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Chewing lice (Phthiraptera) of the Grey-headed Lapwing *Vanellus cinereus* in China

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Two species of chewing lice (Phthiraptera) were collected from seven Grey-headed Lapwings *Vanellus cinereus* (Blyth, 1842), caught in Jinshanyakou, Yunnan Province, China. They are *Actornithophilus hoplopteri* (Mjöberg, 1910a) and *Quadraceps sinensis* Timmermann, 1954a. Both species represent new records for China and *V. cinereus* represents a new host record for *A. hoplopteri*. As neither species has previously been adequately described, we here present illustrations and descriptions of both species, as well as short notes on the microhabitat of both species.

Keywords

Actornithophilus

Quadraceps

Charadriiformes

redescription

INTRODUCTION

Shorebirds (Charadriiformes) have among the best explored host-associations with chewing lice (Phthiraptera) of any group of birds. This is primarily due to a long series of studies by Timmermann (*e.g.* 1952a, b, c, 1953a, b, 1954a, b, c, d, 1974), but also studies by *e.g.* Clay (1949, 1959, 1962, 1981), Gustafsson & Olsson (2012), Hopkins & Timmermann (1954), Martens (1974), and Ward (1955). However, most of the louse species known from shorebirds have been cursorily described and only partially illustrated. Often, most of the descriptive text and illustrations concern only the male genitalia, and females of these species are thus impossible to identify without direct comparison with type specimens. Moreover, as the descriptive text often only denotes measurements or characters that are of dubious taxonomic value at the species level, even identifications of male specimens may be difficult.

We caught a small number of Grey-headed Lapwings *Vanellus cinereus* during ringing of migratory birds in Jinshanyakou, Yunnan Province, China. Two species of chewing lice were recovered from these birds: *Actornithophilus hoplopteri* (Mjöberg, 1910a) and *Quadraceps sinensis* Timmermann, 1954a. Both these species represent new records for China, and *V. cinereus* is a new host record for *A. hoplopteri*. No complete and adequate illustrations or descriptions have been published for either of these species, and we therefore take the opportunity to redescribe both species in detail here. We hope these redescriptions will arouse some interest in the chewing lice of shorebirds among researchers working with lapwings and other charadriiforms. The corresponding author would gladly help with identification or redescription of lice collected from any charadriiform host.

Lice in the genus *Actornithophilus* are known to be quill-boring (*e.g.* Paterson 1954, Clay 1962, Price & Leibovitz 1969). That means that they spend at least some of their lives inside the quills of primary feathers. This lifestyle is very rare in avian chewing lice and the implications for co-evolution of species of *Actornithophilus* and their hosts are poorly understood. As the host associations of *A. hoplopteri* are not well known, we hope our detailed redescription of this species here will facilitate future studies into the *Actornithophilus* species of lapwings.

METHODS

The collection locality and methods for catching birds and collecting parasites, as well as our preparation of slide-mounted specimens, has been described by Gustafsson *et al.* (2019). Grey-headed Lapwings were caught by mist-netting in front of colour lights during night-time migration over a mountain pass in Jinshanyakou, Yunnan (Zhao *et al.* 2014). All birds were examined for lice immediately after capture. Birds were fumigated with ethyl acetate in plastic Ziploc® bags, following the procedure outlined in Gustafsson *et al.* (2019). Due to the size of the lapwings, fumigation was not an efficient method of collecting lice, and all birds therefore had to be examined manually following fumigation.

