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RESEARCH PAPER

Neopanorpa (Mecoptera: Panorpidae) from the Himalayas and adjacent regions, with descriptions of three new species

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Abstract. A total of 21 species of the genus *Neopanorpa* van der Weele, 1909 are currently recorded from the Himalayas and adjacent regions to which three are added herein. I provide a checklist, distributional map and key to these species, with descriptions of the three new species: *Neopanorpa liuxingyuei* sp. nov., *Neopanorpa wuchaoi* sp. nov., and *Neopanorpa zhengyucheni* sp. nov. from Tibet, China. The biology and biogeography for the 21 species of *Neopanorpa* from this region are briefly discussed.

Key words. Mecoptera, Panorpidae, scorpionflies, biodiversity, taxonomy, China, Himalayas, India, Nepal, Tibet

Zoobank: http://zoobank.org/urn:lsid:zoobank.org:pub:5B090AAD-B390-4743-9EDD-4296D60B3EC8

Introduction

The Himalayas is a mountain range separating the Indian subcontinent from the Qinghai-Tibetan Plateau, running from the west-northwest Nanga Parba in Pakistan through northern India, Nepal and Bhutan to the east-southeast Namcha Barwa in Tibet, China, with a length of approximately 2,400 km (Yang & Zheng 2004). Its huge altitude range and diverse topography experience a wide range of climates, from humid subtropical in the southern foothills to cold, arid conditions on the northern side (Kindlmann 2011). As one of the world's biodiversity hotspots, this region represents a transition zone between the Palaearctic and Indo-Malayan Realms, and harbors a great number of endemic species (Behera et al. 2002, Myers et al. 2000, Pandit et al. 2007, Telwala et al. 2013).

The scorpionfly genus *Neopanorpa* van der Weele, 1909 (ca. 170 spp. worldwide) was initially recognized as a subgenus of *Panorpa* Linnaeus, 1758 and elevated by Enderlein (1910) to its current generic status. Generally, members of this genus can be differentiated from *Panorpa* by a short 1A vein proximal to the origin of Rs (ORs), and a single cross-vein between 1A and 2A in the forewings (Carpenter 1945, Cheng 1957, Esben-Petersen 1921). However, some species such as *Neopanorpa appendiculata* (Westwood, 1841) and *Neopanorpa indica* Rust & Byers, 1976 bear a long 1A vein exceeding ORs, similar to most *Panorpa*, suggesting the insufficiency of venations in the generic assignment in Panorpidae. Therefore, more characters (especially male and female genitalia) must be consulted in the taxonomical study of Panorpidae. *Neopanorpa* is an Indo-Malayan group that is mostly constrained to the tropical and subtropical zones, e.g., India, mainland Southeast Asia, southern China, Japan's southernmost Ryukyu Islands, and the Malay Archipelago (Bicha 2018, Chau & Byers 1978, Miyamoto & Makihara 1979, Penny & Byers 1979, Rust & Byers 1976; van der Weele, 1909).

To date, *Neopanorpa* represents the only genus in Panorpidae recorded from the Himalayas and adjacent regions. The first record is *Neopanorpa furcata* (Hardwicke, 1825) described from Nepal. Although originally assigned to *Panorpa,* it was transferred to *Leptopanorpa* MacLachlan, 1875 by Esben-Petersen (1915) and then to *Neopanorpa* by Rust & Byers (1976). Several species were subsequently reported by Navás (1908, 1910, 1913, 1935), Needham (1909), Esben-Petersen (1915), and Cheng (1953) from Bhutan, northern India and Nepal. A monographic revision of the Mecoptera from India and adjacent regions was conducted by Rust & Byers (1976), who also described two *Neopanorpa* species from Shimla,

northwestern India. Several additional species were reported from Nepal (Byers 1971), Darjeeling (Byers 2001) and Tibet (Hua & Chou 1999). *Neopanorpa chillcotti* Byers, 1971 was originally described from Nepal, but was recently discovered also in Tibet (Wang & Hua 2017b).

Eighteen species of *Neopanorpa* were previously recorded form the Himalayas and adjacent regions, ranging from Bhutan, northern India, Nepal, and Tibet. Recently, a series of specimens from Tibet was collected by Messrs. Chao Wu and Yu-Chen Zheng. These species resemble several *Neopanorpa* species from the adjacent regions such as Bhutan and northern India but can be differentiated from them by the male and female genitalia. I herein provide a checklist, a distributional map and a key for *Neopanorpa* species from the Himalayas and adjacent regions, with three new species described and illustrated in detail. In addition, the biology and biogeography of these species are briefly discussed.

Material and methods

All the materials examined in this study are deposited in the Biological Science Museum, Dali University (DALU). Adult scorpionflies were caught with a collecting net, preserved in 95% ethanol or pinned. Photographs of the insects were taken with a Nikon D7000 digital camera in conjunction with a Nikkor AF-S Micro 105 mm f/2.8 lens (habitus), or a Canon MP-E 65 mm f/2.8 1–5× macro lens with a handmade mount adapter (the other images). The measurements follow Wang & Hua (2020). The female habitus images were modified to omit the left antenna, wings and legs. The distribution map was obtained from Maps-For-Free (https://maps-for-free.com) and modified with Adobe Illustrator CC. All pictures were adjusted and grouped with Adobe Photoshop CC. The terminology follows Mickoleit (1975, 1976), Willmann (1989), and Wang & Hua (2017a, b, 2018, 2019a, b, 2020, 2021).

The following acronyms are applied in the main text:

A1	the first abdominal segment;
AbL	abdomen length;
AtL	antenna length;
BL	body length;
FL	forewing length;
FW	forewing width;
HL	hindwing length;
HW	hindwing width;
ORs	origin of Rs;
S1	the first sternum (and so forth for other sterna);
T1	the first tergum (and so forth for other terga).

The following abbreviations and acronyms are applied in the figure annotations:

Ae	aedeagus;
Ap	apodeme of axis;
Ax	axis;
Ce	cercus;
DBr	dorsal bridge of paramere;
DPr	dorsal process;
DV	dorsal valve;
Ep	epandrium;
Gcx	gonocoxite;
Gs	gonostylus;
Hv	hypovalve;
LPr	lateral process;
MP	main plate of medigynium;
PA	posterior arm;
Pm	paramere;
StH	stalk of hypandrium;
StP	stalk of paramere;
VV	ventral valve.

