

## **New Species of Neopanorpa (Mecoptera) from Vietnam, with a Key to the Species of Mecoptera of Vietnam**

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**NEW SPECIES OF *NEOPANORPA* (MECOPTERA) FROM VIETNAM,  
WITH A KEY TO THE SPECIES OF MECOPTERA OF VIETNAM**

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*Abstract.*—Sixteen species of scorpionflies have been reported from Vietnam, consisting of 13 *Neopanorpa* and three *Bittacus* species. One of these scorpionflies from the Central Highlands of Vietnam with hood-shaped hypoalves was determined to be a new species and is described herein as *Neopanorpa cucullata*, n.sp. A second new species, *Neopanorpa ellengreeni*, n. sp., with golden yellow wing membranes and Y-shaped wing markings is described from northern Vietnam. COI DNA analysis of 16 of 17 species of Vietnamese Mecoptera are presented using a neighbor-joining tree indicating that the new species are approximately as distinct from the extant species as the extant species are from each other. A key is provided for all 17 Vietnamese Mecoptera.

*Key Words:* barcode, *Bittacus*, Cytochrome Oxidase 1, DNA, hangingfly, key, scorpionfly

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Mecoptera is a relictual order of holometabolous insects with origins in the Permian (Novokshonov 2004), having approximately 718 described extant species distributed among nine families. Species of Mecoptera are characterized by having a rostrum with mouthparts at the apex, and fore- and hindwings of similar size and venation. Sixteen species of Mecoptera have been reported from Vietnam, including three species of *Bittacus* Latreille (Bittacidae) and 13 species of *Neopanorpa* Weele (Panorpidae) (Bicha 2007, 2010, 2015). Bittacids live in deep to broken shade of moist, undisturbed forest and when approached, fly poorly and might initially be mistaken for craneflies (Diptera: Tipulidae). However, bittacids have four wings, and their resting posture is entirely different than craneflies. Bittacids hold their wings over their abdomen when at rest and are commonly called “hangingflies” because the adults hang under vegetation by their forelegs and capture small arthropod prey using raptorial tarsi of the hind legs. The males of many species provide nuptial gifts of prey to prospective mates (Thornhill 1978). Adults are incapable of standing so females simply drop their eggs to the ground. Larvae feed on detritus and larvae and pupae develop in the soil (Setty 1940).

Panorpids are called “scorpionflies” because the males have a characteristic up-curved abdominal terminalia causing the insects to appear as winged scorpions. Individuals are typically observed sitting on the upper surfaces of herbaceous vegetation in moist, undisturbed forest ecotone. Scorpionflies are saprophagous and we found *Neopanorpa* especially attracted to rotting squid, which we placed as bait. Larvae of *Bittacus* and *Neopanorpa* are similar-appearing, soil-dwelling, eruciform, saprophagous insects bearing numerous stout setae (Yie 1951, Jaing & Hua 2015).

Byers (1965) published a key to Mecoptera species covering Indochina, however since that time, 10 additional Vietnamese Mecoptera species have been reported from Vietnam, more than doubling the number of known species (Willmann 1976; Bicha 2007, 2010, 2015). Further, many Vietnamese Mecoptera were originally described from lone or limited type series. Collecting over the past decade has allowed the range of intraspecific variation to be better understood. Recent collecting in northern Vietnam and the Vietnam Central Highlands resulted in two additional species of *Neopanorpa* being discovered, which we describe herein. One of these species was erroneously reported (Bicha 2010) to be *Neopanorpa angustipennis* (Westwood, 1841), but after morphological and molecular comparison with specimens of *N. angustipennis* collected from near the type locality, the scorpionfly was determined to be a new species. Finally, an updated key to the species of Mecoptera of Vietnam is presented.

#### MATERIALS AND METHODS

We located individuals in the field by examining the tops and undersides of lush, broad-leaved ground vegetation growing in the broken shade of mesic hardwood forest, collected by net, and dropped alive in 80% ethanol. Baiting, by hanging loops of rotting squid from vegetation, was a highly effective attractant for some, but not all *Neopanorpa*. A leg was removed from specimens for DNA extraction and the specimens were pinned and spread following examination and description of the undescribed species. Genitalia of select specimens were dissected and cleared in lactophenol for detailed examination.

We acquired freshly preserved specimens of Vietnamese Mecoptera representing 15 of the 16 species reported from

Vietnam and the two species reported here as new (Appendix 1). We were not successful at collecting fresh specimens of *Neopanorpa ornata* Byers, 1965, which is known only from the holotype. Total genomic DNA was extracted from one leg of each specimen and the Cytochrome Oxidase 1 “DNA barcode” region (Hebert et al. 2003) was amplified, visualized, purified and sequenced following the protocols described in Schiff et al. (2012) and Bicha et al. (2015). Genomic DNA for each sample was amplified using one of the following primer combinations, LCO1490 and HCO2198, Wes1 and HCO1490, K698 and Nancy, HCO2198 and Wes1, Nancy and Wes 1. The primer sequences are: LCO1490: 5'-GGT CAA CAA ATC ATA AAG ATA TTG G-3', HCO2198: 5'-TAA ACT TCA GGG TGA CCA AAA AAT CA-3' (Folmer et al. 1994), WES1: 5'-GGC TTT TCT CTA CTA ATC ATA AGG ATA TTG G-3', NANCY: 5'-CCC GGT AAA ATT AAA ATATAA ACT TC-3' (Simon et al. 1994), and K698 (TY-J-1460): 5'- TAC AAT TTA TCG CCT AAA CTT CAG CC-3' (Simon et al. 1994). Template DNA was sequenced in both directions and the forward and reverse sequences were checked and combined into individual specimen contigs using Lasergene Seqman Pro by DNASTar. Specimen contigs were aligned using Clustal W and analyzed using the neighbor-joining method (Saitou and Nei 1987) and the maximum composite likelihood method (Tamura et al. 2004) in MEGA version 7 (Kumar et al. 2016) Genbank accession numbers and collection locations for a representative of each species are presented in Appendix 1 and are the specimens used to generate the neighbor-joining tree.

