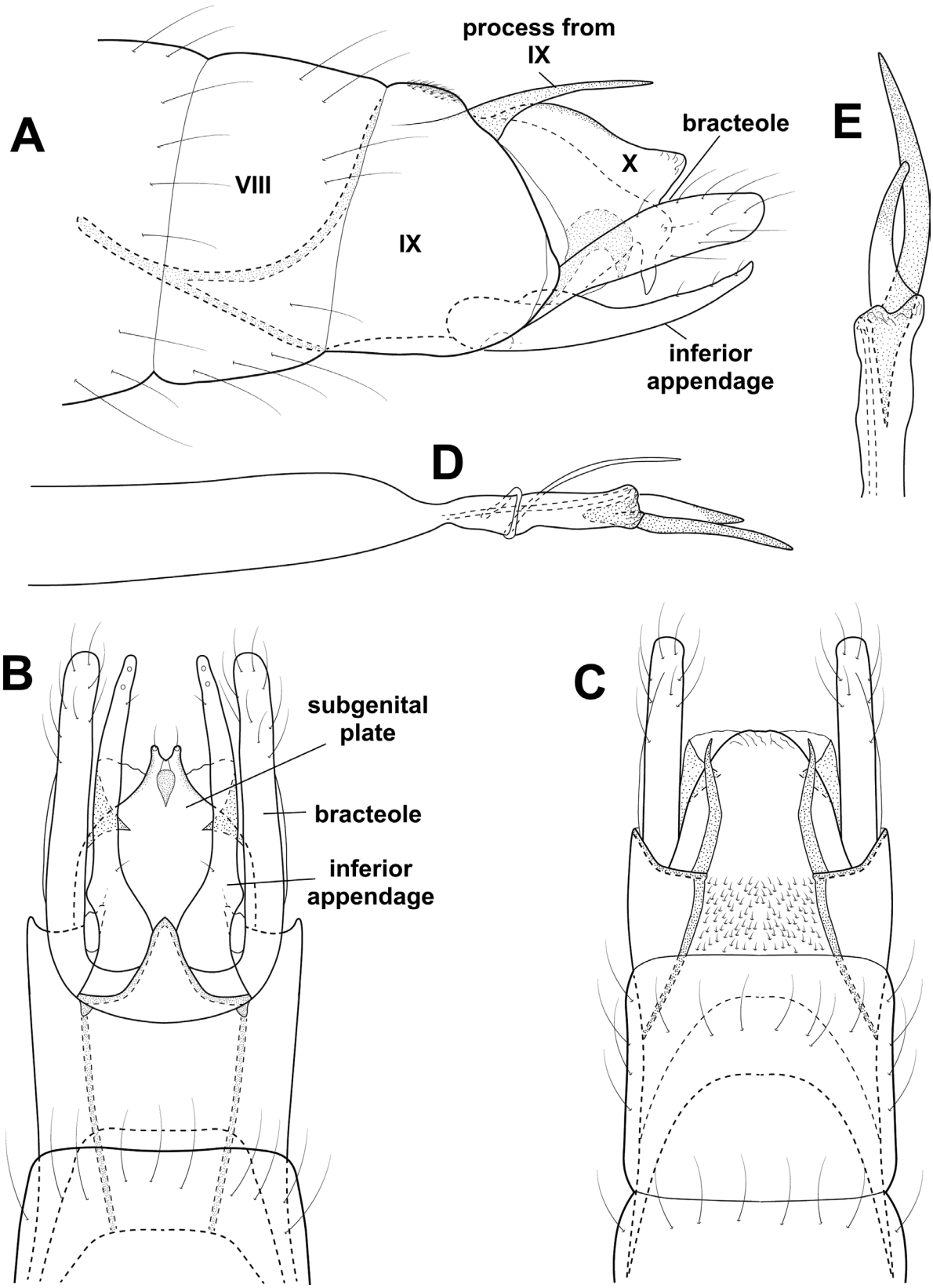

Figure 12. *Neotrichia carlsoni*, sp. n., Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, lateral view. **E)** Phallus apex, dorsal view.

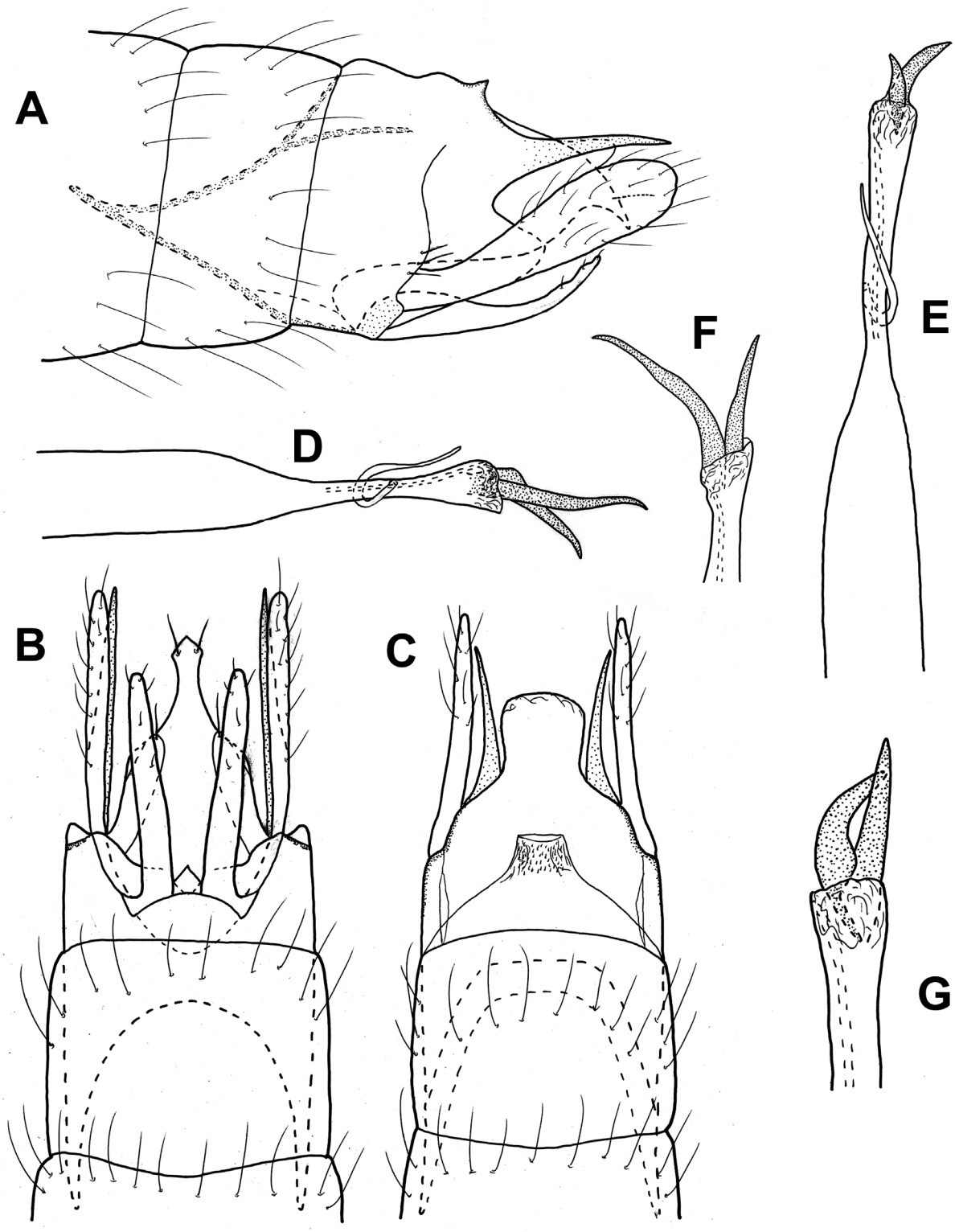

Figure 13. *Neotrichia hiaspa (*Mosely), Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, lateral view, specimen from Panama. **E)** Phallus, lateral view, specimen from Mexico. **F)** Phallus apex, dorsal view, specimen from Panama; **G)** Phallus apex, dorsal view, specimen from Mexico.