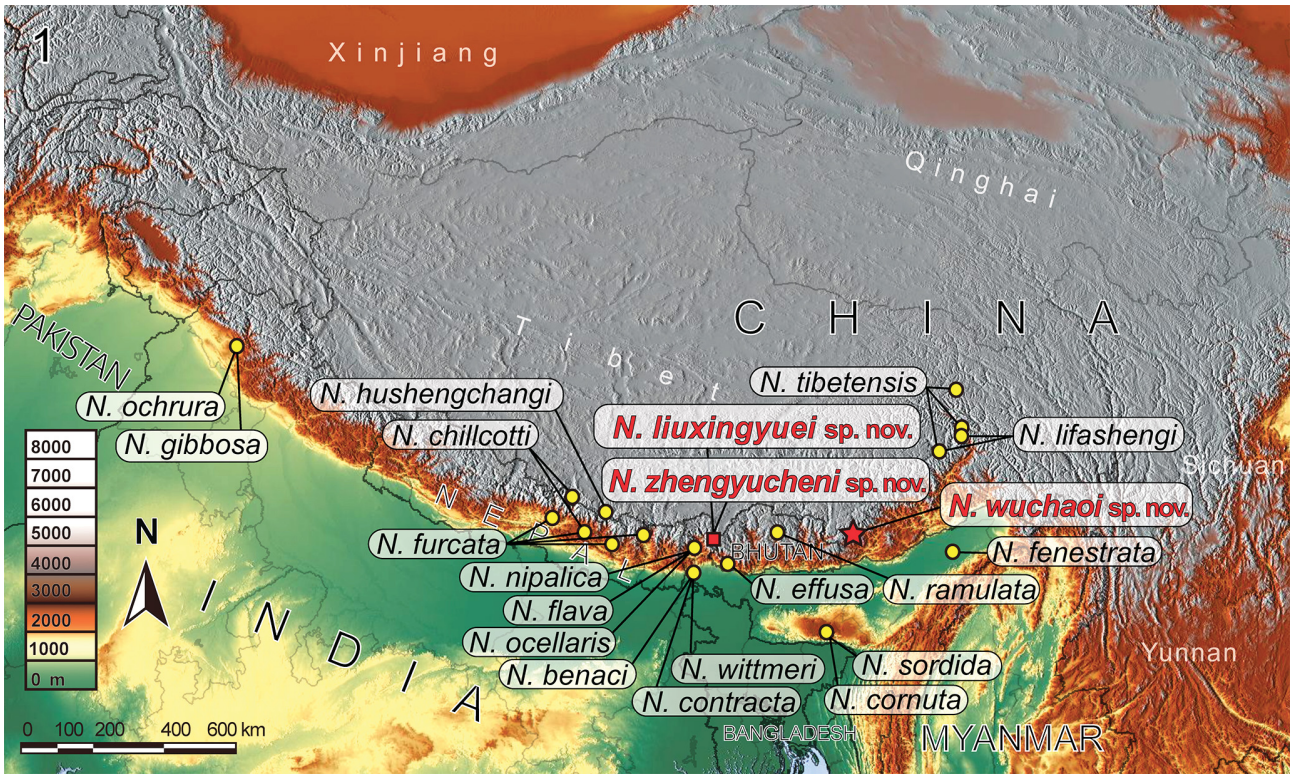


Fig. 1. Distribution of 21 *Neopanorpa* species from the Himalayas and adjacent regions. Localities are denoted by color patterns, and species names are indicated by rectangular frames.

Taxonomy

Checklist of *Neopanorpa* species from the Himalayas and adjacent regions

For distributions see Fig. 1.

N. benaci Navás, 1935	INDIA: West Bengal: Kurseon
N. chillcotti Byers, 1971	CHINA: Tibet: Gyirong; NEPAL: Kathmandu, Godavari, Pulchauki
N. contracta Cheng, 1953	INDIA: West Bengal: Darjeeling
N. cornuta Esben-Petersen, 1915	INDIA: Meghalaya: Khasia Hills
N. effusa (Navás, 1913)	INDIA: Sikkim
N. fenestrata (Needham, 1909)	INDIA: Upper Assam
N. flava Esben-Petersen, 1915	INDIA: Sikkim
N. furcata (Hardwicke, 1825)	NEPAL: Kathmandu, Manga Deorati, Namdu, Solu, Ulleri
N. gibbosa Rust & Byers, 1976	INDIA: Himachal Pradesh: Shimla
N. hushengchangi Hua & Chou, 1999	CHINA: Tibet: Zham
N. lifashengi Hua & Chou, 1999	CHINA: Tibet: Nyinchi, Yi'ong
N. liuxingyuei **sp. nov.**	CHINA: Tibet: Yadong
N. nipalica (Navás, 1910)	INDIA: Sikkim
N. ochrura Rust & Byers, 1976	INDIA: Himachal Pradesh: Shimla
N. ocellaris (Navás, 1908)	CHINA: Guangxi, Guizhou; INDIA: Sikkim
N. ramulata Byers, 1975	BHUTAN: Changra, Tongsa
N. sordida (Needham, 1909)	INDIA: Meghalaya: Khasia Hills
N. tibetensis Hua & Chou, 1999	CHINA: Tibet: Bomê, Nyinchi, Tangmai
N. wittmeri Byers, 2001	INDIA: West Bengal: Darjeeling: Lebong
N. wuchaoi **sp. nov.**	CHINA: Tibet: Cona
N. zhengyucheni **sp. nov.**	CHINA: Tibet: Yadong

Key to *Neopanorpa* species from the Himalayas and adjacent regions

Males. Males of 17 species are included; *N. benaci*, *N. fenestrata*, *N. flava*, and *N. sordida* are not included due to poorly-known characters.