Wings of pinned specimens were photographed using a Nikon D7100 camera with Nikon 50 mm lens and a 20

mm extension tube. Images were digitally processed using Adobe Lightroom<sup>®</sup> CC 2015.4 and Adobe Photoshop<sup>®</sup> CC 2015.1.

The image of the pinned male specimen genitalia was made using a Visionary Digital<sup>™</sup> BK Lab Imaging system outfitted with the Canon EOS 5D and a 100 mm Canon macro-lens. Stacked images were processed in part with Helicon Focus<sup>™</sup> with final editing using Adobe Photoshop<sup>®</sup>. Dissected genitalia were mounted in clear jellied alcohol (Puracell<sup>®</sup> hand sanitizer) and photographed with a Leica Z16 zoom lens attached to a JVC 3-CCD digital camera (KY-F75U). The final image is a montage image stack Syncroscopy, and the image plate created in Adobe Photoshop<sup>®</sup> (Elements 9).

Descriptive nomenclature for wing venation and markings follows Esben-Petersen (1921); terminology for male genitalia is that of Carpenter (1931).

## RESULTS

We generated DNA barcodes for 103 specimens of Vietnamese Mecoptera representing 15 of the 16 known species and specimens of two new species described herein. We also generated barcodes for 3 dry, pinned specimens of *Neopanorpa angustipennis* from southwest Thailand near the type location in southeast Burma. The sequences were all full length (658 bp) except for one specimen each of *N. nielsenii* (444bp), *N. angustala* (534bp), *N. vietnamensis* (620bp), *N. cucullata* (560bp) and one of the three Thai specimens of *N. angustipennis* (545bp). We used the neighbor-joining algorithm to generate a distance tree and calculate divergence, percent identity and intraspecific variation. For clarity, we present divergence and percent identity for a single intermediate individual for each species but intraspecific

Table 1. Percent intraspecific and interspecific identity and interspecific divergence for species of Vietnamese *Neopanorpa* and *Bittacus*.

	Percent Intraspecific Divergence				Percent Interspecific Identity																
	Average	Maximum	N		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
<i>Bittacus monastyrskiyi</i> (1279)	3.0	3.0	2		82.8	83.1	80.5	83.6	83.6	79.9	82.8	84.3	80.9	82.2	80.7	82.2	82.2	80.2	82.8	82.2	82.8
<i>Neopanorpa parvula</i> (2708)	-	-	1		17.0	86.5	85.4	81.3	84.2	82.8	81.6	87.7	87.5	86.8	88.1	86.6	86.0	84.5	86.3	88.4	88.4
<i>Neopanorpa lindsteyi</i> (2795)	1.5	2.0	6		17.3	13.3	86.0	83.6	91.2	85.4	82.7	92.6	87.1	89.7	88.6	87.4	88.4	86.5	90.6	89.1	89.1
<i>Neopanorpa malaisei</i> (2861)	0.9	2.3	6		19.8	14.5	13.5	82.4	86.3	84.2	78.1	86.9	85.9	85.1	84.8	86.8	83.1	85.7	86.5	86.9	86.9
<i>Bittacus tamdaensis</i> (2867)	1.1	1.1	2		16.7	19.0	17.1	18.0	82.2	79.5	83.7	84.2	82.7	82.2	82.8	81.9	82.1	82.1	84.5	83.3	83.3
<i>Neopanorpa angustala</i> (2873)	1.5	2.6	7		17.1	15.7	9.1	13.5	18.3	85.9	81.2	90.4	83.4	87.1	84.8	85.4	86.6	85.3	87.5	85.0	85.0
<i>Neopanorpa ellengreeni</i> (3118)	-	-	1		21.2	17.8	15.0	15.9	22.9	14.8	79.8	85.0	83.6	85.4	85.4	83.9	85.3	85.7	85.9	84.5	84.5
<i>Bittacus bartolozzii</i> (3332)	0.2	0.3	4		17.9	19.6	17.5	23.0	17.3	20.0	22.2	84.2	81.3	82.1	82.1	81.0	79.8	80.9	81.2	82.2	82.2
<i>Neopanorpa bavienis</i> (3420)	1.3	1.9	4		15.9	12.4	7.7	12.8	16.7	9.8	15.8	16.6	86.6	89.7	89.1	86.8	88.3	87.1	89.5	88.9	88.9
<i>Neopanorpa vietnamensis</i> (4611)	2.5	3.6	3		19.7	12.6	12.4	13.9	17.9	16.7	16.7	19.9	13.3	87.1	87.4	87.1	84.2	86.3	86.9	89.1	89.1
<i>Neopanorpa annamensis</i> (4617)	0.7	2.5	14		18.5	13.3	10.8	14.7	18.8	13.5	15.1	19.3	11.0	13.3	86.8	86.0	88.4	86.2	88.6	88.8	88.8
<i>Neopanorpa nielsenii</i> (4620)	9.5	13.1	6		19.3	12.4	11.0	15.0	17.5	15.2	15.0	18.7	11.0	12.2	13.7	86.0	86.8	87.7	88.9	89.5	89.5
<i>Neopanorpa acetabulifera</i> (4625)	0.8	0.8	2		18.4	13.9	12.8	13.3	18.7	15.0	17.0	20.1	13.5	13.7	14.8	14.1	86.3	86.9	88.0	88.8	88.8
<i>Neopanorpa panda</i> (4863)	4.0	8.1	15		18.2	13.3	10.7	16.2	18.1	13.2	14.7	20.4	11.5	15.4	11.4	12.3	13.2	85.3	89.7	87.1	87.1
<i>Neopanorpa dorsalis</i> (4864)	-	-	1		20.4	15.8	13.6	13.9	18.8	15.4	15.0	20.1	13.3	14.0	14.8	12.2	13.4	14.3	87.5	88.0	88.0
<i>Neopanorpa cucullata</i> (5002)	2.5	4.9	21		18.2	13.8	9.6	13.5	15.9	12.8	14.9	20.1	11.0	13.1	12.0	10.8	12.4	10.1	12.6	89.5	89.5
<i>Neopanorpa angustipennis</i> (1658)	0.1	0.2	3		18.1	11.9	10.8	13.3	17.3	15.6	15.8	18.7	11.4	11.3	11.5	10.3	12.3	12.5	12.0	10.8	10.8
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Percent Interspecific Divergence