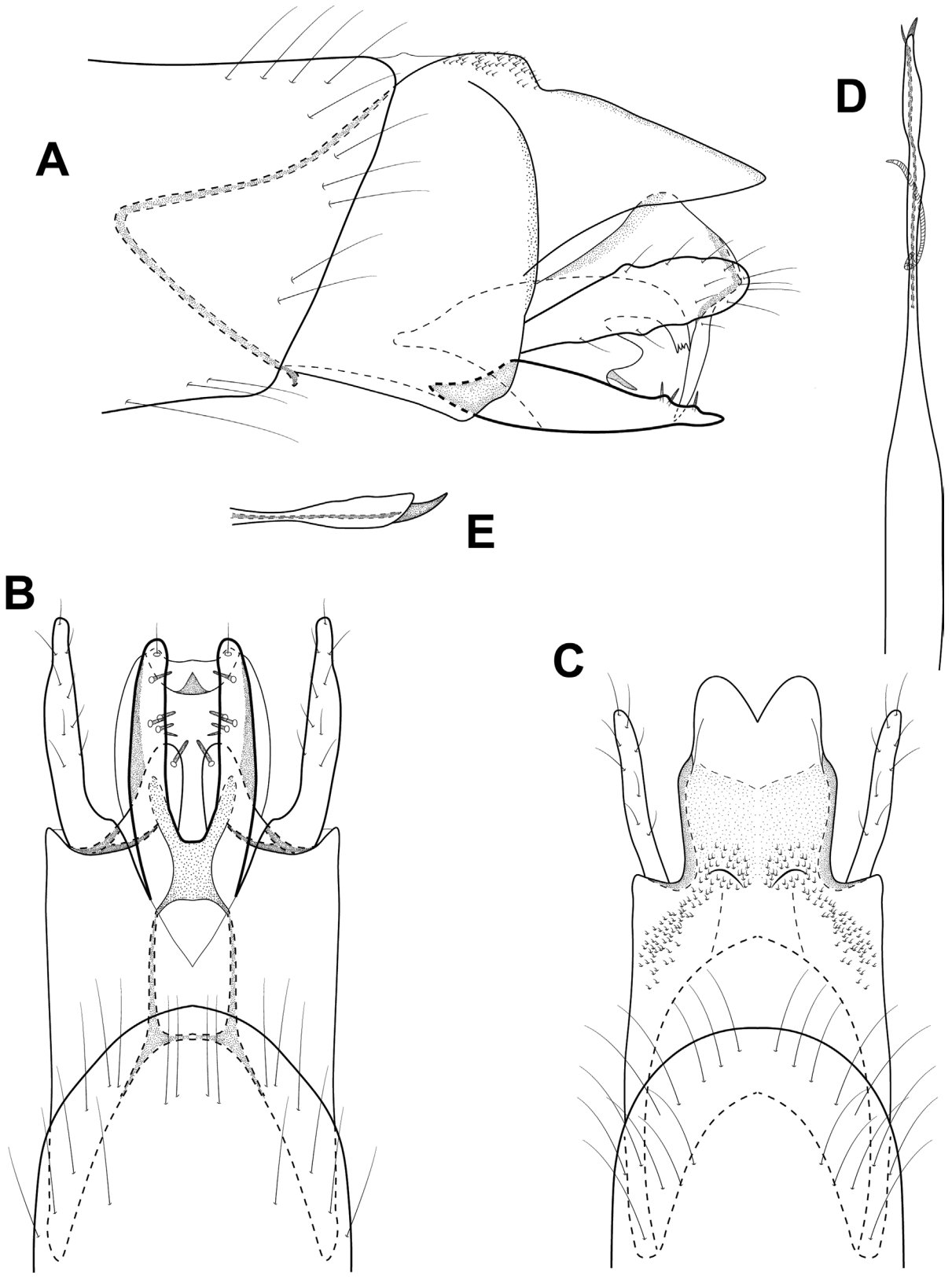

Figure 14. *Neotrichia rambala*, sp. n., Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, dorsal view. **E)** Phallus apex, lateral view.

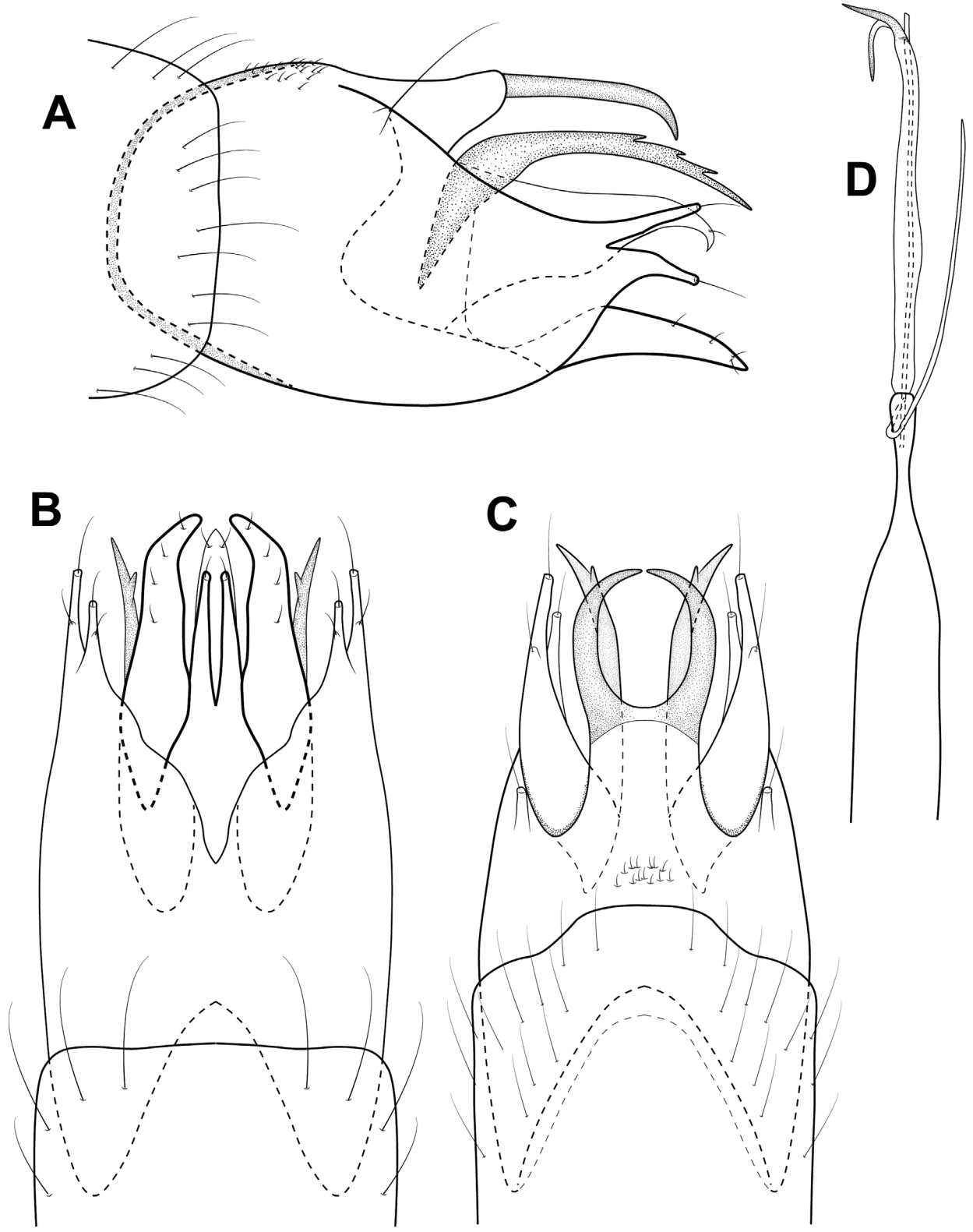

Figure 15. *Neotrichia serrata*, sp. n., Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, dorsal view.

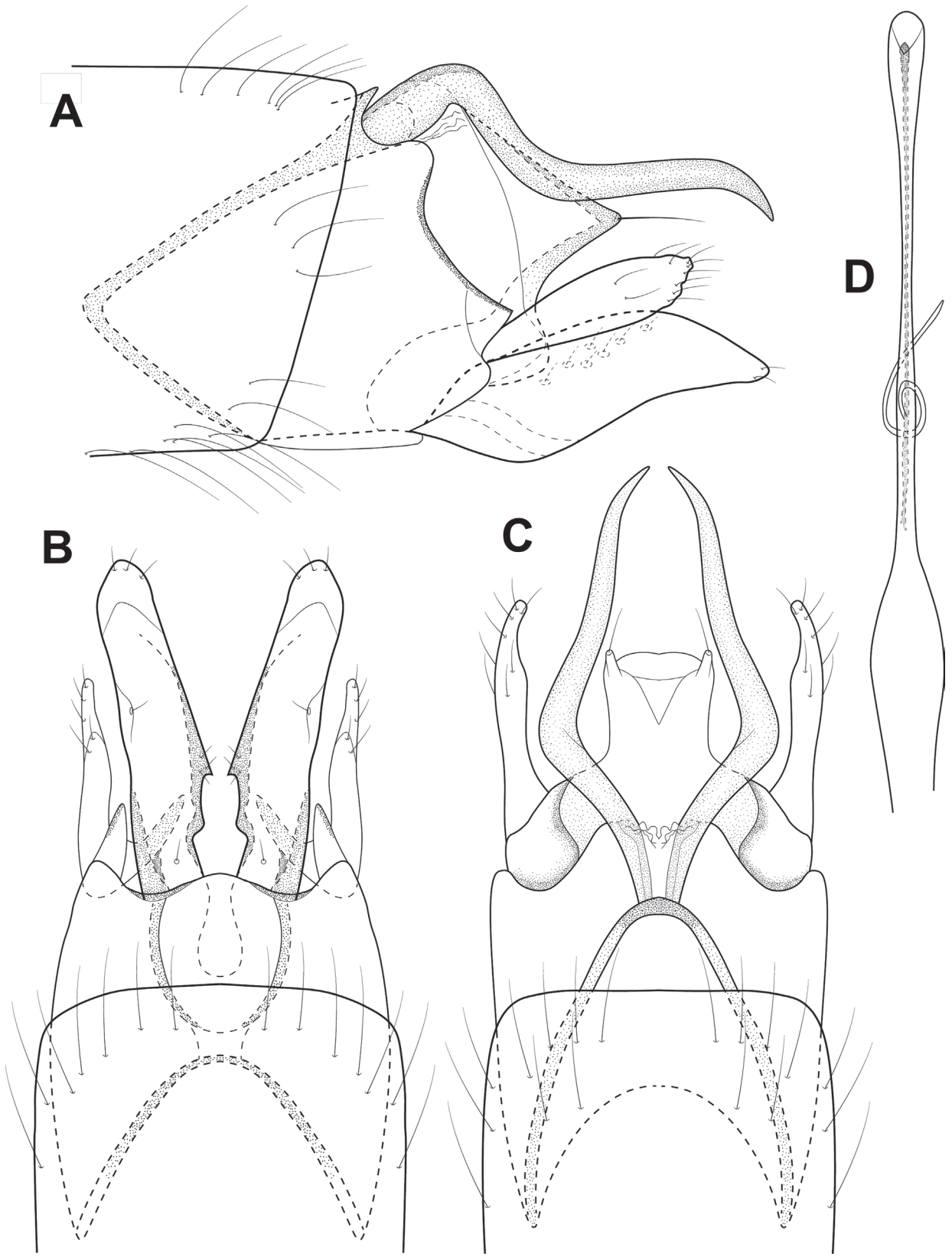

Figure 16. *Neotrichia starki*, sp. n., Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, dorsal view.