1 Wing markings covering more than 2/3 of the wing area; all bands and spots intensively fused to each other to form a distinctive zigzag pattern. ..... ***N. ocellaris*** (Navás, 1908)
– Wing markings covering less than 1/2 of the wing area or reduced. 2
2 A6 with a pair of processes on its dorsal apex. 3
– A6 lacking such processes on its dorsal apex. 4
3 S2 with a finger-like sternal process; A6 with a pair of curved and hook-like processes. ..... ***N. furcata*** (Hardwicke, 1825)
– S2 lacking such process; A6 with a pair of straight and finger-like processes. ..... ***N. cornuta*** Esben-Petersen, 1915
3 Hypovalves with hypandrial process on its mesal base. 4
– Hypovalves lacking hypandrial process on its inner base. 7
4 Notal organ on hind margin of T3 not reaching T4; T4 with a membranous area proximate to postnotal organ. 5
– Notal organ on hind margin of T3 extending beyond caudal margin of T4; T4 lacking a membranous area proximate to postnotal organ. 6
5 A7 and A8 yellowish brown. ..... ***N. ochrura*** Rust & Byers, 1976
– A7 darkish brown in basal half and yellowish brown in apical half; A8 yellowish brown. ..... ***N. lifashengi*** Hua & Chou, 1999
6 Wings with well-developed apical and pterostigmal bands; notal organ on caudal margin of T3 not exceeding T5. ..... ***N. zhengyucheni* sp. nov.**
– Wings with greatly reduced markings; notal organ on hind margin of T4 exceeding T5 and extending approximately to middle of A6. ..... ***N. tibetensis*** Hua & Chou, 1999
7 A7 covered with long stout setae on dorsal apex; epandrium with a finger-like subapical process. ..... ***N. gibbosa*** Rust & Byers, 1976
– A7 lacking such setae; epandrium lacking such process. 8
8 Hypovalves greatly curved and arched ventrad; gonostyli covered with numerous long setae on basal half of lateral margin. ..... ***N. effusa*** (Navás, 1913)
– Hypovalves simple; gonostyli lacking long setae on lateral margin. 9
9 Parameres bifurcated. 10
– Parameres simple. 11
10 Epandrium with a terminal projection; parameres bifurcated in distal 1/3. ..... ***N. ramulata*** Byers, 1975
– Epandrium with an O-shaped terminal emargination and forming a pair of finger-like processes; parameres bifurcated subbasally. ..... ***N. wuchaoi* sp. nov.**
11 Wings lacking markings. ..... ***N. nipalica*** (Navás, 1910)
– Wing markings well-developed. 16
12 Notal organ on T3 greatly elongated, exceeding caudal margin of T5 and greatly enlarged in middle; hypovalves slightly constricted in middle; gonostyli enlarged in basal 2/5. ..... ***N. wittmeri*** Byers, 2001
– Notal organ not exceeding T5 and not enlarged in middle; hypovalves simple; gonostyli simple. 13
13 Hypovalves slender and thread-like. ..... ***N. hushengchangi*** Hua & Chou, 1999
– Hypovalves broad. 14
14 Hypovalves broadening towards a rounded apex. ..... ***N. chillcotti*** Byers, 1971
– Hypovalves tapering towards an acute apex. 15
15 Hypovalves greatly divergent in distal half; parameres slender with an acute apex; dorsal aedeagal processes broad. ..... ***N. liuxingyuei* sp. nov.**
– Hypovalves nearly parallel; parameres thicker with a slightly enlarged apex; dorsal aedeagal processes slender. ..... ***N. contracta*** Cheng, 1953

Females. Females of 14 species are included, females of *N. benaci*, *N. fenestrata*, *N. gibbosa*, *N. hushengchangi*, *N. nipalica*, *N. sordida*, and *N. wittmeri* are unknown.

1 Wings with markings covering more than 2/3 of their area; all bands and spots intensively fused to each other to form a distinctive zigzag pattern. ..... ***N. ocellaris*** (Navás, 1908)
– Wings with markings covering less than 1/2 of their area or reduced. 2

2 Medigynium with well developed main plate. 3
– Medigynium with poorly developed main plate. 4
3 Medigynium with posterior arms slightly shorter than main plate; axis with apodemes extending beyond main plate basally. ..... ***N. ramulata*** Byers, 1975
– Medigynium with posterior arms shorter than half length of main plate; axis with apodemes entirely concealed in main plate. ..... ***N. wuchaoi*** **sp. nov.**
4 Wings with well developed markings. 5
– Wings with greatly reduced markings or lacking markings. 12
5 Medigynium with axis greatly reduced and lacking apodemes. 6
– Medigynium with well developed axis and a pair of apodemes. 7
6 Medigynium with main plate rounded at lateral margins with a U-shaped main plate. ..... ***N. chillcotti*** Byers, 1971
– Medigynium with main plate greatly projected laterally with a subtrapezoidal main plate. ..... ***N. furcata*** (Hardwicke, 1825)
7 Medigynium with apodemes of axis greatly divergent basally. 8
– Medigynium with apodemes of axis nearly parallel. 9
8 Medigynium with posterior arms nearly parallel. ..... ***N. contracta*** Cheng, 1953
– Medigynium with posterior arms slightly convergent apically. ..... ***N. liuxingyuei*** **sp. nov.**
9 Medigynium with axis narrow, approximately half as wide as base of posterior arms. 10
– Medigynium with axis stout, wider than half width of base of posterior arms. 11
10 Medigynium with posterior arms rounded at apex. ..... ***N. tibetensis*** Hua & Chou, 1999
– Medigynium with posterior arms subacute at apex. .....***N. cornuta*** Esben-Petersen, 1915
11 Medigynium with posterior arms longer than axis. ..... ***N. effusa*** (Navás, 1913)
– Medigynium with posterior arms approximately as long as axis. ..... ***N. flava*** Esben-Petersen, 1915
12 Medigynium with apodemes of axis nearly parallel. ..... ***N. zhengyucheni*** **sp. nov.**
– Medigynium with apodemes of axis greatly divergent at base. 13
13 Medigynium with posterior arms slightly longer than axis. ..... ***N. ochrura*** Rust & Byers, 1976
– Medigynium with posterior arms slightly shorter than axis. ..... ***N. lifashengi*** Hua & Chou, 1999

Descriptions of new species

Neopanorpa liuxingyuei sp. nov.