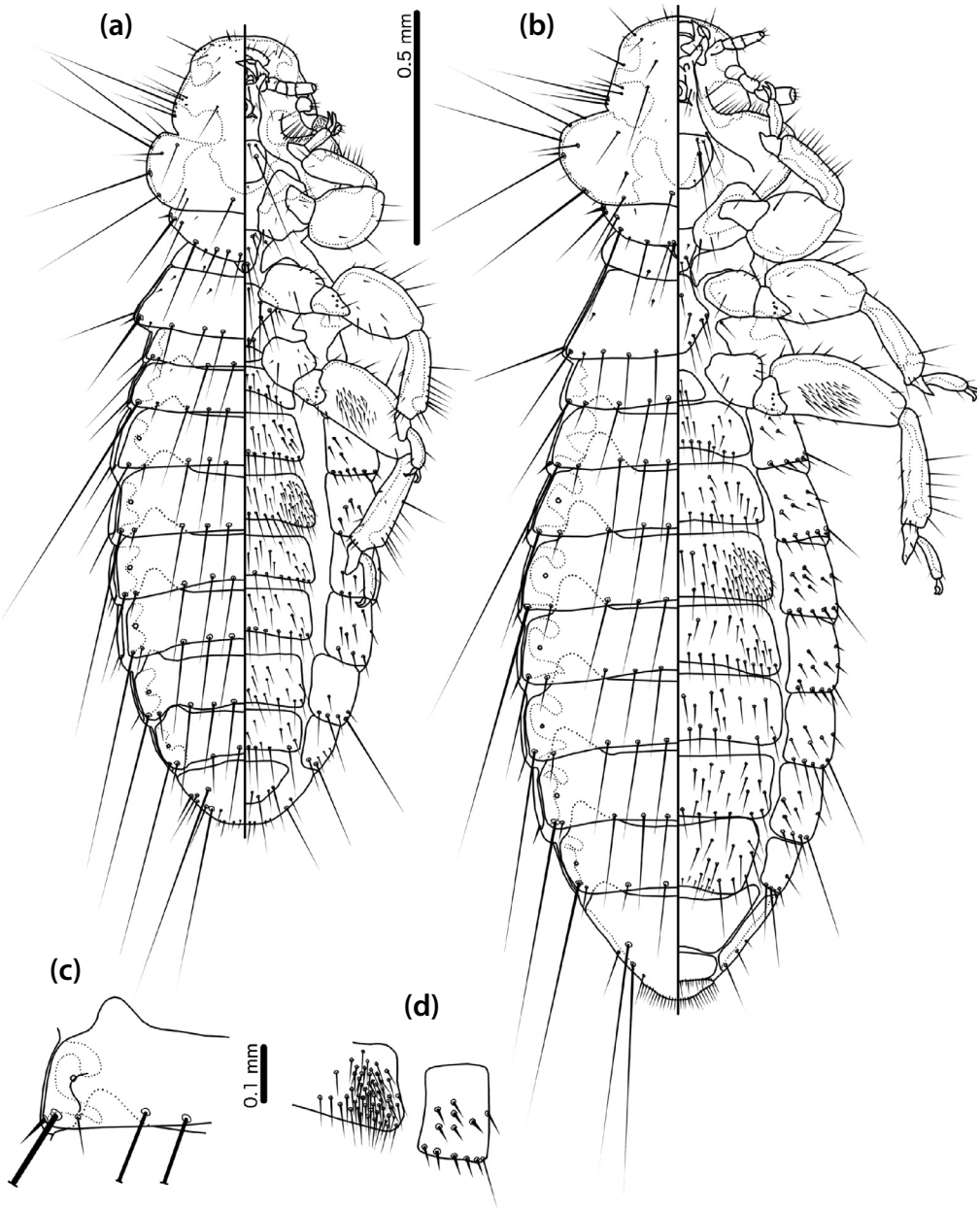

Fig. 1. *Actornithophilus hoplopteri* (Mjöberg, 1910a). **(a)** Male habitus, dorsal and ventral view. **(b)** Female habitus, dorsal and ventral views. **(c)** Female tergite IV, dorsal view. **(d)** Female sternite and pleurites IV, ventral view.

Manual examination focused on the wings, back, rump, flanks, neck and head of the birds, roughly in that order. Feathers were lifted carefully with forceps, and any louse seen was collected with other forceps. In addition, lice seen crawling across the plumage were collected whenever possible. As birds were mainly examined manually, there is a risk that some lice on each bird were overlooked. We therefore did not calculate intensity or abundance of lice for either louse species.