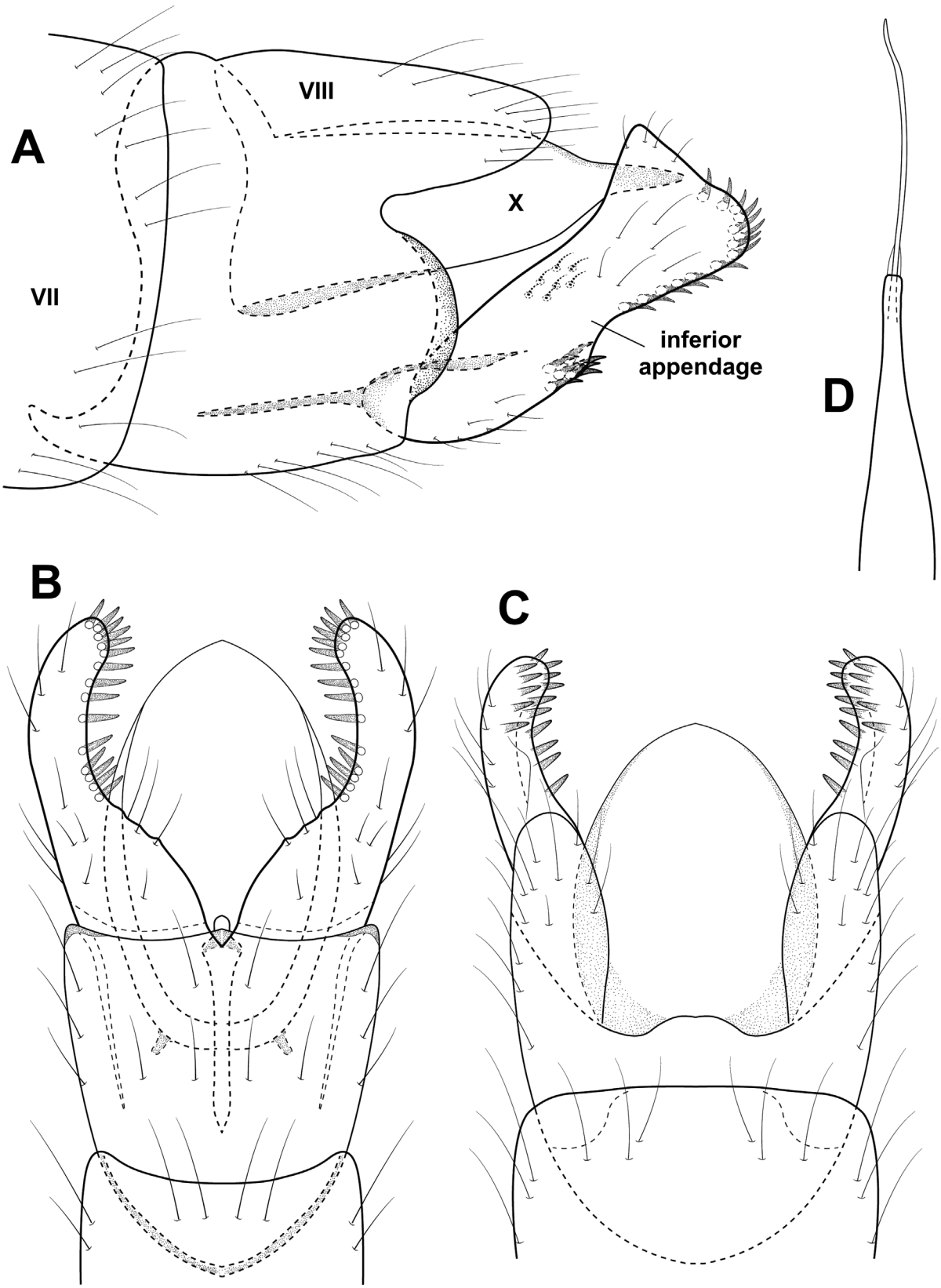

Figure 17. *Ochrotrichia birdae*, sp. n., Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, dorsal view.

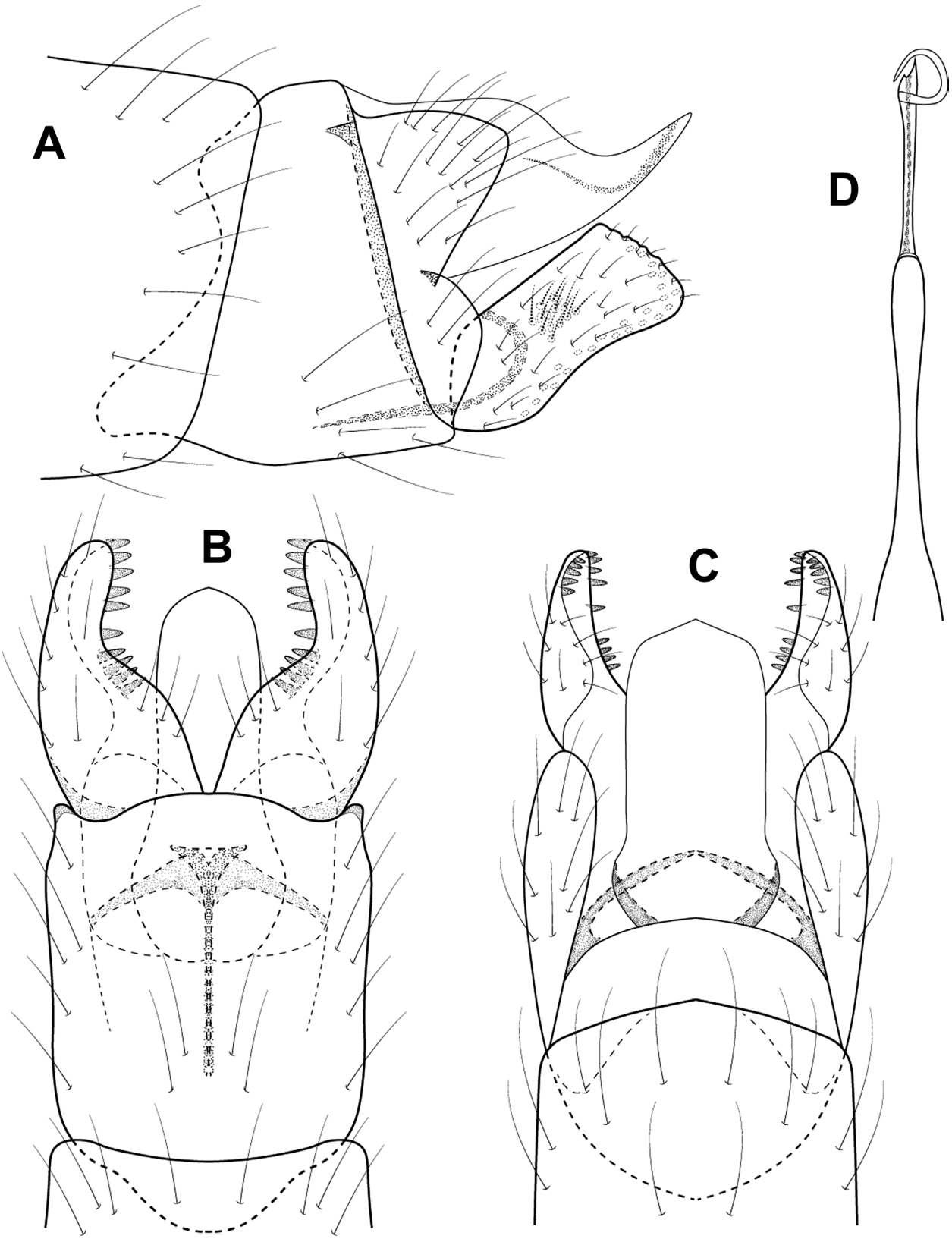

Figure 18. *Ochrotrichia flagellata* Flint, Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, dorsal view.