(Figs 2–10)

Type material. Holotype: **CHINA: Tibet:** ♂, Shigatze Prefecture, Yadong County, Kambu Maqu (Yadong River), 27°19′47″N, 89°00′06″E, 2250 m, 05.viii.2020, leg. Yu-Chen Zheng (DALU). Paratype: 1 ♀, same data as the holotype (DALU).

Diagnosis. The new species closely resembles *Neopanorpa contracta* Cheng, 1953, but can be differentiated from the latter by the following characters: in males, 1) hypovalves greatly divergent in the distal half (*versus* nearly parallel); 2) parameres slender, and smoothly tapering towards an acute apex (*vs*. thick at base, greatly constricted in distal 1/3 with a slightly enlarged and rounded apex); 3) dorsal aedeagal processes broad and semi-foliate (*vs*. narrow and blade-like); and in females, 4) medigynium with posterior arms slightly convergent in distal half (*vs*. nearly parallel).

Description. ***Measurements*** (mm). *Male* (holotype): AtL 15.3, AbL 13.2, BL 18.5, FL 16.0, FW 3.5, HL 14.1, HW 3.2. *Female* (paratype): AtL 14.1, AbL 8.8, BL 1.4, FL 15.8, FW 2.9, HL 13.8, HW 2.7.

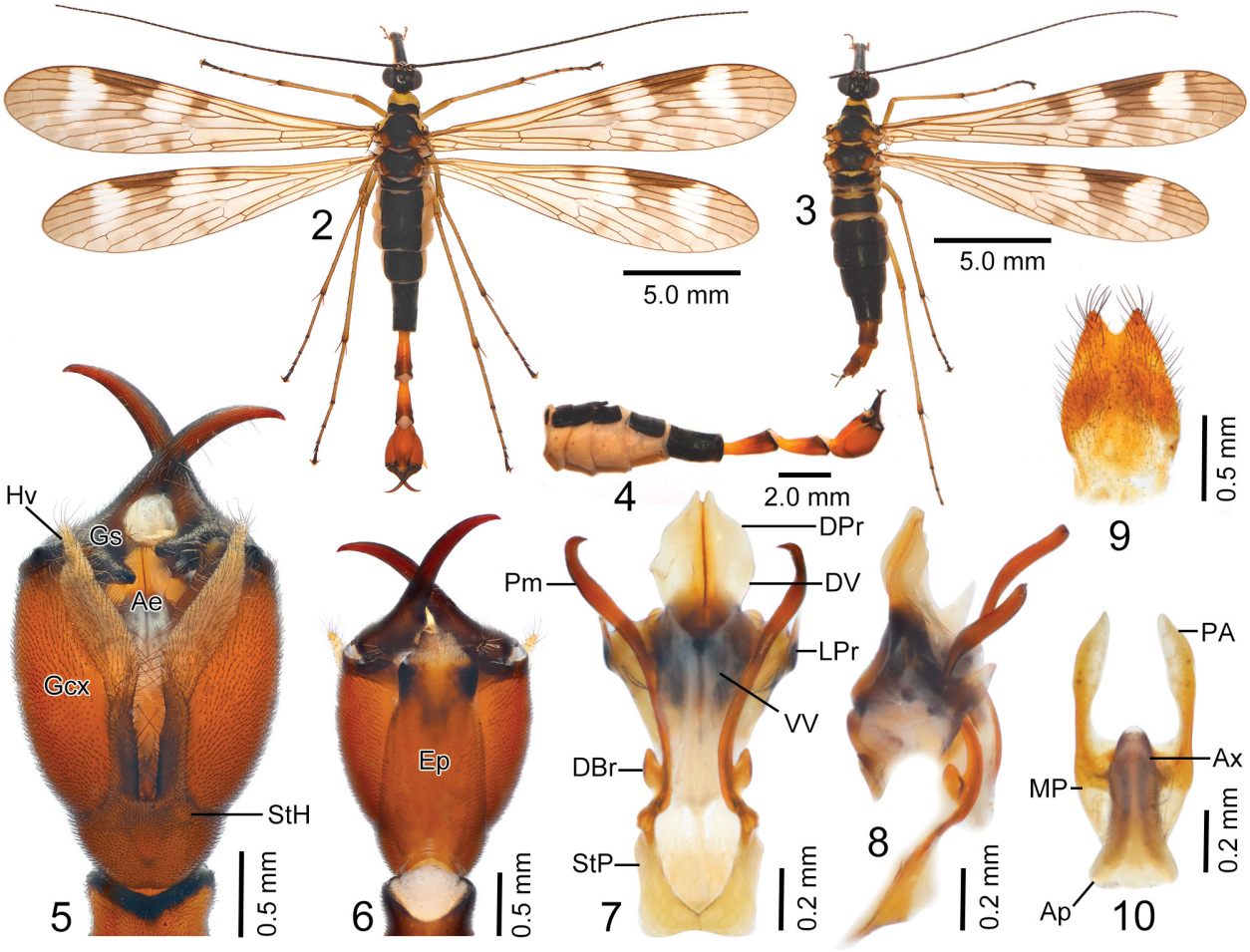
Male. *Head* (Fig. 2). Vertex, ocellar triangle and occiput shining black. Rostrum dark brown with genal area yellowish brown, maxillae and labial palps yellowish brown with blackish apices. Antennae black with 46 flagellomeres.

Thorax (Fig. 2). Pronotum dark brown with three stout setae on each side of anterior margin. Meso- and metanotum mostly black with small brown spot on each side of posterior portion. Pleura and legs yellowish with apex of tibia and distal tarsomeres black.

Wings (Fig. 2). Narrow basally with rounded apex. Membrane subhyaline and tinged with grayish brown; markings brown; pterostigma dark brown; veins mostly dark brown with distal cross-veins whitish. Forewing apical band broad and faded, with small hyaline spot above ending of M_1; pterostigmal band dense in anterior half and faded in posterior half, with basal branch narrow and apical branch broad; hyaline spot at termination of M_3; posterior portion of apical band and apical branch of pterostigmal band merged; area between apical and pterostigmal bands whitish and distinctly lighter than remainder of wing; marginal spot elongated posteriorly and nearly connected with basal branch of pterostigmal band; basal band represented by small spot proximal to ending of CuP; basal spot absent; Sc extending to pterostigmal area; R_1 simple; Rs six-branched with R_2 trifurcated, R_{2a} bifurcated near wing margin; M_4 greatly bent at m-cu; 1A ending far before origin of Rs (ORs); one cross-vein between 1A and 2A. Hindwings similar to forewings with more reduced markings.