Preparation of slides followed Gustafsson *et al.* (2019). All specimens are stored at the Guangdong Institute for Applied Biological Resources, Guangzhou, Guangdong, China (GIABR). Specimens of *Actornithophilus* were identified using the key of Clay (1962); specimens of *Quadraceps* were compared to the original description (Timmermann 1954a). Terminology for morphological and setal characters and abbreviations thereof follow Clay (1969) for *Actornithophilus,* and Gustafsson & Olsson (2012) and Gustafsson & Bush (2017) for *Quadraceps*. Note that Clay (1962, 1969) used different terminology for amblyceran head setae (Table 1). As her terminology in Clay (1969) has been followed by most workers after 1969, we follow this terminology unless otherwise noted, but provide Table 1 to help interpret these differences between Clay (1969) and our treatment and the key to *Actornithophilus* she published in Clay (1962). Many setae and sensilla were not explicitly named by Clay (1969). As a more thorough examination of variation within the Menoponidae is needed to establish homologies and suitable names for these, we do not propose any new terms for head chaetotaxy here.

Specimens of lice were examined in a Nikon Eclipse N*i* microscope (Nikon Corporation, Tokyo, Japan), and illustrations drawn by hand with the aid of a fitted drawing tube. Illustrations were scanned, then compiled and edited in software GIMP (*www.gimp.org*). Measurements (all in mm) were made from live images in NIS-Elements (Nikon Corporation, Tokyo, Japan) for the following dimensions: AW = abdominal width (at segment IV in *Actornithophilus* and segment V in *Quadraceps*); GL = genital length (for *Actornithophilus*; at midline, including all genitalic elements); HL = head length (at midline); HW = head width (at temples); PANW = pre-antennal width (for *Actornithophilus*); MSW = mesothoracic width (for *Actornithophilus*); MTW = metathoracic width (for *Actornithophilus*); PRW = prothoracic width; PTW = pterothoracic width (for *Quadraceps*; represents the fused meso- and metathorax); TL = total length (along midline). Fine dotted lines in figures show approximate extent of dark pigmentation. However, this varies slightly between specimens and should only be taken as a rough guide.

RESULTS

A total of seven Grey-headed Lapwings were caught during 10–16 Sep 2018 in Jinshanyakou, Yunnan Province, China. Of these, four birds (57%) were parasitized by *Actornithophilus hoplopteri* (9 males, 10 females, 8 nymphs), and one bird (14%) was parasitized by *Quadraceps sinensis* (6 males, 3 females). The only bird parasitized by *Q. sinensis* was also parasitized by *A. hoplopteri*. A third species of chewing louse known from this host, *Saemundssonia africana* Timmermann, 1951 (Price *et al.* 2003), was not recovered in Yunnan. Some of the collected specimens have been retained in 95% ethanol for future DNA studies. The other specimens were slide-mounted and are redescribed below.

***Actornithophilus hoplopteri* (Mjöberg, 1910a)**

(Figs. 1–2)

Colpocephalum hoplopteri Mjöberg, 1910a: 40.

Actornithophilus hoplopteri (Mjöberg, 1910a); Hopkins & Clay 1952: 21.

Actornithophilus hoplopteri maculosus Carriker, 1963: 294.

Actornithophilus hoplopteri peruvianus Carriker, 1963: 295.

Type host: *Vanellus spinosus* Linnaeus, 1758 – Spur-winged Lapwing.

Description. ***Both sexes.*** Pre-antennal head relatively slender, temples broader, but differing in shape between sexes (Fig. 1–2); frons somewhat flattened. Head nodi prominent (Fig. 2a). Head chaetotaxy as in Fig. 2a; head seta *20* and head sensilla *a, e* not visible in examined specimens; dorsal head seta *a* (*sensu* Clay 1962) spine-like. Last segment of antennae with clear, dense annulation. Hypopharyngeal sclerite reduced (Fig. 2b). Subocular row of setae with 18–20 setae; 1–2 of the later setae in this row are markedly shorter and slenderer than the rest. Thoracic and abdominal segments as in Fig. 1. Anterior processes prominent on tergopleurites II–VIII (Fig. 1a–c). Anterior tergal setae absent on all segments in all examined specimens of both sexes. Tergopleurites II–VII with setal pattern A (three setae of more or less equal length on each side). Anterior setae absent on terminal segment of both sexes. Post-spiracular setae on tergopleurites III and V markedly shorter than those of segments II and IV. Sternal setae of both sexes variable in number and position between specimens of both sexes; a representative distribution of setae is illustrated here.