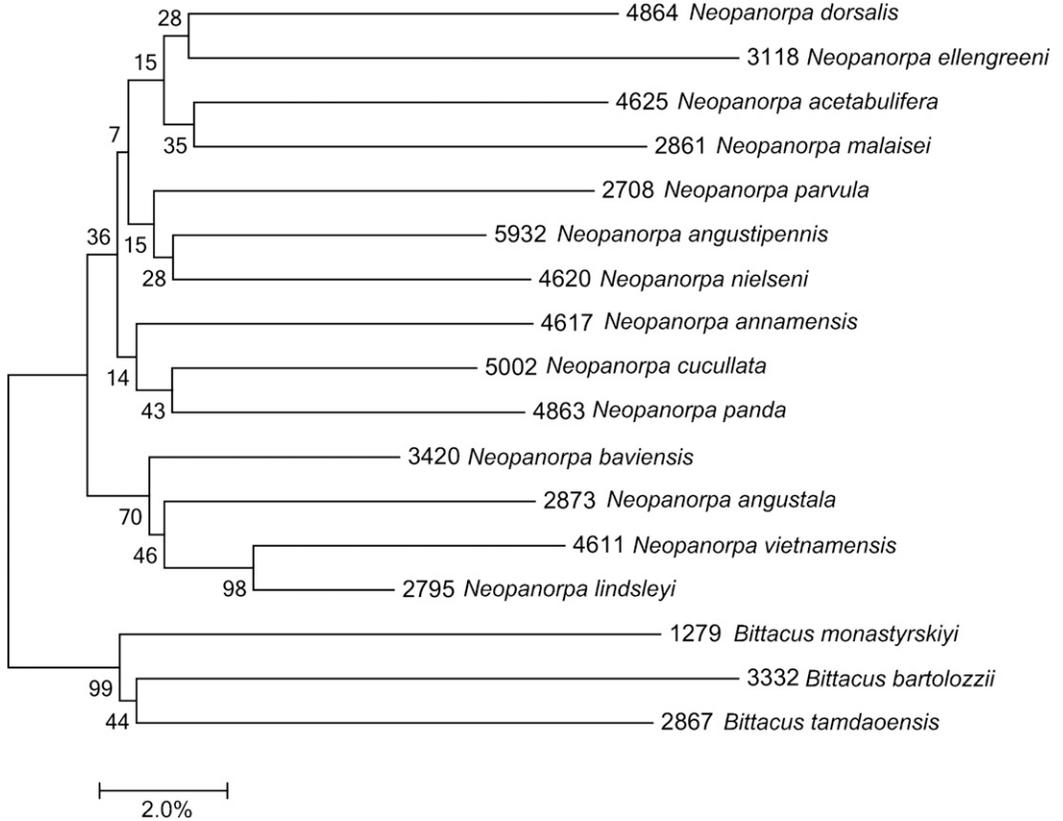


Fig. 1. COI DNA Neighbor-joining tree for Vietnamese Mecoptera species. Numbers are bootstrap values based on 500 replicates.

variation for all specimens (Table 1). We also present a neighbor-joining tree for a single individual of each species (Fig. 1). Interspecific differences are approximately 10 to 20% while average intraspecific variation is less than 3% except for *N. nielseni* and *N. panda* at 9.5% and 4.0% respectively. In both cases these species appear to have somewhat distinct populations which we cannot separate morphologically at this time but may resolve into new species. In both cases, all populations of a species were on the same branch of the tree so all specimens were unambiguously identified to the correct species. The new species *N. ellengreeni* and *N. cucullata* are each more than

10% divergent from their nearest neighbors and *N. cucullata* is more than 10% different from the Thai species *N. angustipennis* with which we initially confused it. The neighbor-joining distance tree graphically represents that *N. ellengreeni* and *N. cucullata* are as different from already described Vietnamese species as the already described species are from each other.