Abdomen (Figs 2, 4). T1–T5 black, S1–S5 brown, pleura sordid white. Notal organ on T3 triangular in basal half and finger-like in distal half, extending beyond approximate middle of T4; postnotal organ on T4 rounded. T6 black and cylindrical. A7 reddish brown basally and gradually darkening towards apex, greatly constricted at base and broadening towards truncated apex; A8 similar to A7 but slightly curved at base and beveled at apex.

Male genitalia (Figs 5–8). Genital bulb stout, oval, mostly reddish brown with distal half dark brown. Epandrium (T9) broad, slightly constricted in distal 1/4, with pale and narrowed apex, and slightly emarginated terminally; epandrial lobes stout. Hypandrium (S9) with short and broad basal stalk and split into pair of hypovalves; hypovalves approximately three times as long as basal stalk of hypandrium, narrow in basal 2/5 and slightly broader in distal 3/5, tapering to subacute apex, bearing sparse long bristles along inner margin, extending slightly



Figs 2–10. *Neopanorpa liuxingyuei* sp. nov. 2, 4–8 – male. 3, 9, 10 – female. 2, 3 – habitus, dorsal view; 4 – abdomen, left-lateral view; 5, 6 – genital bulb, ventral and dorsal views, respectively; 7, 8 – aedeagal complex, ventral and left-lateral views, respectively; 9 – subgenital plate, ventral view; 10 – medigynium, ventral view.

beyond base of gonostyli. Gonostyli slightly shorter than gonocoxites, slender, with large basal lobe and subtriangular median process. Parameres slender, extending slightly beyond apex of gonocoxites, with slightly curved, hook-like apex; stalk of parameres fused basally, dorsal bridge detached with lateral processes; ventral aedeagal valves pale and V-shaped distally; dorsal aedeagal processes broad and semi-foliate, two processes closely aligned along inner margin but slightly divergent at acute apex; lateral processes acute and triangular.

Female. Similar to males in general appearance but with denser wing markings (Fig. 3). *Female genitalia* (Figs 9, 10). Subgenital plate oval with deep V-shaped emargination terminally, and bearing long stout setae marginally. Medigynium with poorly developed main plate; posterior arms slender and twisted in basal half, and slightly spatulate in distal half; axis stout, approximately as long as posterior arms, with apodemes greatly divergent basally.

Etymology. The new species is named after Dr. Xing-Yue Liu, for his constant encouragement of the author and great support for the current study.

Distribution. Indo-Malayan Realm: China: Tibet (Yadong) (Fig. 1).

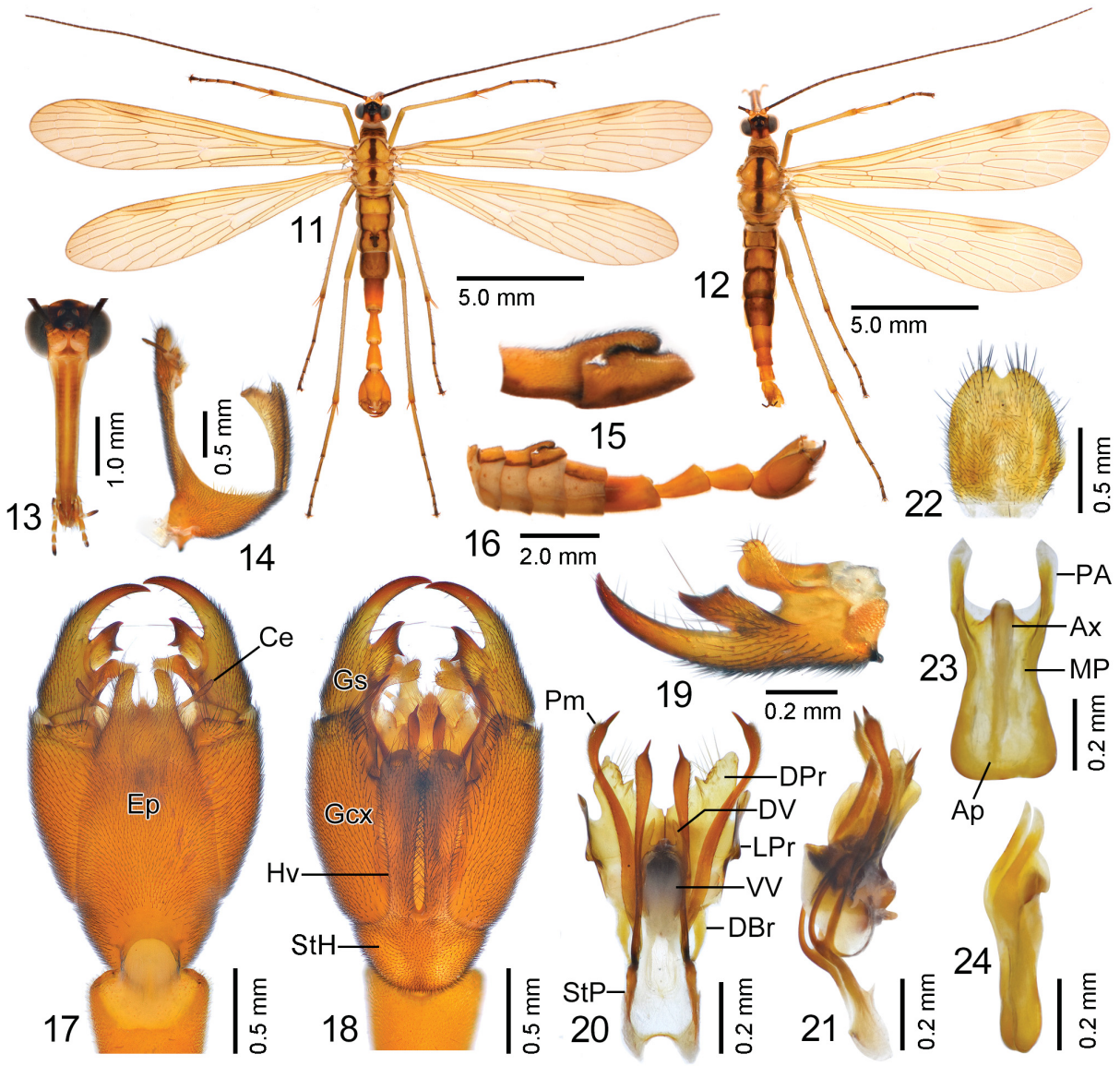
This species was collected along the river Kambu Maqu only a few hundred meters northwest from the Jigme Khesar Strict Nature Reserve, Bhutan. It is highly possible that this species also occurs in northwestern Bhutan.