Males. Femur III with 31–33 setae in setal patch. Sternite IV with 39–47 setae in setal patch on each side. Male genitalia as in Fig. 2c. Basal apodeme short. Distal mesosome flaring distinctly. Central section of genital sclerite diffuse in examined males, and here illustrated approximately. Measurements as in Table 2.

Table 1. Differences in head chaetotaxy terminology between Clay (1962) and Clay (1969). We followed Clay (1969) exclusively. Researchers wishing to use Clay's (1962) key to the species of *Actornithophilus* will need to translate the setal nomenclature.

Clay's (1962) key to Actornithophilus	Clay's (1969) key to Menoponidae
Head seta a	Unnamed
Head seta b	Unnamed
Head seta c	*Head seta 16*
Head seta d	*Head seta 18*
Head seta e	*Head seta 23*
Head seta f	*Head seta 22*
Head sensilla 2	*Head sensilla b*
Head sensilla 3	*Head sensilla c*
Head sensilla 4	*Head sensilla d*

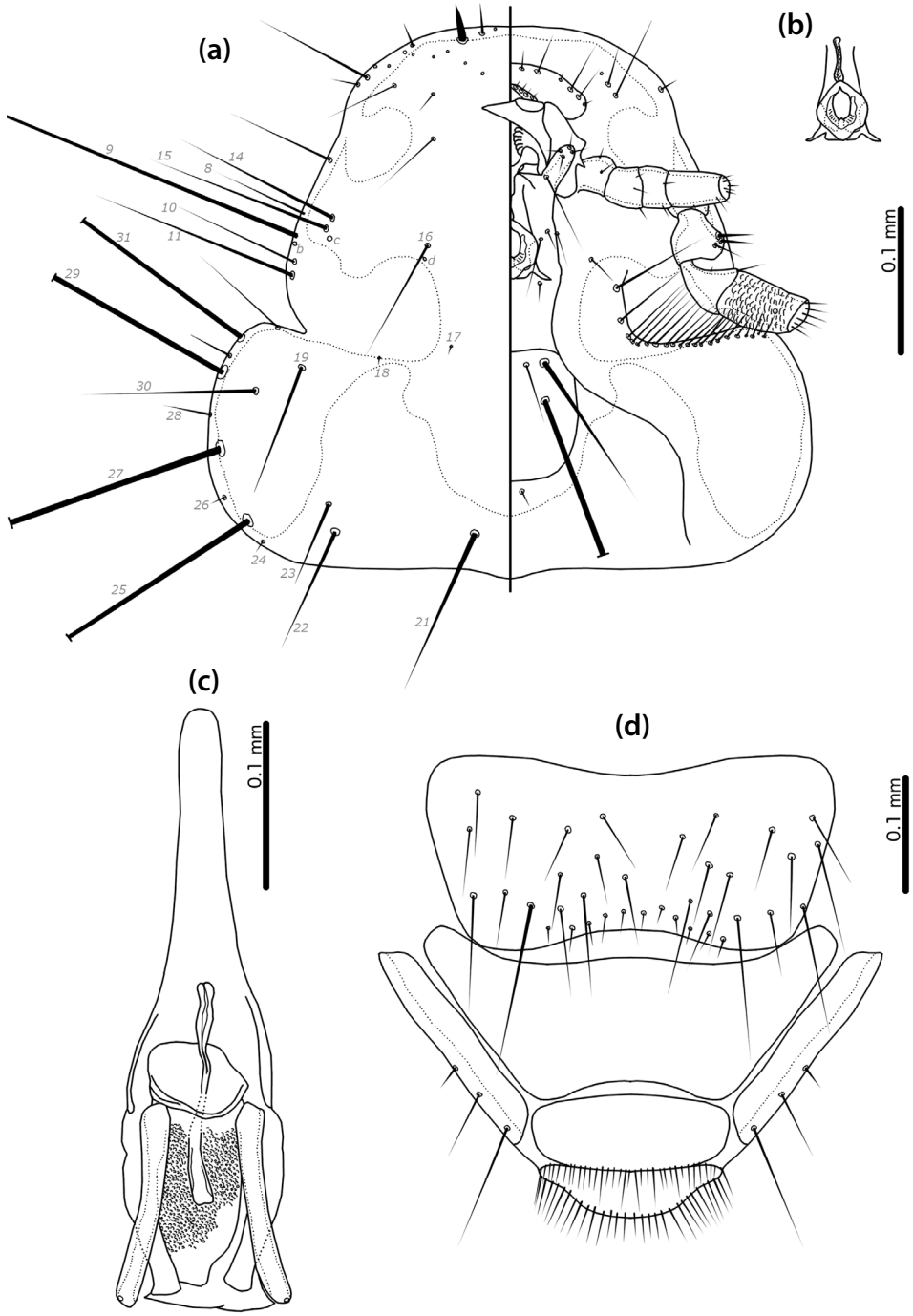

Fig. 2. *Actornithophilus hoplopteri* (Mjöberg, 1910a). **(a)** Male head, dorsal and ventral views. **(b)** Male hypopharyngeal sclerite, ventral view (same scale as head). **(c)** Male genitalia, ventral view. **(d)** Female terminalia, ventral view. Longer setae have been cut off in illustration. Numbers (in grey) in Fig. 2a correspond to setal numbers, following Clay (1969), which differ from those of Clay (1962). See Table 1 for more detail. Note that Clay (1969) did not specify which setae represent setae 1–7. Anterior sensilla, some dorsal setae and all ventral setae and sensilla were also not numbered in Clay (1969).

Females. Femur III with 35–39 setae in setal patch. Sternite IV with 52–59 setae in setal patch on each side (Fig. 1d). Terminalia as in Fig. 2d; dorsal vulval fringe with 30–34 setae; ventral vulval fringe with 34–39 setae; ventral setae shorter and more slender than dorsal setae, but 4–6 ventral setae much longer than others. Measurements as in Table 2.