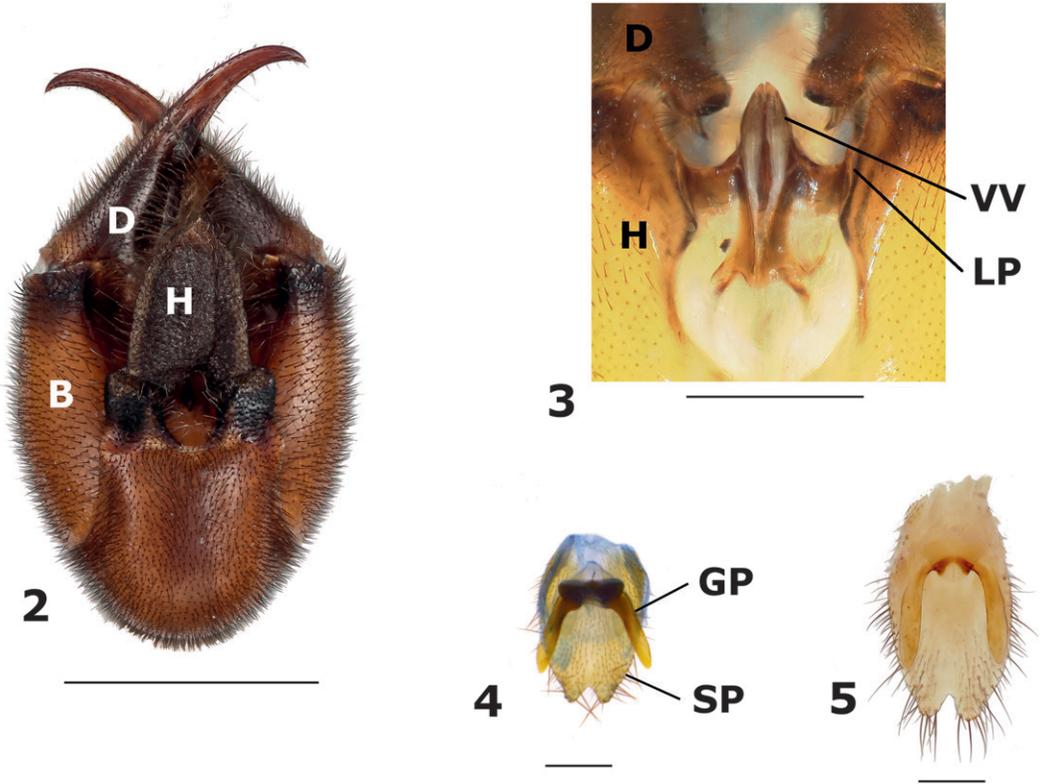
#### DISCUSSION

Although it is unusual to describe a new species of scorpionfly from a single female because there are few suitable morphological characters, we demonstrate that supplementing morphology with DNA

barcodes may be sufficient to differentiate lone females as new species.

In June of 2015, we visited Bi Doup-Nui Ba National Park in the Vietnam Central Highlands to collect males of a putative undescribed *Neopanorpa* with unusual hyaline wings (Fig. 10), which was initially discovered there in 2009 as a lone female by Alexandre Monastyrskii (Bicha 2010). Although we were successful in collecting males and females of the new species, we also discovered a lone female of another new species with unusual golden yellow wing membranes (Fig. 14). When we compared the COI "barcode" of these two species with the DNA from 15 of the 16 species of Mecoptera previously recorded from Vietnam, the DNA from these two putative new species were found to be as different from other Vietnamese species as the DNA of those species were from each other, providing independent confirmation that the two represented unique and undescribed species (Table 1, Fig. 1). The new species could not be confused with the only unsequenced Vietnamese species, *N. ornata*, known only from the type (Bishop Museum, Honolulu, Hawaii) which has unmistakable black wings (Fig. 13). In the process, we realized that the DNA of specimens with slight markings on the wings (Fig. 11) previously recorded from Hon Ba (Bicha 2010) as *Neopanorpa angustipennis* matched the DNA of the specimens with the hyaline wings from Bi Doup-Nui Ba National Park, rather than recently-acquired specimens of *Neopanorpa angustipennis* collected near the Burma type locality. We now consider these scorpionflies with the slight wing markings from Hon Ba as specimens of the new species (*N. cucullata*). There are slight differences in color pattern (Figs. 10 and 11) and DNA sequence among

individuals of *N. cucullata* but we consider them insufficient to separate *N. cucullata* into two separate species. We illustrate the DNA results for comparison of the different Vietnamese Mecoptera species as a neighbor-joining distance tree (Fig. 1). Neighbor-joining is a distance algorithm that approximates phylogeny quite well but we would be remiss to suggest that this tree represents the true phylogeny of *Neopanorpa* or even Vietnamese *Neopanorpa*. For true phylogeny reconstruction we would need to sequence additional genes, use a cladistics based algorithm and include representatives of other Southeast Asian species which are not available at this time. In our study, the neighbor-joining distance tree (Fig. 1) is a graphic representation that the new species are as genetically isolated from the known species as the known species are from each other. Here, we describe the two new species, provide a morphological key of Vietnamese Mecoptera and barcodes for 17 of the 18 Vietnamese species. We chose to base the key, as much as possible, on characters which will not require dissection, clearing, and microscopic examination of details within the male genital bulb or female abdomen for several reasons. First, we wish to provide a key that would be as useful as possible in the field and second, we have found after detailed morphological and molecular comparison that wing patterns are diagnostic for *Neopanorpa* species within Vietnam. Additionally, while male *Panorpa* possess conspicuous ventral parameres with different characteristics that are typically used for species determination, Vietnamese *Neopanorpa* have vestigial male ventral parameres and the interior of the male genital bulb is comparatively featureless and obscured under a pair of overlapping hypovalves. The



Figs. 2–5. *Neopanorpa cucullata*. 2, Male genital bulb, ventral aspect, B = basistyle, D = dististyle, H = hypovalve. 3, male aedeagus with hypovalves removed, LP = lateral paramere, VV = ventral valve. 4, Female subgenital (SG) and genital (GP) plates, ventral aspect. Fig. 5. *Neopanorpa ellengreeni* female subgenital and genital plates, ventral aspect. Scale bars. Fig. 2, 1 mm, Fig. 3, 0.5 mm, Figs. 4–5, 0.25 mm.

morphological differences between female *Neopanorpa* genitalia are even more subtle and difficult to use for species determination, while wing patterns are consistent, at least they match the DNA barcodes, and unique.

***Neopanorpa cucullata* Bicha,  
new species**

urn:lsid:zoobank.org:act:F4A4CDC8-4ED2-4EBF-A1C8-E544B04FB892

(Figs. 2–4, 6, 10–11)

Diagnosis.—*Neopanorpa cucullata* males have broad, overlapping, sub-triangular hood-shaped hypovalves and

wings that range from nearly immaculate to faintly patterned, while all other known Vietnamese scorpionflies, except *Neopanorpa malaisei* Byers, 1999, have males with long, comparatively narrow hypovalves extending well beyond the bases of the dististyles and several brown to black bands on the wings. Hyaline forms of *N. cucullata*, have pronounced pterostigma which are readily differentiated from *N. malaisei*, which has weakly pigmented pterostigma and thin, separated male hypovalves with apices curved ventro-mesad.