Neopanorpa wuchaoi sp. nov.

(Figs 11–24)

Type material. Holotype: ♂, **China: Tibet:** Shannan Prefecture, Cona County, 27°48′41″N, 91°45′06″E, 2438 m, 16.vii.2019, leg. Chao Wu (DALU). Paratypes: 1♂ 2 ♀♀, same data as the holotype (DALU).

Diagnosis. The new species resembles *Neopanorpa ramulata* Byers, 1975, but can be differentiated from the latter by the following characters: 1) antennae longer than forewings (*versus* shorter); 2) wings with greatly reduced markings (*vs*. well developed); in males, 3) notal organ on T3 extending near the posterior border of T4 (*vs*. extending to middle of T4); 4) epandrium greatly emarginated terminally (*vs*. simple); 5) basal lobe of gonostylus bifurcated basally (*vs*. simple); 6) paramere bifurcated subbasally (*vs*. subapically); 7) dorsal processes of aedeagus broadly leaf-shaped and divergent distally (*vs*. blade-shaped and convergent distally); and in females, 8) axis completely concealed in main plate basally (*vs*. extending beyond main plate basally).



Figs 11–24. *Neopanorpa wuchaoi* sp. nov. 11, 13–21 – male; 12, 22–24 – female. 11, 12 – habitus, dorsal view; 13 – head, frontal view; 14 – epandrium and hypandrium, left-lateral view; 15 – T3 and T4, left-lateral view; 16 – abdomen, left-lateral view; 17, 18 – genital bulb, dorsal and ventral views, respectively; 19 – left gonostylus, ventral view; 20, 21 – aedeagal complex, ventral and right-lateral views, respectively; 22 – subgenital plate, ventral view; 23, 24 – medigynium, ventral and left-lateral views, respectively.

Description. ***Measurements*** (mm). *Male* (holotype). AtL 14.0, AbL FL 8.8, BL 12.4, FL 12.6, FW 2.7, HL 11.6, HW 2.5. *Female* (paratypes). AtL 14.0, AbL 7.4, BL 11.8, FL 13.0, FW 2.8, HL 12.0, HW 2.7.

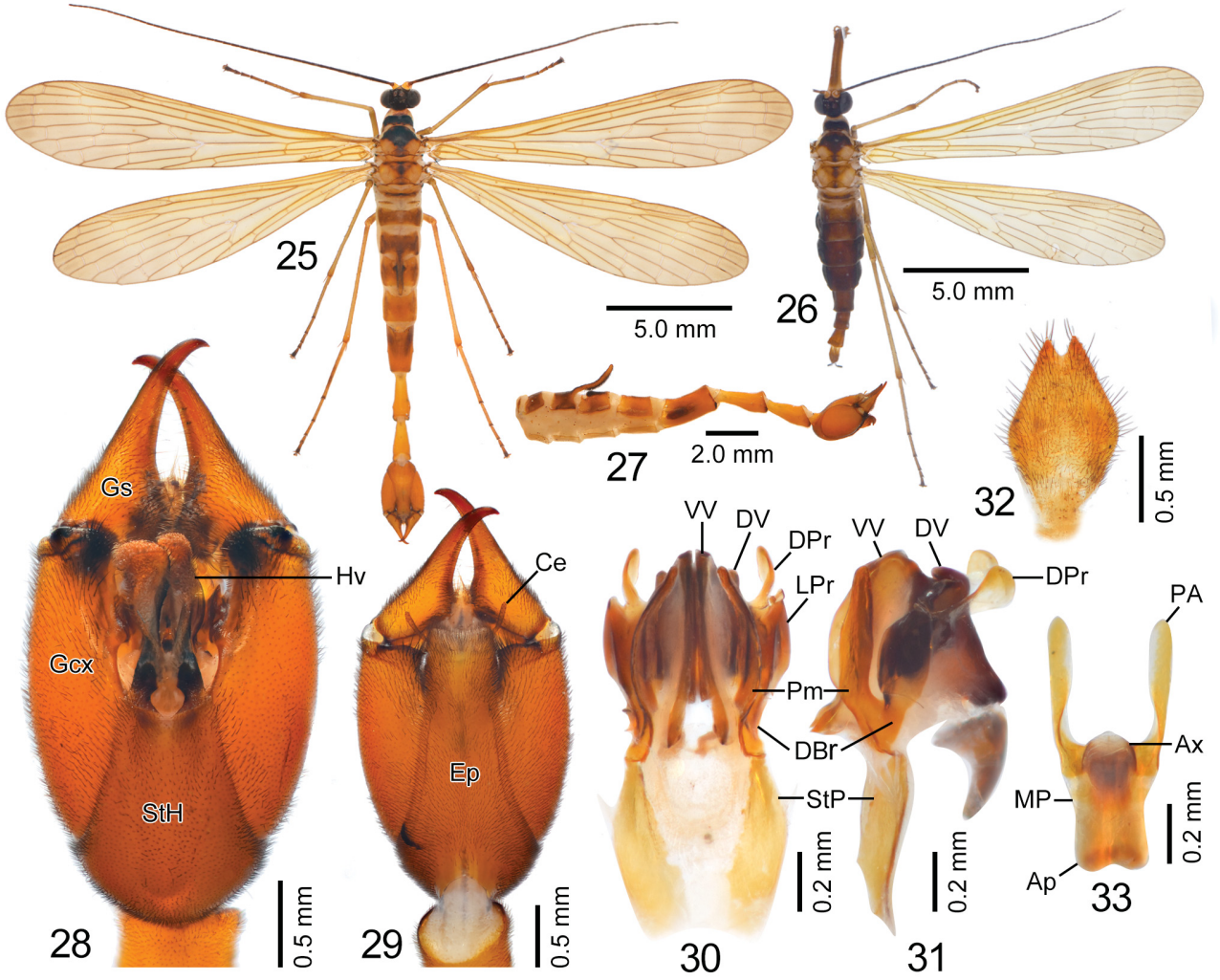
Male. *Head* (Figs 11, 13). Vertex and occiput mostly black, large yellowish brown spot on each side of occiput. Rostrum slender, yellowish brown with pair of brown longitudinal stripes. Scape yellowish brown, pedicel dark brown, flagellum black with 47–49 flagellomeres.