Specimens examined. 3♂, 4♀, Jinshanyakou, elev. 2360 m, Zhenyuan County, Yunnan Province, China, 11 Sep 2018, leg. D.R. Gustafsson & L. Lei, bird ID J-3793, louse IDs GD-PHTH-00001–7. 1♂, 3♀, same data as previous except bird ID J-3794, louse IDs GD-PHTH-00008–11. 2♀, same data as previous except bird ID J-3798, louse IDs GD-PHTH-00012–13.

Remarks. Since its original description (Mjöberg 1910a), *Actornithophilus hoplopteri* has been reported many times from various hosts (*e.g.* Timmermann 1954b, Clay 1962, Carriker 1963, McClure *et al.* 1973, Złotorzycka *et* al. 1999, Özkan *et al.* 2017), but has never been thoroughly described or illustrated. Some of these records may thus be erroneous, but we have not examined material from outside China to establish this. To our knowledge, this is the first report of *A. hoplopteri* from *V. cinereus*.

Mjöberg's (1910a) original description is inadequate, and the only illustration provided is of the female abdomen without any setae. The only subsequent illustration of this species is that of Carriker (1963), who described two new subspecies of *A. hoplopteri*; these subspecies were considered synonyms of the nominate subspecies by Price *et al.* (2003). The abdominal chaetotaxy in these illustrations differs from that described by Clay (1962) and found in our specimens. This suggests either that Carriker's illustrations are erroneous, that the chaetotaxy is variable, or that the Neotropical hosts he examined are parasitized by a different species of *Actornithophilus*. Carriker's (1963) illustration of the male genitalia does not show the prominent postero-lateral extensions of the mesosome found in our specimens. This may strengthen the suggestion that more than one species of *Actornithophilus* is involved, and that the synonymy of Carriker's species with *A. hoplopteri* may be unwarranted.