Description.—30 males, 38 females initially preserved in ethanol, subsequently pinned and wings spread. *Head*: Dorsum of head black, sordid

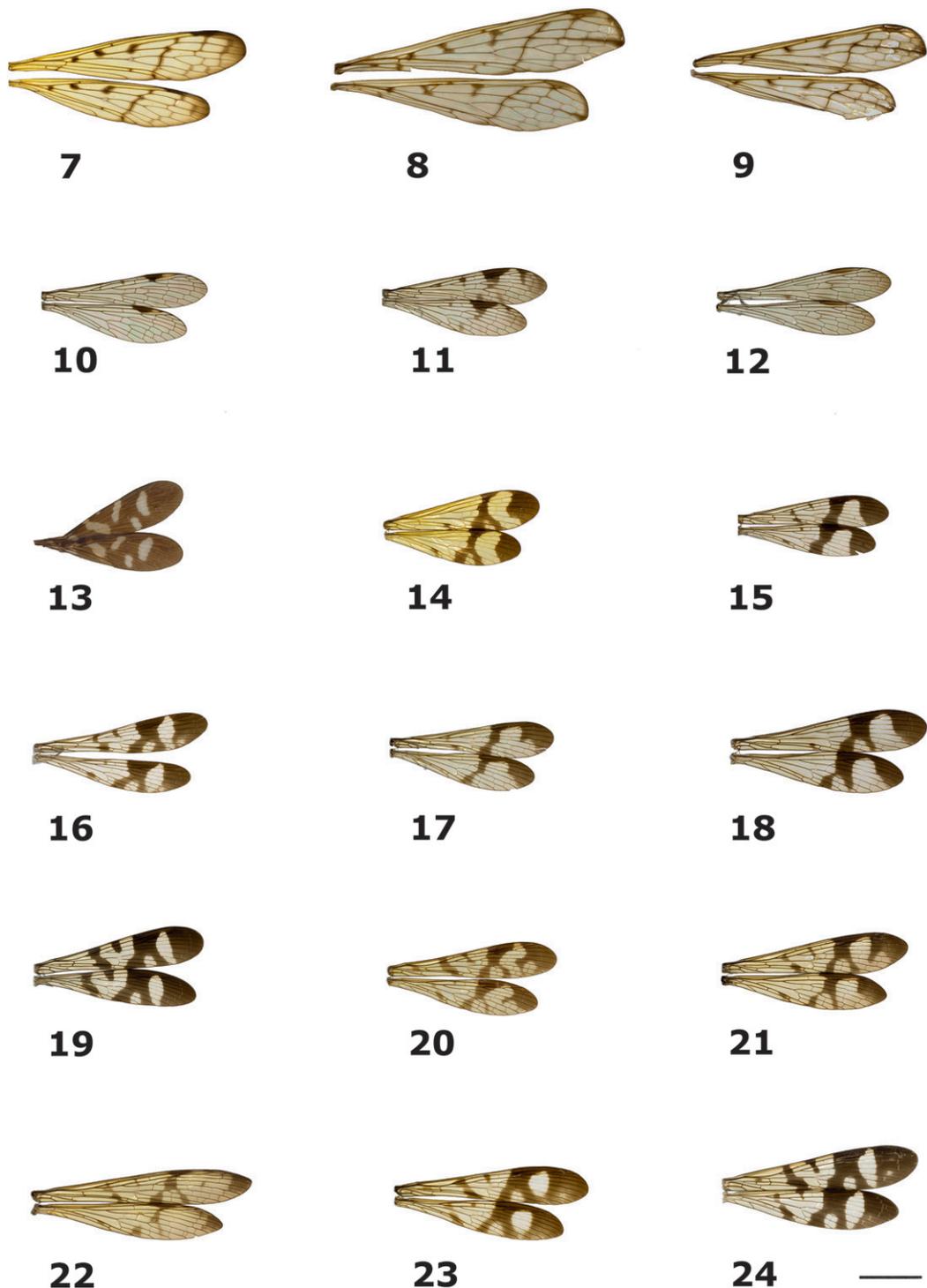


Fig. 6. *Neopanorpa cucullata*, n. sp. Feeding on squid bait at type locality near Giang Ly Station, Bi Doup National Park, Vietnam.

white below ocelli. Ocelli amber; eyes plum to grey. Rostrum sordid white to light brown; labrum and mouthparts light brown except apex of maxillary palps dark brown. Antennae long, approximately 8.6 mm, extending to pterostigma of forewing, with 44–45 flagellomeres; scape sordid white, pedicel brown, flagellomeres black.

*Thorax:* Pronotum sordid white to brownish-black. Mesonotum anterior half brownish-black, remainder sordid white with broad brownish-black medial

stripe including scutellum. Metanotum with broad brownish-black median band including scutellum, metanotum lateral portions sordid white. Pleural areas sordid white (in ethanol) to golden (dry). Coxae, femora, tibiae, and tarsi sordid white to light brown with numerous fine black apically-directed setae; tibiae with few sparse, longer, black setae and two dark brown apical spurs; each tarsus with two serrate claws with dark brown teeth. Wing membranes noticeably yellowish, not seemingly iridescent; wings



Figs. 7–24. Right fore and hind wings of Vietnamese Mecoptera. 7, *Bittacus tamdaoensis*. 8, *Bittacus monastyrskiyi*. 9, *Bittacus bartolozzii*. 10–11, *Neopanorpa cucullata*. 12, *Neopanorpa malaisei*. 13, *Neopanorpa ornata*. 14, *Neopanorpa ellengreeni*. 15, *Neopanorpa dorsalis*. 16, *Neopanorpa acetabulifera*. 17, *Neopanorpa parvula*. 18, *Neopanorpa nielseni*. 19, *Neopanorpa panda*. 20, *Neopanorpa vietnamensis*. 21, *Neopanorpa lindsleyi*. 22, *Neopanorpa angustala*. 23, *Neopanorpa baviensis*. 24, *Neopanorpa annamensis*. Scale bar: 5 mm.

of specimens from Bi Doup (Fig. 10) immaculate except for prominent pterostigma. Wings of specimens from Hon Ba (Fig. 11) faintly marked with apical band sometimes entire; anterior portion of pterostigmal band inverted triangular to broad and complete; both distal and basal branches of the posterior portion of pterostigmal band may be present, but thin; marginal spot may be present; basal band may be present as two thin, faint spots. Thyridium present. Nygma in cells  $R_{4+5}$  and  $1R_5$ . Two or four rows of microtrichia in center of cells distal to pterostigmal band. Posterior base of forewings and anterior base of hindwings with 2–3 stout setae.