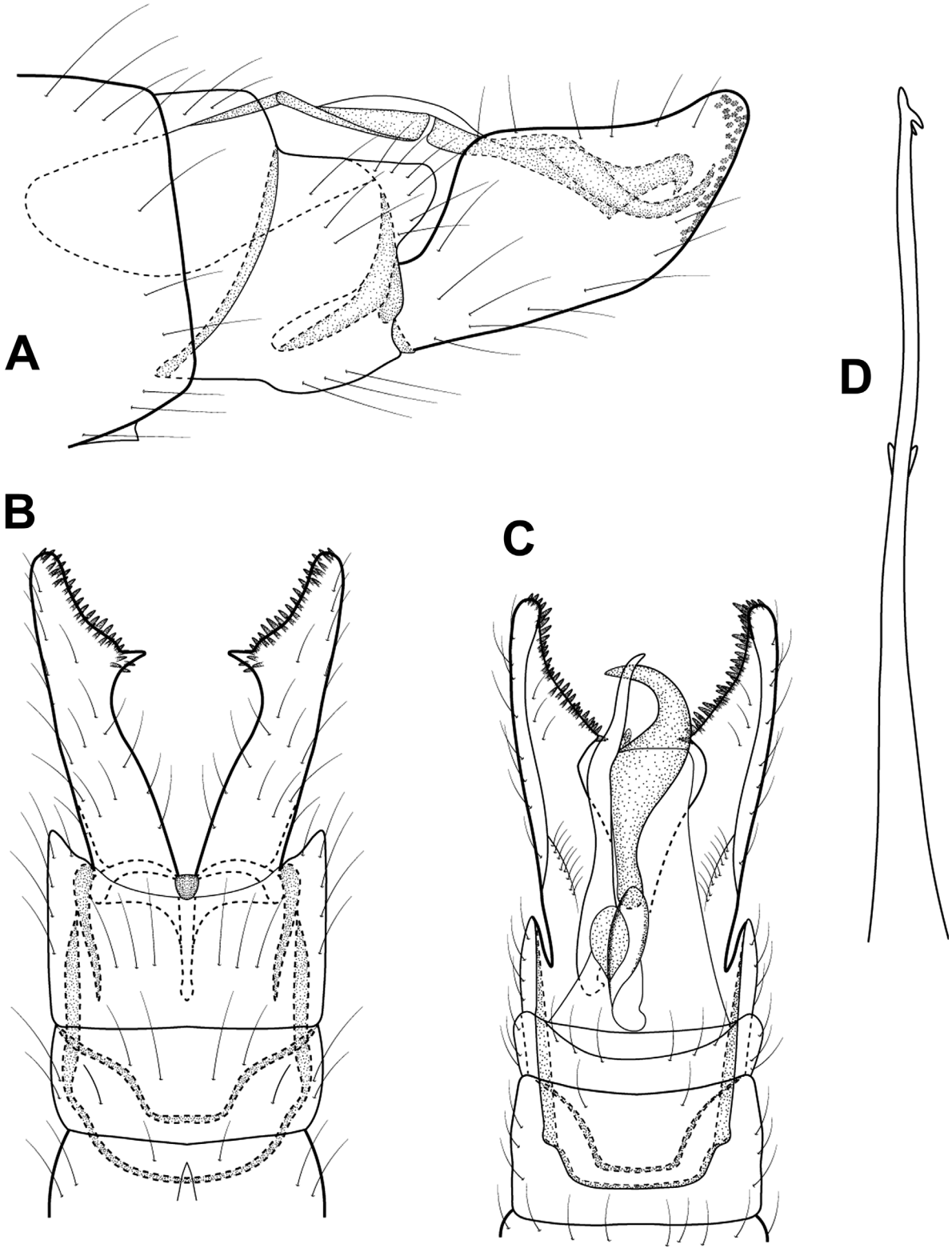

Figure 19. *Ochrotrichia dewalti*, sp. n., Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, dorsal view.

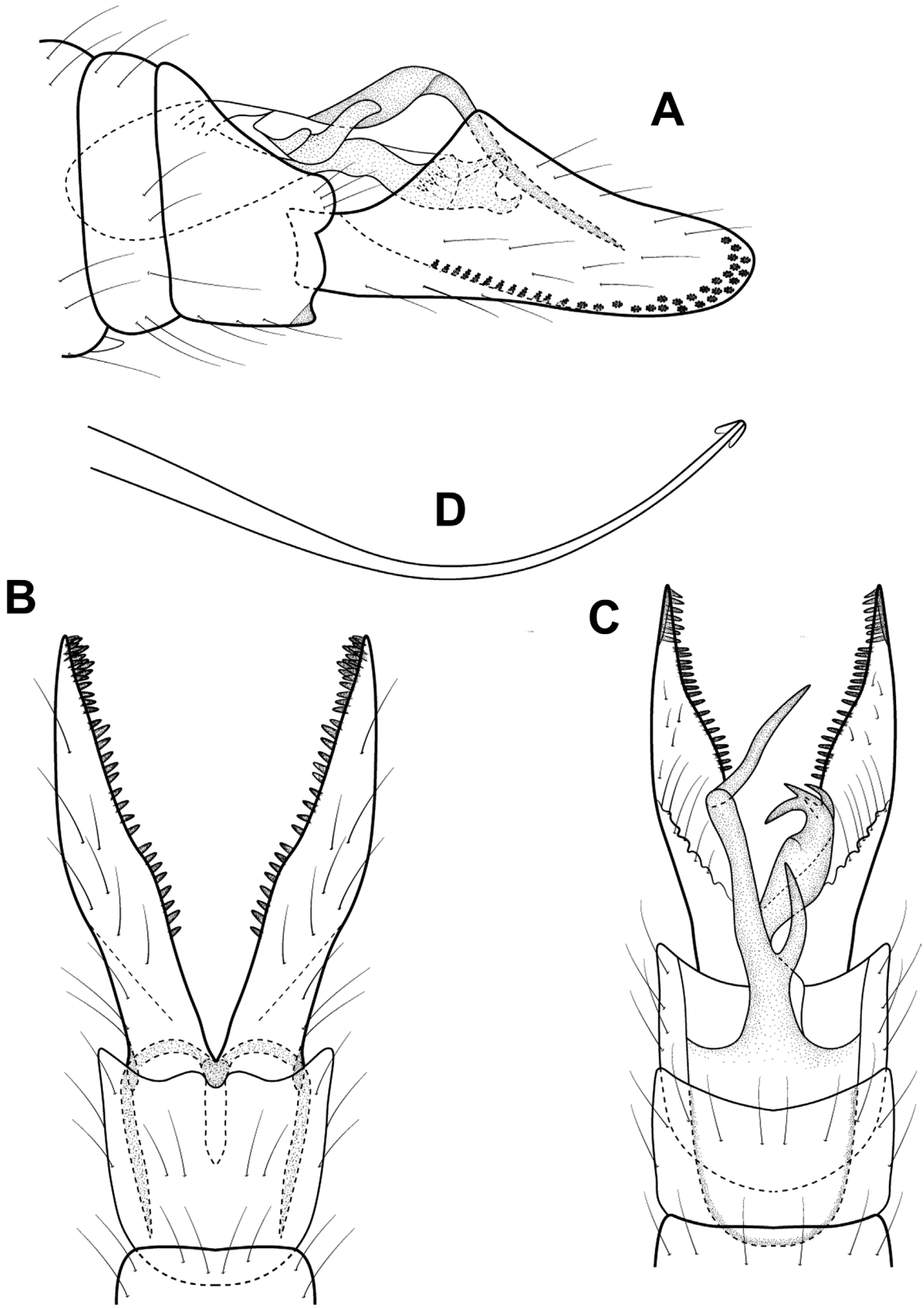

Figure 20. *Ochrotrichia kondratieffi*, sp. n., Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, dorsal view.

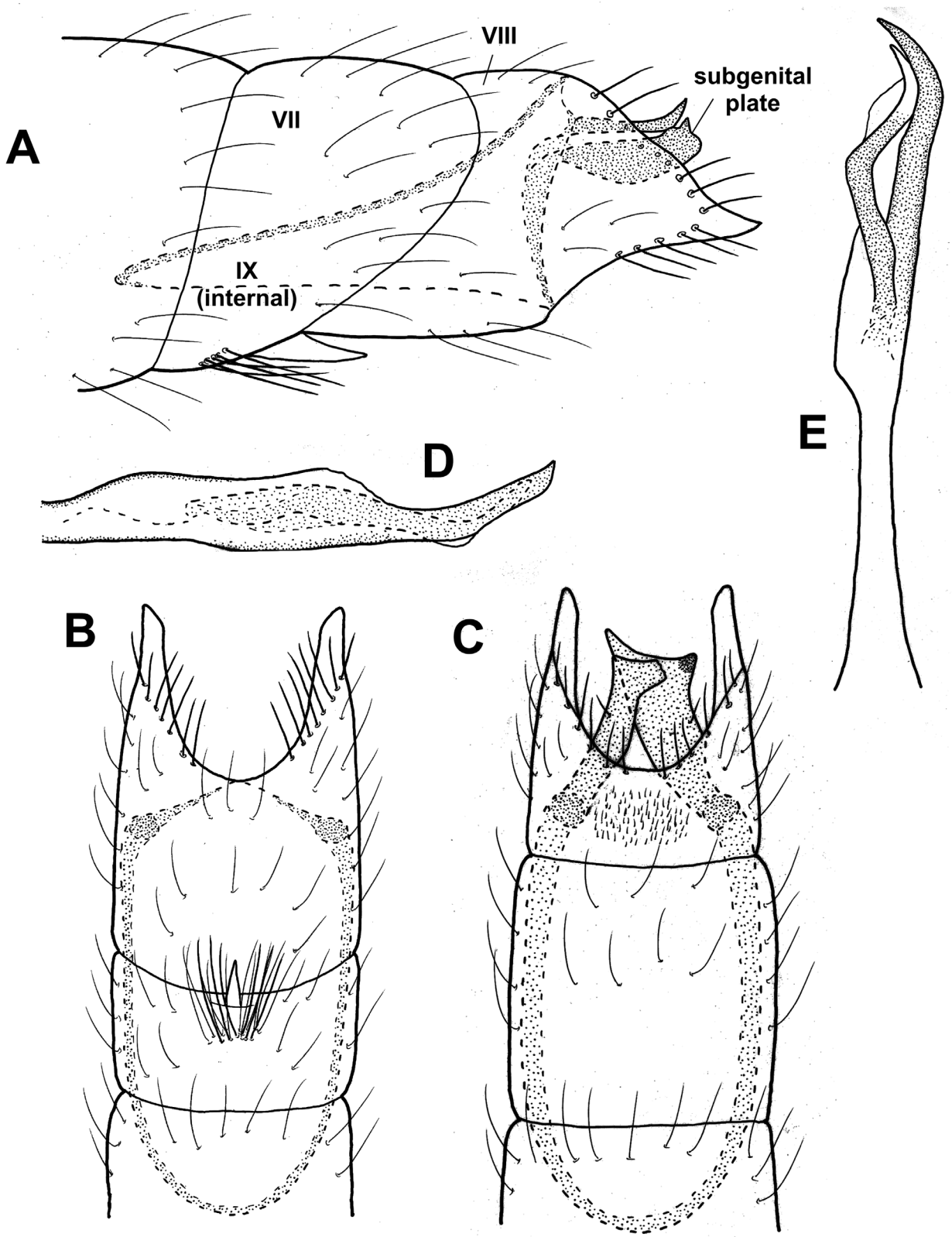

Figure 21. *Oxyethira buenoi*, sp. n., Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus apex, lateral view. **E)** Phallus apex, dorsal view.