The type host species of *A. hoplopteri* is African (Mjöberg 1910a), and thus extralimital to our field of study. In light of the variation in this species mentioned by Clay (1962) and the differences between Carriker's (1963) material and ours discussed above, our redescription and illustration of this species should therefore be seen as provisional. Ultimately, a thorough revision of *Actornithophilus* is needed to establish whether the populations on different host species are conspecific. However, such a revision is outside the scope of the present study.

***Quadraceps sinensis* Timmermann, 1954a**

(Figs. 3–4)

Quadraceps sinensis Timmermann, 1954a: 203.

Type host: *Vanellus cinereus* (Blyth, 1842) – Grey-headed Lapwing.

Description. ***Both sexes.*** Head shape as in Fig. 4a; pre-antennal area elongated, hyaline margin wide. Marginal carina interrupted medianly and laterally near site of *as1*. Ventral anterior plate not clearly visible, and not illustrated. Dorsal anterior plate widens anteriorly, and lacks posterior projection. Dorsal pre-antennal suture completely surrounds dorsal anterior plate and continues posteriorly along midline. Head chaetotaxy as in Fig. 4a; *pos* located behind eye; head sensilla not visible in examined specimens. Gular plate with distinct translucent fenestra in central section. Thoracic and abdominal segments, chaetotaxy and pigmentation patterns as in Fig. 3; anterior setae of segment II very short in both sexes.

Table 2. Measurements of the species redescribed here. See *Methods* for definitions of morphometric abbreviations.

	Actornithophilus hoplopteri		*Quadraceps sinensis*	
	Male (*n* = 4[1])	**Female (*n* = 9[2])**	**Male (*n* = 4[3])**	**Female (*n* = 2[4])**
TL	1.66–1.74	1.93–2.12	1.74–1.79	–
Head				
HL	0.37–0.38	0.28–0.41	0.48–0.52	0.53–0.54
HW	0.39–0.47	0.41–0.53	0.32–0.35	0.37
PANW	0.24–0.30	0.29–0.41	–	–
Thorax				
MSW	0.29–0.37	0.33–0.42	–	–
MTW	0.44–0.47	0.52–0.53	–	–
PRW	0.32–0.33	0.33–0.38	0.22–0.23	0.21–0.24
PTW	–	–	0.30–0.31	–
Abdomen				
AW	0.53–0.57	0.68–0.71	0.29–0.42	0.47
GL	0.53–0.58	–	–	–

[1] *n* = 2 for TL and PANW, and *n* = 3 for HL and GL.
[2] *n* = 5 for TL, *n* = 8 for MSW, and *n* = 7 for MTW.
[3] *n* = 2 for PTW.
[4] TL and PTW not measurable due to dissection of specimens.