*Abdomen of male:* Terga 2–5 dark brown to black; corresponding sterna sordid white with brown caudal margins; pleural areas sordid white (in ethanol) to golden (dry); posterior process of tergum 3 (notal organ) broadly triangular, extending one-third length of tergum 4, and short, slightly raised, setose ridge on tergum 4; segment 6 subconical, decreasing slightly in diameter caudally, dorsal anterior four-fifths dark brown to black, remainder orange, orange ventrally; segments 7–8 subconical, expanding from anterior to posterior, pale orange, covered with fine, black, caudally-directed hairs. Segment 7 with slight swelling caudal four-fifths; tergum 9 apical margin truncate; apex extended slightly beyond segment 10; cerci brown. Sternum 9 orange basally, base width one-half length, apex width one-fourth length, bearing two hypovalves, each folded mesally. Hypovalves hood-like in ventral aspect, ovoid in lateral aspect; vertex circular, brown; bases sigmoidal, apices grey to black, broad, overlapping subtriangular; extending one-fourth length beyond base of dististyles obscuring genital bulb interior; densely covered with fine black setae

(Fig. 2). Basistyles fused basal four-fifths of length, elliptical with width equal to length, orange-brown, apical margins truncate, dark brown. Basistyles, dististyles, and sternum 9 covered with black, caudally directed setae. Aedeagus (Fig. 3) elongate; ventral valves conspicuous, long, extending just beyond base of dististyles; dorsal valves approximately similar in size and shape as ventral valves; ventral parameres vestigial; lateral parameres pronounced, blade-like; dorsal parameres vestigial. Dististyles falcate, with slender narrow brownish-black apices; bases orange-brown; mesal bases of dististyles bearing curved hook.

*Abdomen of female:* Terga 2–6 brownish-black; sterna 2–9 sordid white to grey; terga 7–10 orange-brown, dark brown caudally; sterna 6–10 reddish-brown; cerci black. Subgenital plate of sternum 8 dark brown, subtriangular, incised apically; lobes and lateral edges with long setae, remainder with shorter setae (Fig. 4). Genital plate with axial portion absent; arms broad, spatulate, subquadrate with base.

*Measurements:* Body length of holotype male approximately 15 mm; allotype female approximately 14 mm. Forewing length 14 mm.

Type material.—Holotype male, VIETNAM, Lam Dong Province, Bi Doup-Nui Ba National Park, forest adjacent to fish farm near Giang Ly Station  $12^{\circ}10.94'N$ ,  $108^{\circ}40.80'E$  1457 m, 10 June 2015, *leg.* L. Bezark, W. Bicha, A. Mudge, and N. Schiff. Allotype female, same locality, 10 June 2015. Paratypes: same locality, 6 June 2015, 2 males, 1 female; same locality, 7 June 2015, 3 females; same locality, 9 June 2015, 1 male, 1 female; same locality, 10 June 2015, 2 males, 7 females; Bi Doup-Nui Ba National Park, unknown locality, May 2009, 1 female, *leg.* A. Monastyrskii.

Hon Ba Preserve, 12°7.17'N, 108°56.89'E 1500 m, 22 June 2005, 2 males, 3 females, *leg.* W. Bicha; same locality, 23 June 2005, 3 males, 7 females; same locality; 12 June 2015, 12 males, 14 females, *leg.* L. Bezark, W. Bicha, A. Mudge, and N. Schiff; same locality, 13 June 2015, 3 males; same locality 14 June 2015, 4 males. Holotype and allotype deposited in the Vietnam National Museum of Nature (VNMN), Hanoi. Paratypes deposited in the United States Natural History Museum (USNM), Washington, DC, Florida Collection of Arthropods (FSCA), Gainesville, Florida, and collection of the author (WJB).

**Etymology.**—The specific epithet, *cucullata*, meaning “hood-shaped” was chosen to characterize the unique shape of the male hypovalves.

**Remarks.**—This species was first collected by Dr. Aleksandre Monastyrskii, but was not described earlier because it was known only from a lone female (Bicha 2010). *Neopanorpa cucullata*, with its immaculate wings, was readily differentiated in the field from the other species of scorpionfly, *Neopanorpa dorsalis* Byers, 1965, which occurred at the same location, but with a pterostigmal band on the wings. On close examination males of *N. dorsalis* have an unusual, elongated process on the 3<sup>rd</sup> tergum.

Individuals of both species were observed sitting with wings outstretched in a V on the tops of broad-leaved ground vegetation (Fig. 6) in the deep shade of a hardwood montane forest, not far from a slow-moving river. The insects were never observed to be abundant and were found together with the even less abundant *Neopanorpa dorsalis* Byers, 1965. The panorpids were only observed on one occasion without using squid bait placed on the top surfaces of vegetation.

***Neopanorpa ellengreeni* Bicha & Schiff, new species**

urn:lsid:zoobank.org:act:AC13CA70-39E7-4F9F-91E4-C6DD7CBC3B32

(Figs. 5, 14)

**Diagnosis.**—*Neopanorpa ellengreeni* has golden yellow wing membranes and pronounced inverted Y-shaped pterostigmal band, while all other known Vietnamese *Neopanorpa* have colorless to pale yellow wing membranes. The rostrum and mouthparts of *N. ellengreeni* are light yellow, while those of other Vietnamese scorpionflies are brown to black.