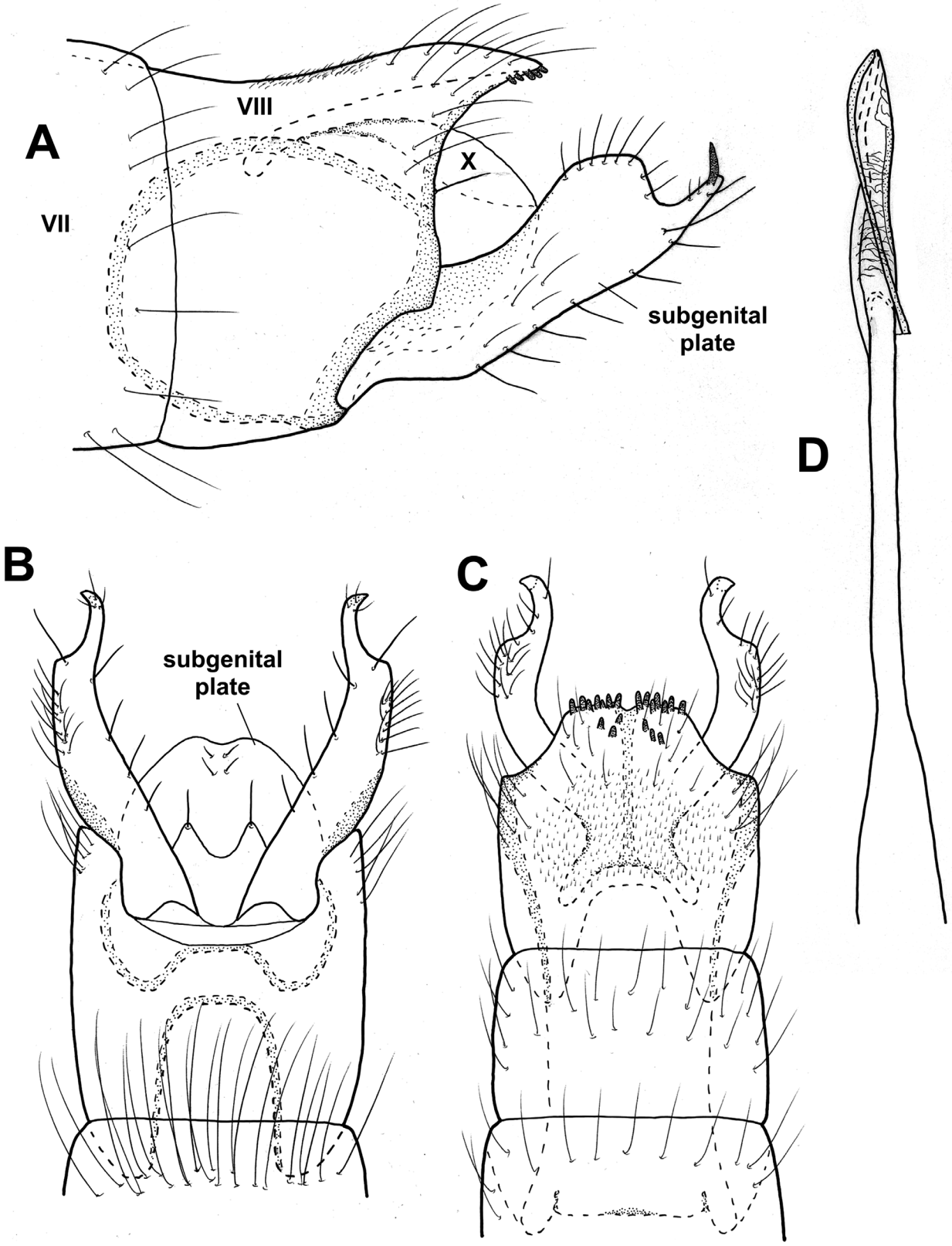

Figure 22. *Rhyacopsyche holzenthali*, sp. n., Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, dorsal view.

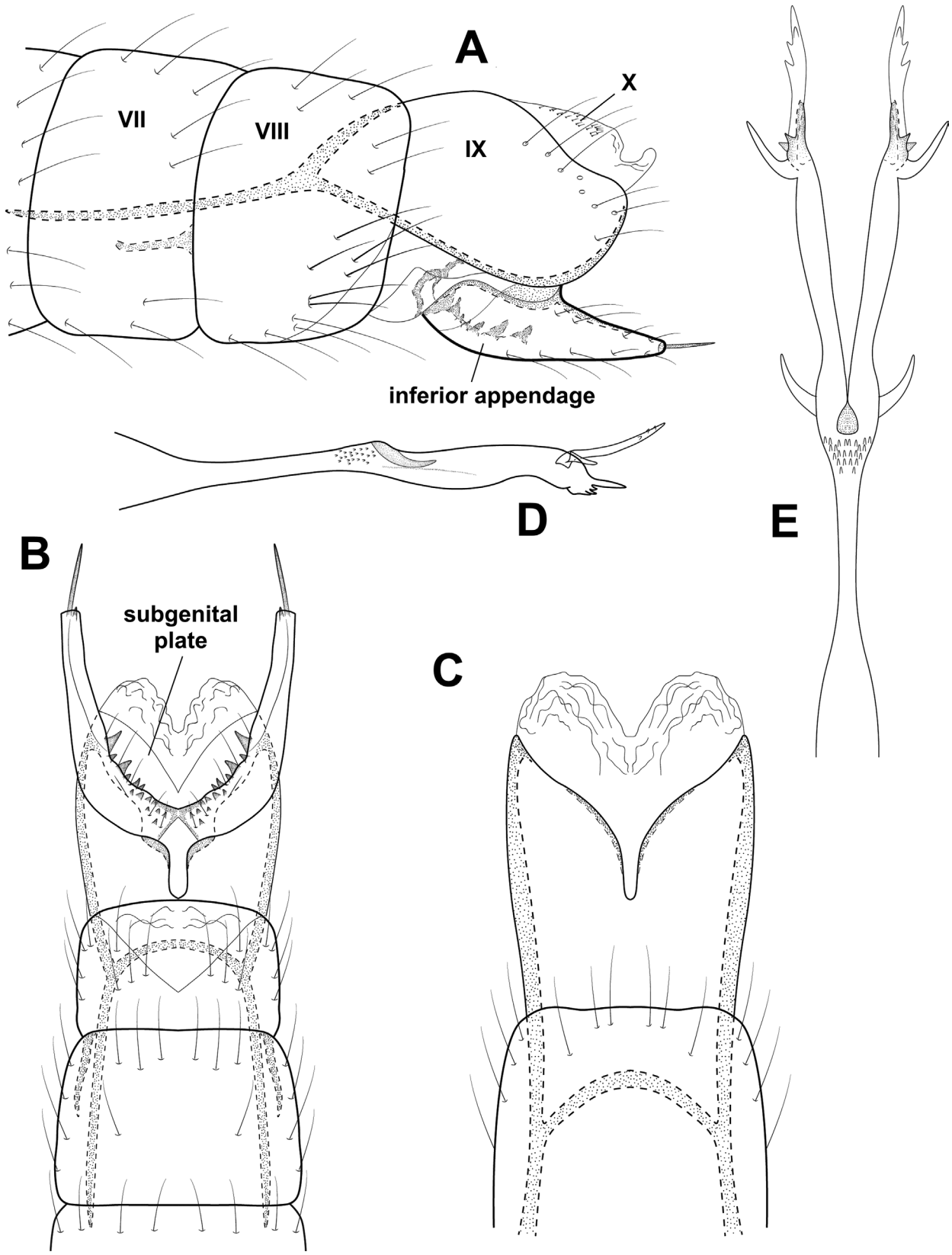

Figure 23. *Tizatetrichia panamensis*, sp. n., Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, lateral view. **E)** Phallus, dorsal view.