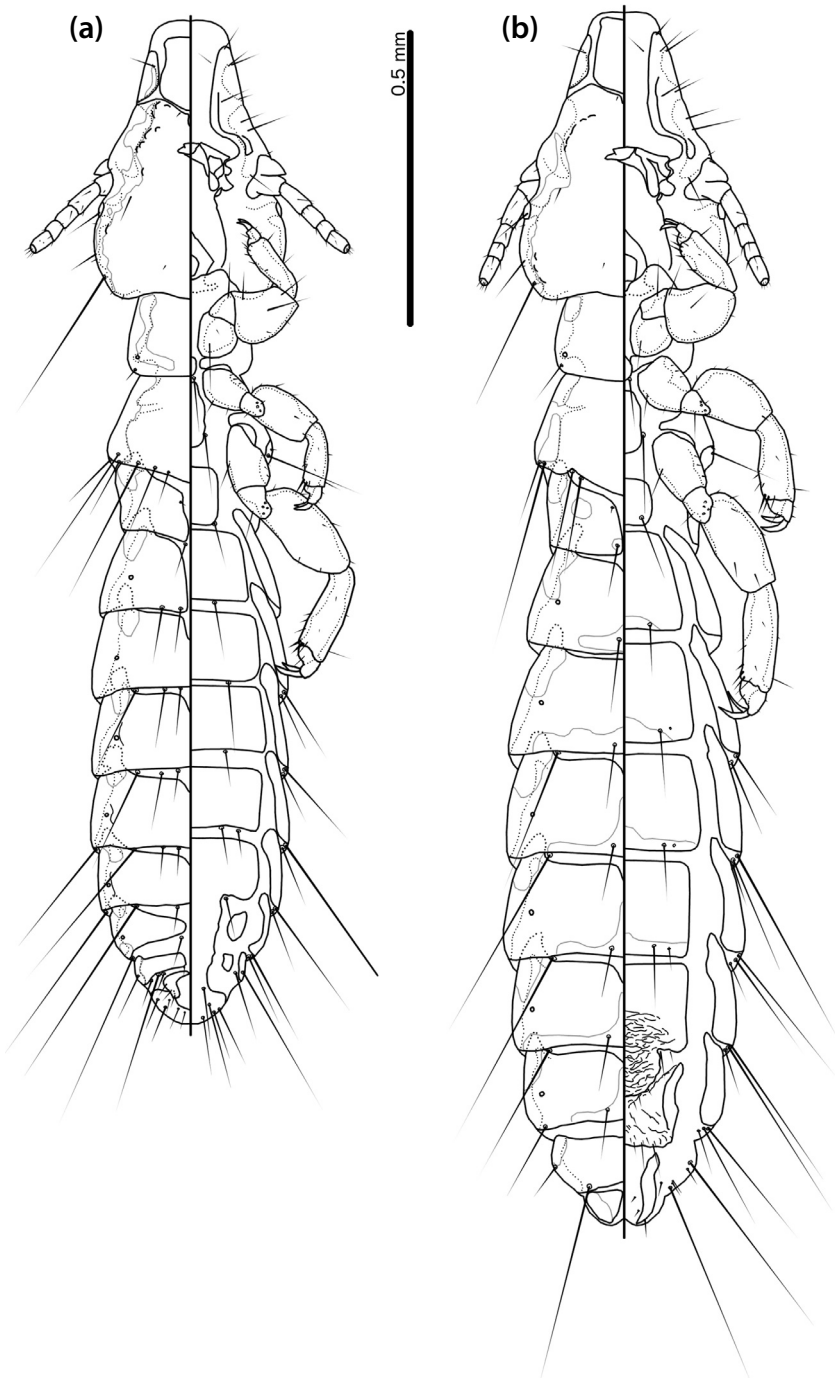

Fig. 3. *Quadraceps sinensis* Timmermann, 1954a. **(a)** Male habitus, dorsal and ventral view. **(b)** Female habitus, dorsal and ventral views.

Male. Tergopleurites II–III and VIII–XI+X interrupted medianly, tergopleurites IV–VII medianly continuous, but with median indentation in anterior end. Basal apodeme indistinct in anterior end in all examined specimens (Fig. 4b). Lower endomere not visible. Mesosome as in Fig. 4b–c. Postero-lateral projections of mesosome seemingly hardened, endophallus soft. Chaetotaxy: two spike-like setae on ventral surface on each side in middle of postero-lateral projections; one anterior pore on ventral surface on each side may support microsetae, but none visible. Parameres as in Fig. 4d, distal end significantly less sclerotized. Measurements as in Table 2.

Female. The thoracic segments of both examined females were partially destroyed during the slide mounting process, and have here been reconstructed based on what is clearly visible. Tergopleurites II–III interrupted medianly, IV–IX+X medianly continuous, but IV–VIII with median indentation in anterior end. Subgenital plate seemingly divided into two parts: a proximal, faintly reticulated section on segment VII–VIII, and a less well sclerotized section covering most of VIII and the anterior end of IX+X. These sections appear to be separated by a narrow gap, but the gap is irregular in shape, and the distal section is poorly sclerotized; the exact