Thorax (Fig. 11). Pronotum dark brown and lacking stout setae along anterior margin. Meso- and metanotum mostly yellowish brown with narrow black median stripe. Legs and pleura yellow with apex of tibia and distal tarsomeres blackish.

Wings (Fig. 11). Narrow basally with rounded apex. Membrane hyaline and strongly tinged with yellow; markings entirely reduced; pterostigma brown; veins mostly brown with distal cross-veins whitish. Forewing Sc extending to pterostigmal area; R_1 simple; Rs six-branched with R_2 trifurcated, R_{2a} bifurcated; M_4 greatly bent at m-cu; 1A ending far before origin of Rs (ORs); one cross-vein between 1A and 2A. Hindwings similar to forewings with more reduced markings.

Abdomen (Figs 11, 15, 16). T1–T5 yellowish brown with lateral margin blackish, S1–S5 light yellowish brown. Notal organ on T3 extending approximately to 4/5 of T4, finger-like and clavate terminally; postnotal organ on T4 rounded. A6 yellowish brown, cylindrical. A7 yellowish brown, greatly constricted basally and gradually enlarged towards truncated apex; A8 similar to A7 but shorter and beveled at apex.

Male genitalia (Figs 17–21). Genital bulb yellowish brown, long elliptical. Epandrium broad and tapering towards apex, with deep O-shaped emargination and



Figs 25–33. *Neopanorpa zhengyucheni* sp. nov. 25, 27–31 – male; 26, 32, 33 – female. 25, 26 – habitus, dorsal view; 27 – abdomen, left-lateral view; 28, 29 – genital bulb, ventral and dorsal views, respectively; 30, 31 – aedeagal complex, ventral and right-lateral views, respectively; 32 – subgenital plate, ventral view; 33 – medigynium, ventral view.

forming pair of finger-like processes laterally, epandrial lobes small. Hypandrium with greatly shortened basal stalk, split into pair of hypovalves and lacking hypandrial processes. Hypovalves approximately three times as long as basal stalk of hypandrium, parallel, and bifurcated into pair of finger-like processes terminally, with inner branch short, outer branch longer and greatly curled inward. Gonocoxites slightly beveled apically. Gonostyli slightly shorter than gonocoxites, with basal process and median tooth greatly elongated; median tooth shortly bifurcated terminally into two pointed apices. Parameres bifurcated subbasally; basal stalk fused basally; ventral branch approximately 4/5 times as long as dorsal branch, enlarged subbasally and greatly tapering into pointed apex; dorsal branch similar in shape but slightly sinuate, with distal 1/3 stretching into groove between basal lobe and median tooth of gonostyli; both branches covered with numerous microtrichia along distal half of outer margin. Ventral aedeagal valves pale with subacute apex; dorsal aedeagal valves greatly elongated with acute apex, and slightly convergent; dorsal processes greatly elongated and broad, with subtriangular, acute process in middle of inner margin, and 10–12 long stout setae on distal half of inner margin; lateral processes elongated posteriorly; dorsal bridge slender and connected to base of lateral processes.

Female. Similar to males in general appearance but with greatly reduced, spot-like pterostigmal band in pterostigmal area (Fig. 12). *Female genitalia* (Figs 22–24). Subgenital plate broadly oval, with V-shaped terminal emargination and long stout setae on distal portion. Medigynium with main plate greatly developed, subtrapezoidal and constricted in distal 1/3; posterior arms approximately half as long as main plate, greatly twisted subbasally, and subacute apically; axis completely concealed in main plate with apodemes closely aligned.

Etymology. The specific epithet is dedicated to my friend Mr. Chao Wu for collecting the type specimens.

Distribution. Indo-Malayan Realm: China: Tibet (Cona) (Fig. 1).

Neopanorpa zhengyucheni Wang, sp. nov.

(Figs 25–33)

Type material. Holotype: ♂, **CHINA: Tibet:** Shigatze Prefecture, Yadong County, Kambu Maqu (Yadong River), 27°19′47″N, 89°00′06″E, 2250 m, 05.viii.2020, leg. Yu-Chen Zheng (DALU). Paratype: 1 ♀, same data as the holotype (DALU).

Diagnosis. This new species is greatly similar to *N. tibetensis* Hua & Chou, 1999 and *N. xingmini* Wang & Hua, 2019, but can be readily differentiated from them by the immaculate wings (*versus* with greatly developed markings), and the shorter (slightly exceeding T4) notal organ on T3 (*vs*. longer, exceeding T5).

Description. ***Measurements*** (mm). *Male* (holotype). AtL 13.8, AbL 14.4, BL 18.6, FL 15.6, FW 3.3, HL 13.3, HW 3.2. *Female* (paratype). AtL 12.5, AbL 7.0, BL 11.1, FL 13.8, FW 2.8, HL 12.5, HW 2.7.

Male. *Head* (Fig. 25). Vertex, ocellar triangle and occiput shining black. Rostrum dark brown with genal area yellowish brown, maxillae and labial palps yellowish brown with dark apices. Antennae black with 42–44 flagellomeres.

Thorax (Fig. 25). Pronotum dark brown and lacking stout setae along anterior margin. Meso- and metanotum mostly dark brown with large yellowish brown spot on each side of hind portion. Legs and pleura yellowish brown with apex of tibia and distal tarsomeres blackish.

Wings (Fig. 25). Narrow basally with rounded apex. Membrane hyaline and strongly tinged with reddish brown; markings entirely reduced; pterostigma light brown; veins mostly brown with distal cross-veins whitish. Forewing Sc extending to pterostigmal area; R_1 simple; Rs five-branched with R_2 simple; M_4 greatly bent at m-cu; 1A ending far before origin of Rs (ORs); one cross-vein between 1A and 2A. Hindwings similar to forewings with more reduced markings.