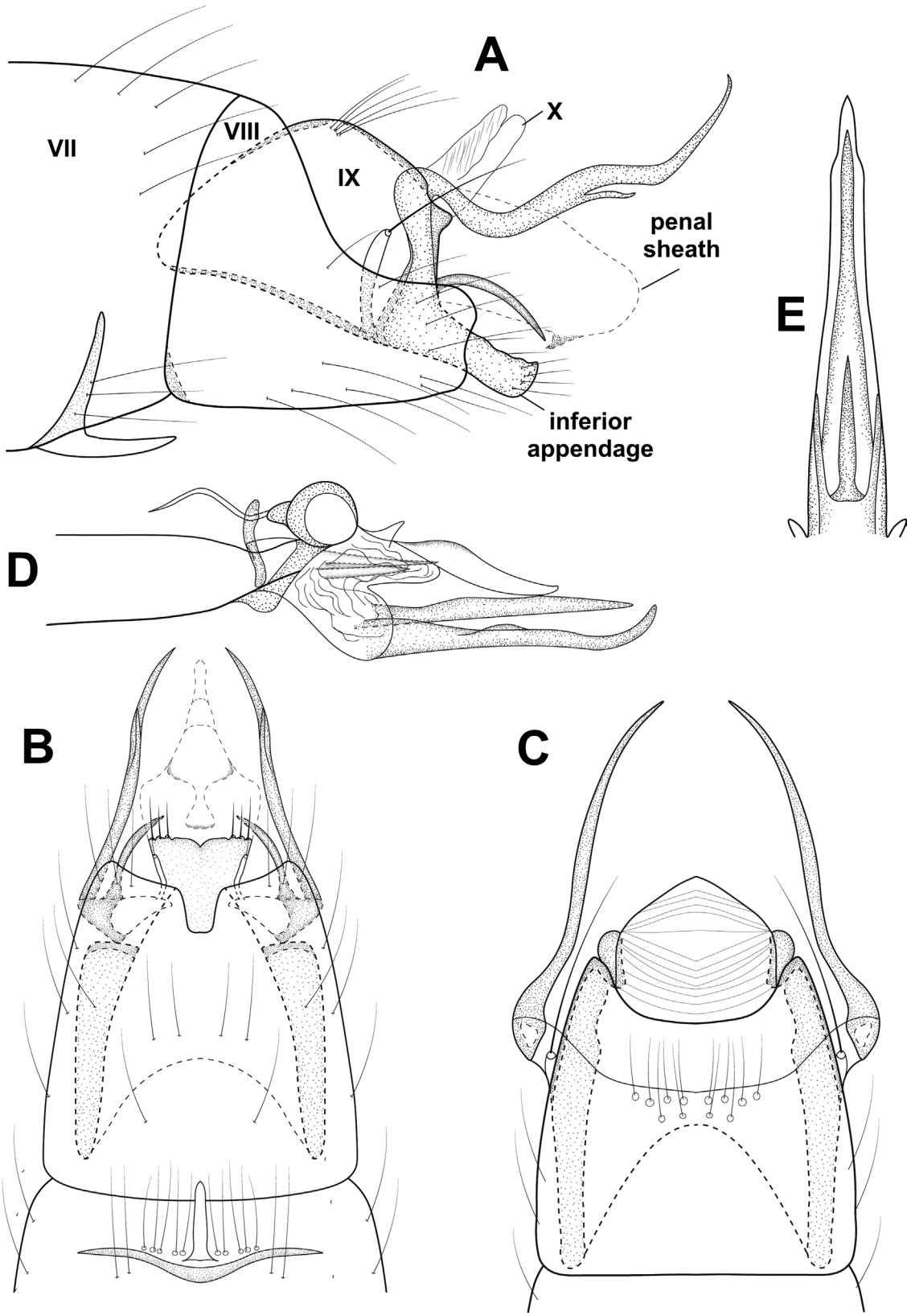

Figure 24. *Zumatrichia flinti*, sp. n., Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, lateral view. **E)** Phallus apex, dorsal view.

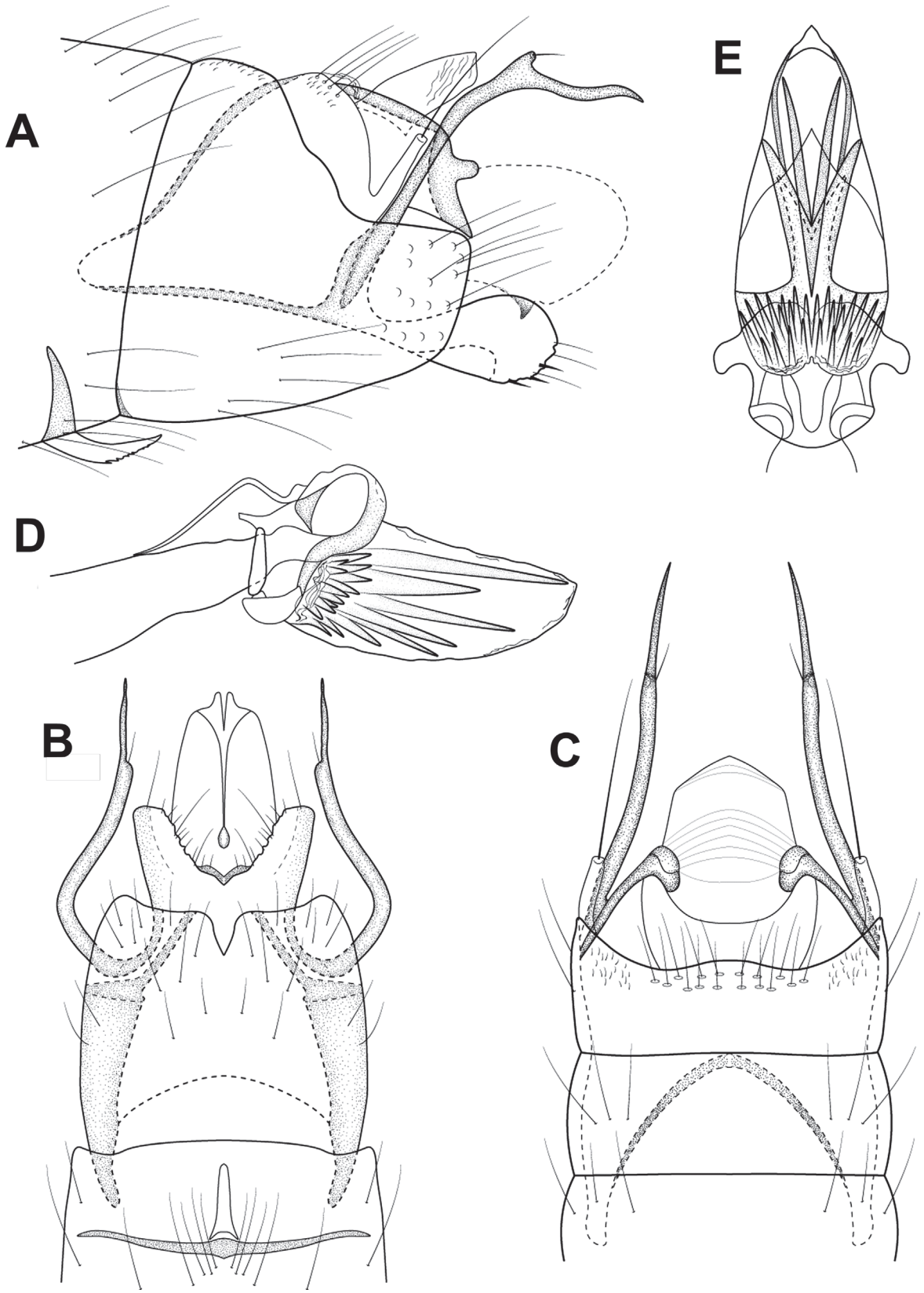

Figure 25. *Zumatrichia hazelae*, sp. n., Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, lateral view. **E)** Phallus apex, dorsal view.

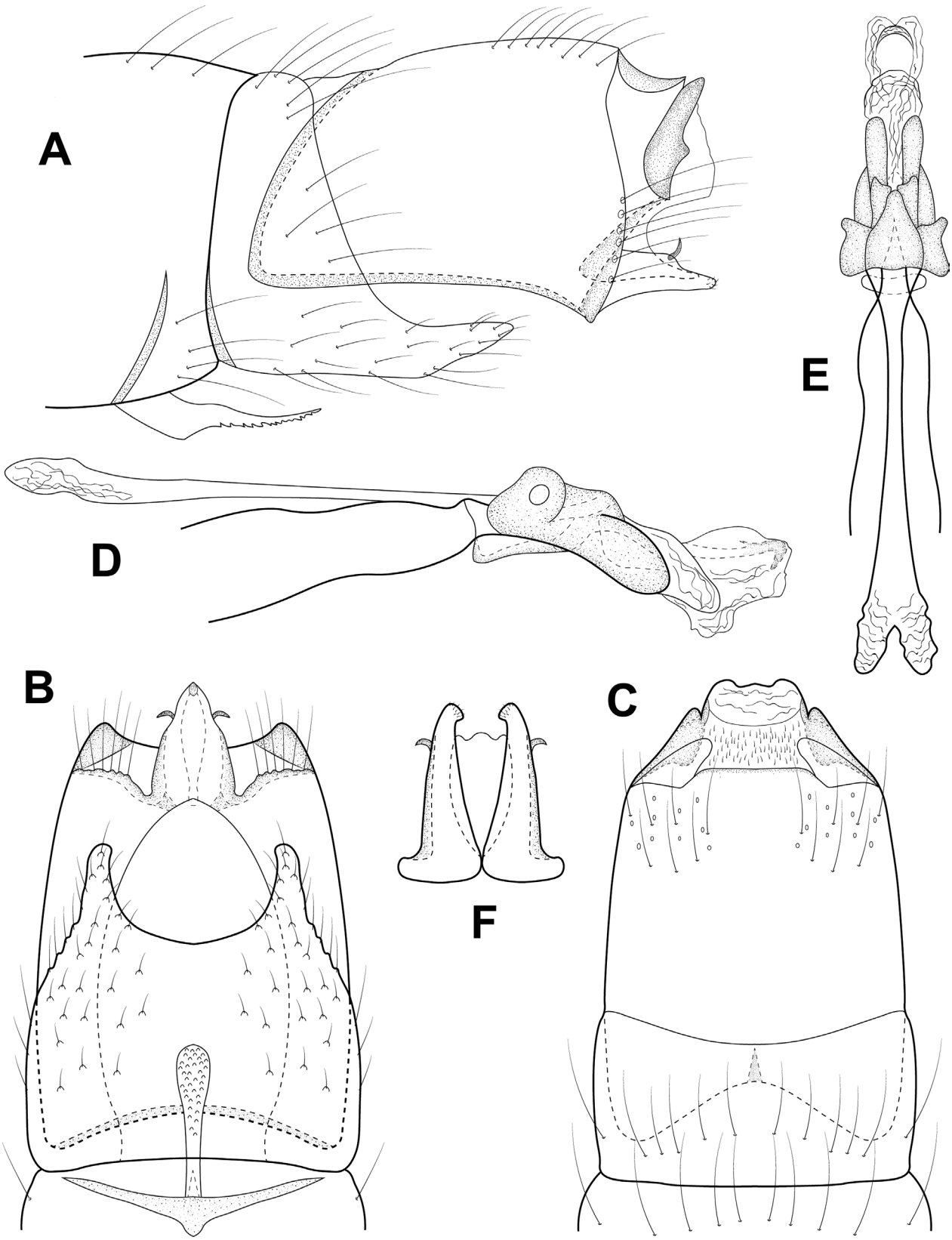

Figure 26. *Leucotrichia extraordinaria* Bueno-Soria, Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, lateral view. **E)** Phallus, dorsal view, **F)** Variation in inferior appendages, ventral view.