**Description.**—Two females initially preserved in ethanol, subsequently pinned and wings spread. **Head:** Dorsum of head black, light yellow below antennae. Ocelli amber; eyes plum to grey. Rostrum light yellow; labrum and mouthparts light yellow. Antennae long, approximately 12.5 mm, extending to pterostigma of forewing, with 41 flagellomeres; scape light yellow, pedicel light brown, flagellomeres black. **Thorax:** Pronotum brownish-black. Mesonotum anterior half brownish-black, remainder pale yellow with broad brownish-black medial stripe including scutellum. Metanotum with broad brownish-black median band including scutellum, metanotum lateral portions sordid white. Pleural areas pale yellow (in ethanol) to golden (dry). Coxae, femora, tibiae, and tarsi sordid white to pale yellow with numerous fine black apically-directed setae; tibiae with few sparse, longer, black setae and two light orange apical spurs; each tarsus with two serrate claws with dark brown teeth. Wing (Fig. 14) relatively short and broad; membranes golden yellow; pterostigmal band bold, brown inverted “Y;” apical band truncated posterior to M<sub>1</sub>; brown spot between Cu<sub>1</sub> and Cu<sub>2</sub>. Pterostigma not noticeable. Thyridium present. Nygma

in cells  $R_{4+5}$  and  $1R_5$ . Two or four rows of microtrichia in center of cells distal to pterostigmal band. Posterior base of forewings and anterior base of hindwings with 2–3 stout setae.

*Abdomen of female:* Terga 2–6 brownish-black; sterna 2–3 sordid white; sterna 4–6 brown; terga 7–10 brown; sterna 7–10 light brown; cerci black. Subgenital plate of sternum 8 brown, incised apically; lobes and lateral margins with long setae, remainder with shorter setae (Fig. 5). Genital plate with axial portion reduced to thickened region on base; arms broad, spatulate, subquadrate with base to slightly diverging.

*Measurements:* Body length of holotype female approximately 16 mm. Forewing length 13.2 mm.

Type material.—Holotype female, VIETNAM, Cao Bang Province, Phia Den Environs, ca. 965 m. 22.56576°N, 105.87043°E, 18–24 May 2013, *leg.* N. M. Schiff. One additional female paratype, Ninh Binh Province, Cuc Phuong National Park, 4–6 April 2017, *leg.* L. Bartolozzi. Holotype deposited in the USNM, Washington, DC.

*Etymology.*—The specific epithet, *ellengreeni*, is named in honor of Dr. Ellen Green, Delta State University, Cleveland, MS, wife of the collector of this species.

*Remarks.*—We would typically refrain from describing Mecoptera from a lone female, however the wings of this species are unique among Southeast Asian Mecoptera and the COI DNA neighbor-joining tree reveals that this species is unique among Vietnamese Mecoptera (Table 1, Fig. 1). The male of this species should be readily recognized when discovered by its unique wing markings and membrane coloration. DNA analysis should conclusively confirm the association. This rationale was partially validated by the

acquisition of a second identical female from a different locality after our initial study was completed.

#### KEY TO THE MECOPTERA OF VIETNAM

1. Tarsi with one raptorial apical claw (*Bittacus*) ..... 2
  - Tarsi with two apical claws (*Neopanorpa*) ..... 4
2. Antennae plumose ..... 3
  - Antennae filiform. Wings as Fig. 7 ..... *Bittacus tamdaoensis* Bicha, 2015
3. Male epiandrium with ventral extension. Wings as Fig. 8 .....
  - ..... *Bittacus monastyrskiyi* Bicha, 2007
  - Male epiandrium lacking ventral extension. Wings as Fig. 9 ..... *Bittacus bartolozzii* Bicha, 2015
4. Wings without distinct, darkened bands (Figs. 10–12) ..... 5
  - Wings with distinct, darkened bands (Figs. 13–24) ..... 6
5. Wings with pronounced stigma and possible faint bands (Figs. 10–11), males with overlapping hypoalves forming subtriangular hood. Central Highlands .....
  - ..... *Neopanorpa cucullata*, n. sp.
  - Wings with indistinct stigma (Fig. 12), apices of male hypoalves curved ventromesad. Northern Vietnam ..... *Neopanorpa malaisei* Byers, 1999
6. Wings with broad, black bands (Fig. 13) .....
  - ..... *Neopanorpa ornata* Byers, 1965
  - Wings with thin bands (Figs. 14–24) .... 7
7. Wing membranes golden yellow (Fig. 14). Pterostigmal band Y-shaped, pronounced. Rostrum light yellow; labrum and mouthparts light yellow .....
  - ..... *Neopanorpa ellengreeni*, n. sp.
  - Wing membranes colorless or pale yellow. Rostrum and mouthparts brown ..... 8
8. Male with posterior process of 3<sup>rd</sup> tergum long and slender, extending well beyond 4<sup>th</sup> tergum. Wing lacking basal band. Pterostigmal band anteriorly merging with apical band (Fig. 15). Small species.