Abdomen (Figs 25, 27). T1–T5 yellowish brown, S1–S5 light yellowish brown. Notal organ on T3 extending slightly beyond caudal margin of T4, stick-like and greatly raising dorsad in distal 2/3; postnotal organ on T4 rounded. A6 mostly yellowish brown and blackish at lateral base and apical margin, cylindrical. A7 yellowish brown with blackish apical margin, greatly constricted basally and gradually enlarged towards truncated apex; A8 similar to A7 but shorter and beveled at apex.

Male genitalia (Figs 28–31). Genital bulb yellowish brown, long oval. Epandrium long, slightly tapering towards truncated apex with strong epandrial lobes. Hypandrium with subtrapezoidal long basal stalk and split into pair of slightly shorter hypovalves. Hypovalves greatly curved, with earlobe-like hypandrial processes at inner base and forming subcircular area basally. Gonocoxites darkened apically; gonostyli slender and slightly longer than half length of gonocoxites, with rounded basal process. Paramere arcuate, simple; stalk broad and slightly fused basally; dorsal bridge short and broad. Ventral valves greatly sclerotized along inner margin and acutely projected basally; dorsal valves short; dorsal processes greatly constricted basally and enlarged distally, waterdrop-like postero-dorsad, slightly exceeding ventral valves in ventral view.

Figs 34–35. Type locality of *Neopanorpa liuxingyuei* sp. nov. and *N. zhengyucheni* sp. nov. (taken by Yu-Chen Zheng). 34 – Kambu Maqu (Yadong River); 35 – dense vegetation along the river bank.

***Female*.** Similar to males in general appearance (Fig. 26). *Female genitalia* (Figs 32, 33). Subgenital plate long and suboval, with shallow V-shaped emargination apically and long stout setae marginally. Medigynium with axis slightly shorter than half of total length, parallel apodemes densely sclerotized; posterior arms slightly longer than axis, distinctly twisted subbasally and slightly spatulate in apical half.

Etymology. This species is named in honor of my friend Mr. Yu-Chen Zheng for collecting the type specimens.

Distribution. Indo-Malayan Realm: China: Tibet (Yadong) (Fig. 1).

Like in *N. liuxingyuei* sp. nov., this species is also highly possible to occur in northwestern Bhutan.

Discussions

By adding three new species, the number of *Neopanorpa* species (same for Panorpidae) from the Himalayas and adjacent regions has increased from 18 to 21 (Fig. 1). Like many other scorpionflies, these species inhabit dense vegetation in moist and mountainous regions. For example, *N. chillcotti* was found on low shrubs or shaded herbs at the edge of broad-leaved forest mixed with coniferous trees from Gyirong, Tibet (Wang & Hua 2017b); and *N. liuxingyuei* sp. nov. and *N. zhengyucheni* sp. nov. were captured on the dense vegetation along the Kambu Maqu (Yadong River) from Yadong, Tibet (Figs 34, 35).

Morphologically, most species in this region can be categorized into three groups: 1) the *N. chillcotti* group; 2) the *N. furcata* group; and 3) the *N. pielina* group (sensu Wang & Hua 2021, named after *N. pielina* Navás, 1936). The *N. chillcotti* group includes eleven species: *N. benaci*, *N. chillcotti*, *N. contracta*, *N. effusa*, *N. flava*, *N. hushengchangi*, *N. nipalica*, *N. ramulata*, *N. wittmeri*, *N. liuxingyuei* sp. nov., and *N. wuchaoi* sp. nov., characterized by the male hypandrium lacking hypandrial lobes. *Neopanorpa chillcotti* is supported to be the sister taxon of all the other examined species of *Neopanorpa* in recent molecular analyses (Hu et al. 2015, Miao et al. 2019). However, systematic positions of the other species in the Himalayas and adjacent regions remain largely unknown to date. Due to the lack of the hypandrial lobes, eleven species in the *N. chillcotti* group differ from most species in *Neopanorpa*, but they are similar to *Leptopanorpa* MacLachlan, 1875 from Indonesia (Lieftinck 1936; Wang & Hua 2020, 2021). Therefore, the *N. chillcotti* group likely merits a generic status but still needs more research (Wang & Hua 2021).

The *N. furcata* group includes only two species: *N. cornuta* and *N. furcata*, characterized by the male bearing a pair of subapical claws on dorsal apex of A6. Their systematic positions are not fully resolved (Wang & Hua 2021). The *N. pielina* group includes four species in this region: *N. lifashengi*, *N. ochrura*, *N. tibetensis*, and *N. zhengyucheni* sp. nov., characterized by the poorly developed main plate, and the very long axis and posterior arms in the female medigynium. *Neopanorpa lifashengi* and *N. ochrura* are obviously related to some species from northeastern Myanmar (e.g., *N. malaisei* Byers, 1999 and *N. pennyi* Byers, 1999) and western China (e.g., *N. nigritis* Carpenter, 1938). *N. tibetensis* and *N. zhengyucheni* sp. nov. closely resemble *N. xingmini* Wang & Hua, 2019 (China: Yunnan) and *N. normpennyi* Bicha, 2019 (Thailand: Kamphaeng Phet).

Two Indian species, *N. fenestrata* and *N. sordida*, are difficult to place to any of these groups due to their poorly known morphology. *Neopanorpa gibbosa* is unique due to the males bearing humped dorsal apex of A6, numerous long curved setae on dorsal apex of A7, a median projection on epandrium subapically, and it is also unmatched with the previous groups. *Neopanorpa ocellaris* was originally described from Sikkim, together with *N. cavaleriei* (Navás, 1908) in the same article. Recently, *N. ocellaris* was reported from Guizhou and Guangxi, southwest China, and co-occurred with *N. cavaleriei* in Libo County, Guizhou, China (Wang & Hua 2019a). Therefore, the disjunctive distribution of *N. ocellaris* (Sikkim and southwestern China) raises a doubt that Navás (1908) might have somehow erroneously reported this species from Sikkim. Future expeditions are expected to obtain more materials to solve this problem.

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