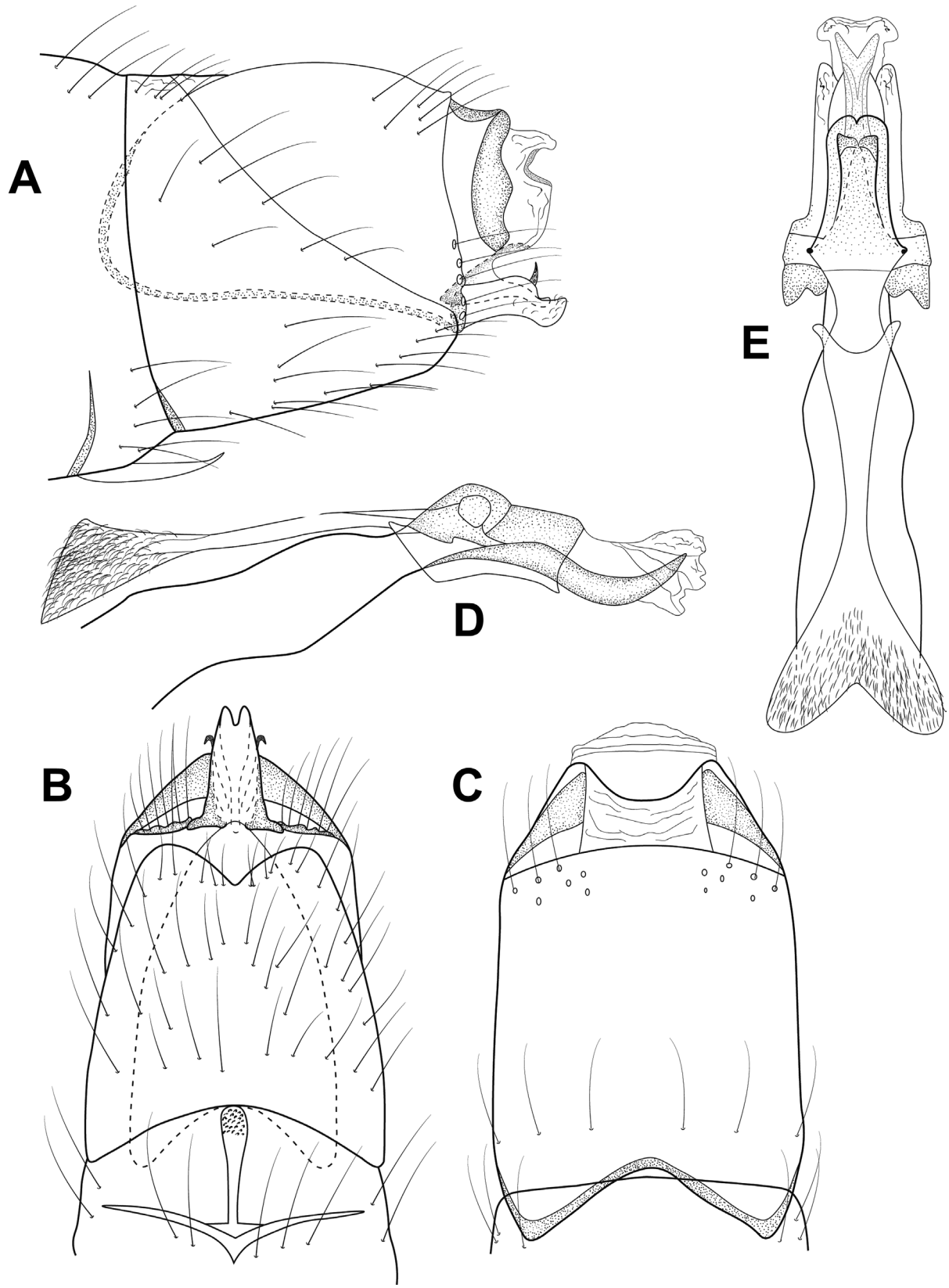

Figure 27. *Leucotrichia mutica* Flint, Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, lateral view. **E)** Phallus, dorsal view.

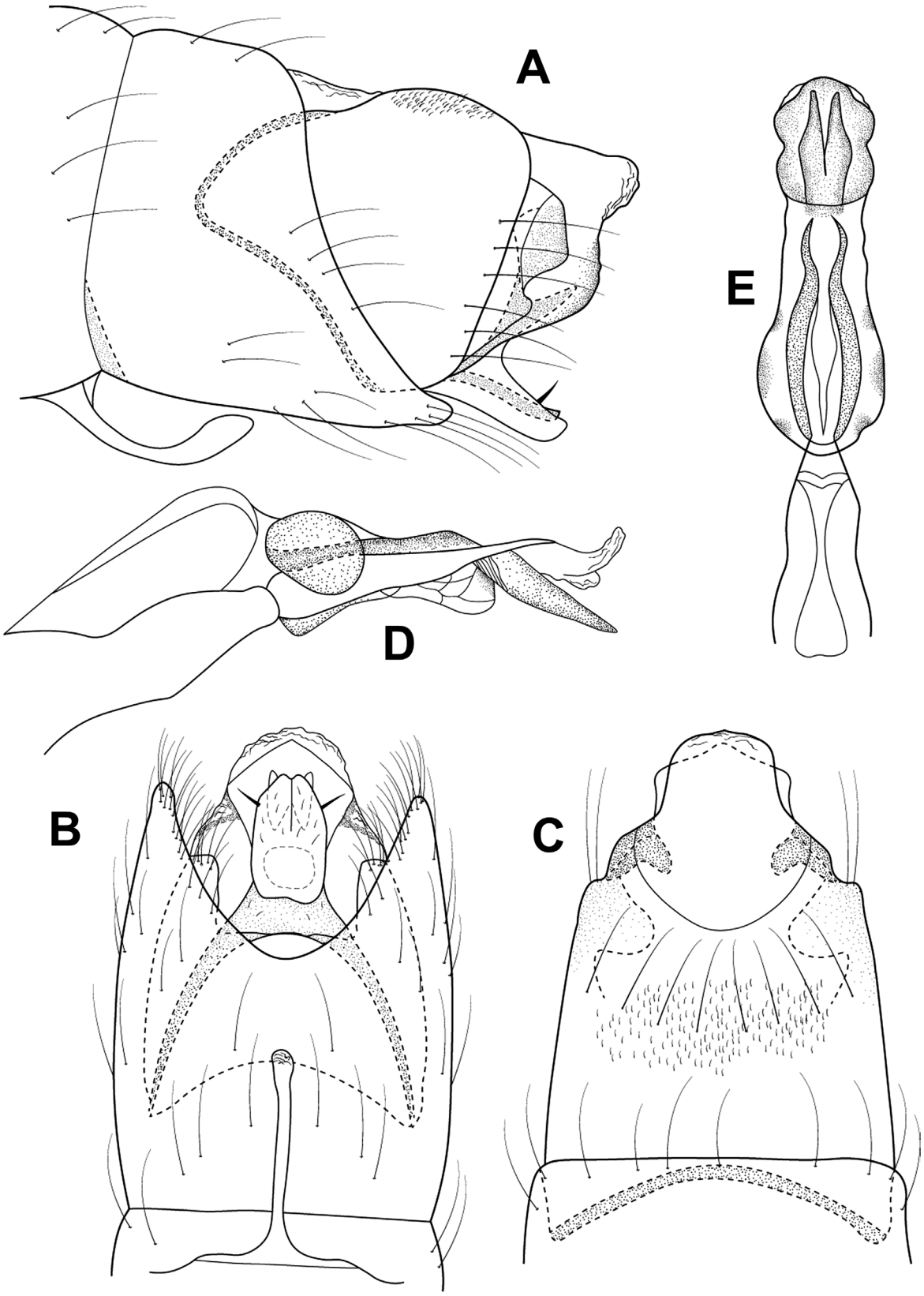

Figure 28. *Leucotrichia melleopicta* Mosely, Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, lateral view. **E)** Phallus, dorsal view.