Central Highlands .....	Wing markings brown (Fig. 20). Northern Vietnam .....
..... <i>Neopanorpa dorsalis</i> Byers, 1965	.. <i>Neopanorpa vietnamensis</i> Willmann, 1976
– Male posterior process of 3 <sup>rd</sup> not extending to 4 <sup>th</sup> tergum .....	9
9. Bases of male dististyles with large mesal cups. Wings as Fig. 16. Central Highlands .....	14. Mesal margins of male hypovalves slightly emarginate. Northern Vietnam ...
..... <i>Neopanorpa acetabulifera</i> Bicha, 2015	..... 15
– Bases of male dististyles without large mesal cups. ....	– Mesal margins of male hypovalves straight .....
..... 10	..... 16
10. Male hypovalves thin, not overlapping. Wing lacking basal band. Pterostigmal band anteriorly merging with apical band (Fig. 17). Small species .....	15. Basal half of male hypovalves mesal margins slightly emarginate. Wings (Fig. 21) wide. Medium-sized species .....
..... <i>Neopanorpa parvula</i> Willmann, 1976	..... <i>Neopanorpa lindsleyi</i> Bicha, 2015
– Male hypovalves overlapping.....	– Basal one-fourth or less of male hypovalves mesal margins slightly emarginate. Wings (Fig. 22) long and narrow. Among the largest of Indochinese species .....
11. Wing markings glossy dark brown to black (Fig. 18). Among the largest of Vietnamese species. Posterior process (notal organ) of male 3 <sup>rd</sup> tergum narrow and extending over three-fourths length of 4 <sup>th</sup> tergum. Male dististyle mesal basal lobe with elongate, incurved dorsal tooth. Northern Vietnam .....	..... <i>Neopanorpa angustala</i> Bicha, 2015
..... <i>Neopanorpa nielsenii</i> Byers, 1965	17. Northern Vietnam. Wings as Fig. 23 .....
– Wing markings brown. Posterior process of male 3 <sup>rd</sup> tergum short and broad, not extending over half length of 4 <sup>th</sup> tergum .....	..... <i>Neopanorpa baviensis</i> Cheng, 1953
..... 12	– Central Highlands. Wings as Fig. 24 .....
12. Small-sized species (Forewing less than 15 mm) .....	..... <i>Neopanorpa annamensis</i> Byers, 1965
– Medium to large-sized species (Forewing greater than 15 mm) .....	
..... 14	
13. Male hypovalves conspicuously bent mesally near mid-length, outer margins sinuate. Anterior portion of pterostigmal band of wing broad; proximal margin of apical band truncate. Wing markings black (Fig. 19). Central Highlands.....	
..... <i>Neopanorpa panda</i> Byers, 1965	
– Male hypovalves elliptical, not conspicuously bent mesally near mid-length. Anterior portion of pterostigmal band of wing thin; extra band or markings between pterostigmal band associated with incomplete apical band (proximal margin of apical band not truncate).	

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Appendix 1. Specimen data for exemplar Vietnamese Mecoptera specimens used to generate divergence, percent identity and the neighbor-joining tree.

Species	Collected By	Collection Date	Country	Province	Location	Latitude/Longitude	Specimen Voucher Number	GENBANK Accession Number
<i>Bittacus monastyrskiyi</i>	W. Bicha	22-Jul-05	Vietnam	Ninh Binh	Cuc Phuong National Park	20.316 N 105.608 E	CBHR1279	KX657764
<i>Neopanorpa parvula</i>	W. Bicha	19-May-2012	Vietnam	Lao Cai	Sa Pa environs	22.322 N 103.82 E	CBHR2708	KX657765
<i>Neopanorpa lindsleyi</i>	W. Bicha	26-May-2012	Vietnam	Vinh Phuc	Tam Dao National Park	21.476111 N 105.62722 E	CBHR2795	KX657766
<i>Neopanorpa malaisei</i>	W. Bicha	23-May-2012	Vietnam	Lao Cai	Sa Pa environs	22.350277 N 103.777222 E	CBHR2861	KX657767
<i>Bittacus tamdaoensis</i>	W. Bicha	26-May-2012	Vietnam	Vinh Phuc	Tam Dao National Park	21.476111 N 105.62722 E	CBHR2867	KX657768
<i>Neopanorpa angustata</i>	A. Monastyrskii	1-Sep-2010	Vietnam	Hoa Binh	Ba Vi National Park	21.083 N 105.133 E	CBHR2873	KX657769
<i>Neopanorpa ellengreeni</i>	N. Schiff	24-May-2013	Vietnam	Cao Bang	Phia Den	22.56576 N 105.87043 E	CBHR3118	KX657771
<i>Bittacus bartolozzi</i>	L. Bartolozzi	12-Jun-2013	Vietnam	Hoa Binh	Pa Co Hang Kia Nature Preserve	20.725 N 104.933 E	CBHR3332	KX657772
<i>Neopanorpa bavensis</i>	L. Bartolozzi	12-Jun-2013	Vietnam	Hoa Binh	Pa Co Hang Kia Nature Preserve	20.725 N 104.933 E	CBHR3420	KX657773
<i>Neopanorpa vietnamensis</i>	L. Bartolozzi	5-May-2014	Vietnam	Ninh Binh	Cuc Phuong National Park	20.316 N 105.608 E	CBHR4611	KX657774
<i>Neopanorpa annamensis</i>	L. Bartolozzi	28-May-2014	Vietnam	Thua Thien Hue	Bach Ma National Park	16.194 N 107.859 E	CBHR4617	KX657775
<i>Neopanorpa nielsenii</i>	L. Bartolozzi	26-May-2011	Vietnam	Lao Cai	Van Ban Nature Reserve	20.467 N 105.175 E	CBHR4620	KX657776
<i>Neopanorpa acetabulifera</i>	L. Bartolozzi	28-May-2014	Vietnam	Thua Thien Hue	Bach Ma National Park	16.194 N 107.859 E	CBHR4625	KX657777
<i>Neopanorpa panda</i>	W. Bicha	8-Jun-2015	Vietnam	Lam Dong	Da Lat City	11.899 N 108.438 E	CBHR4863	KX657778
<i>Neopanorpa cucullata</i>	W. Bicha	10-Jun-2015	Vietnam	Lam Dong	Bi Doup N.P.	12.182 N 108.680 E	CBHR5002	KX657779
<i>Neopanorpa dorsalis</i>	W. Bicha	13-Jun-2015	Vietnam	Khanh Hoa	Hon Ba Preserve	12.115 N 108.978 E	CBHR4864	KX657781
<i>Neopanorpa angustipennis</i>	M. Sharkey	1-8-Sep-2008	Thailand	Nakhon Si Thammarat	Namtok Yong N.P.	8.2377 N 99.8048 E	CBHR5932	MF362669