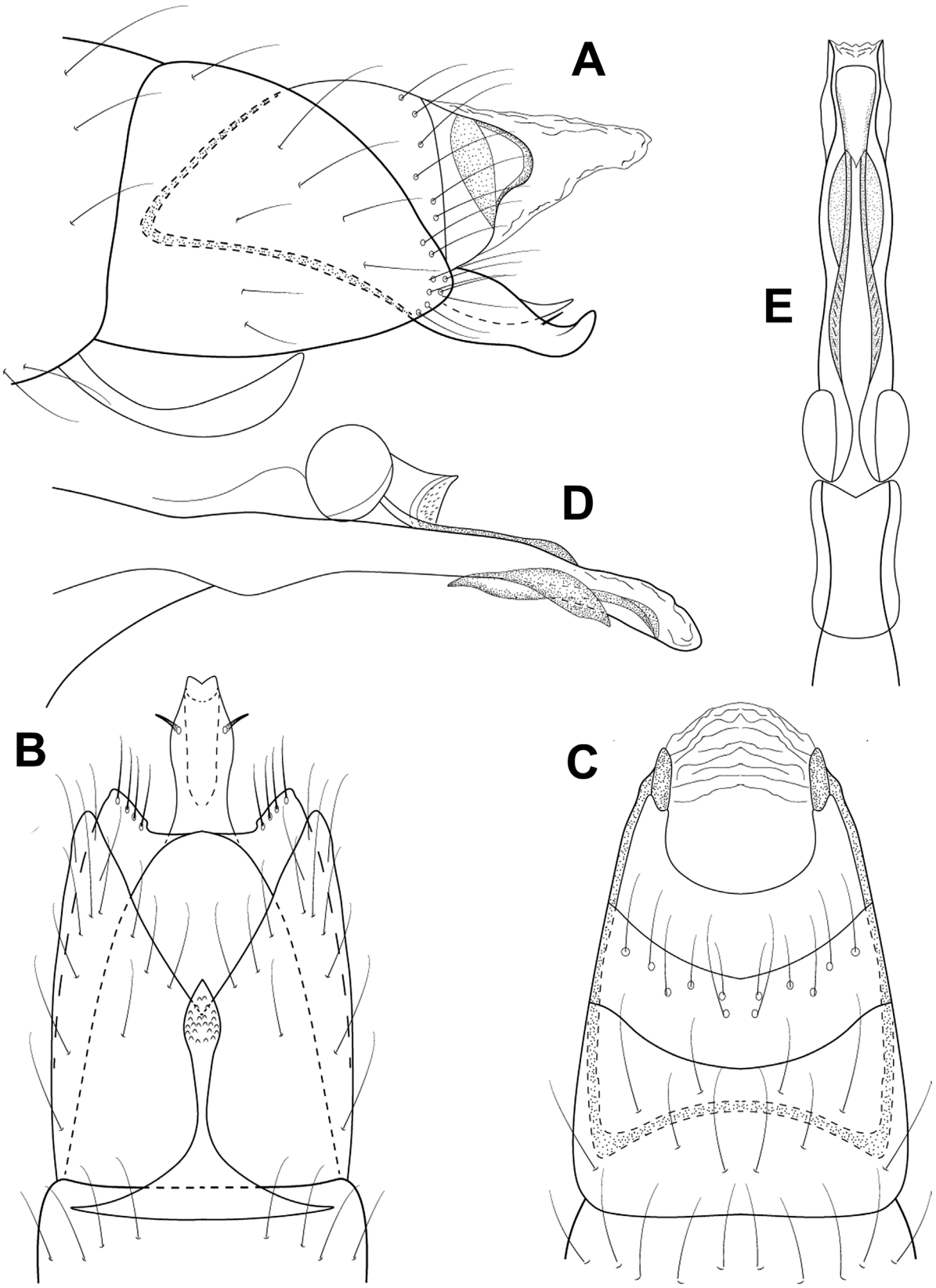

Figure 29. *Leucotrichia rhomba* Thomson and Holzenthal, Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus, lateral view. **E)** Phallus, dorsal view.

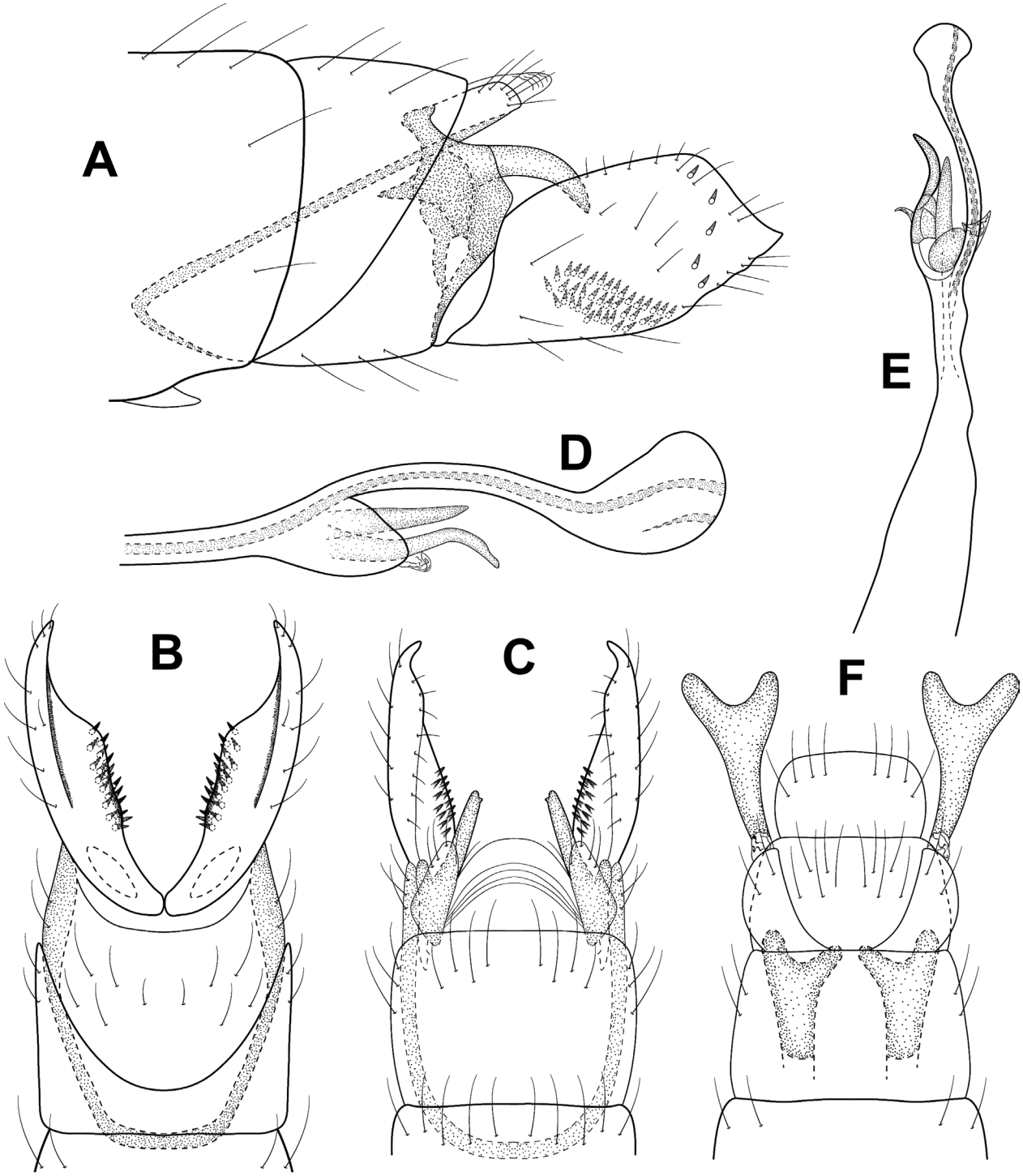

Figure 30. *Metrichia sacculifera* (Flint), Male genitalia. **A)** Lateral view. **B)** Ventral view. **C)** Dorsal view. **D)** Phallus apex, lateral view. **E)** Phallus, dorsal view. **F)** Abdominal segments V, VI, VII and VIII, dorsal view.

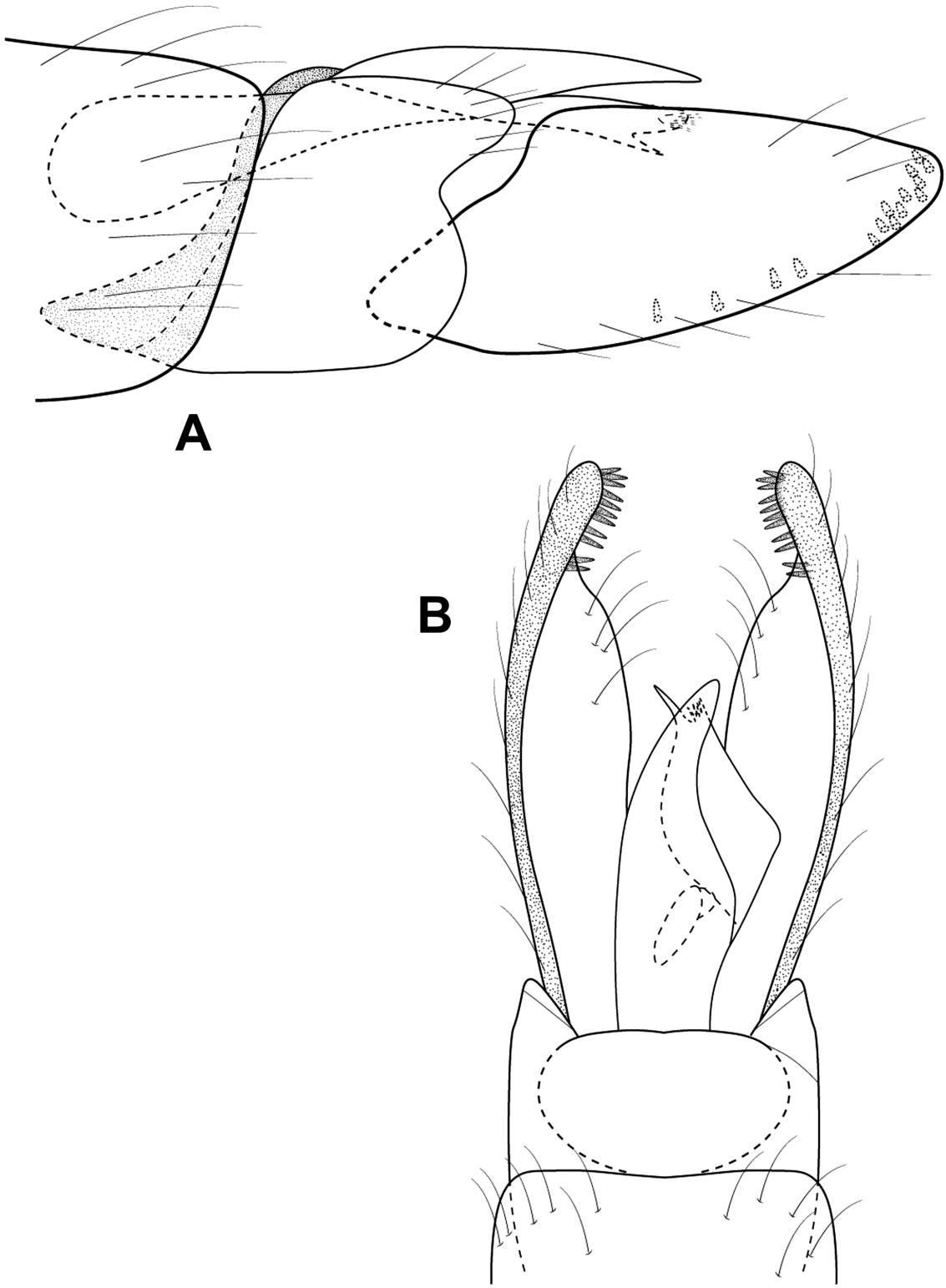

Figure 31. *Ochrotrichia paraldama* Bueno-Soria, Male genitalia. **A)** Lateral view. **B)** Dorsal view.