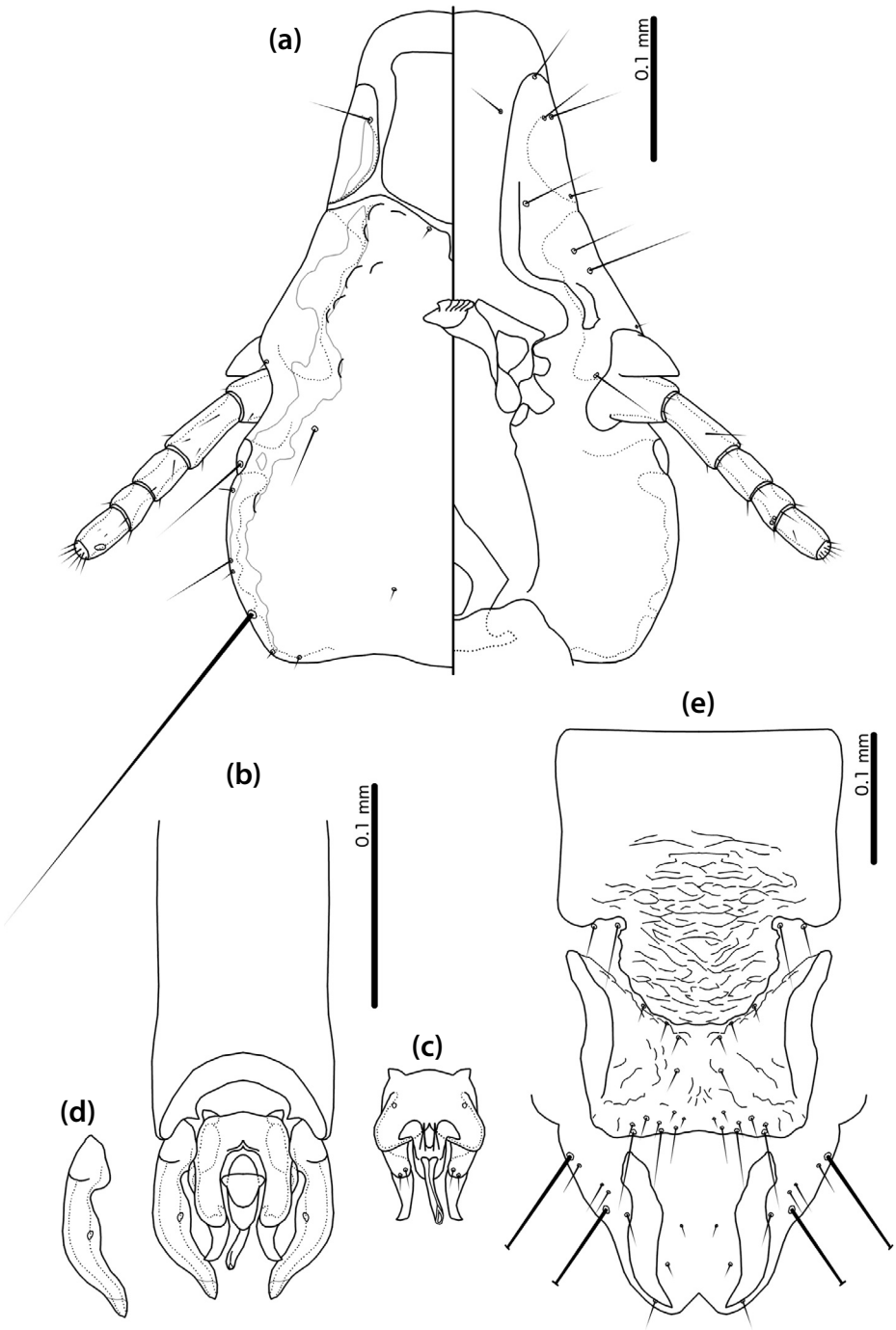

Fig. 4. *Quadraceps sinensis* Timmermann, 1954a. **(a)** Male head, dorsal and ventral views. **(b)** Male genitalia, dorsal view. **(c)** Male mesosome, ventral view. **(d)** Male parameres, dorsal view. **(e)** Female terminalia, ventral view.

nature of this gap is therefore hard to assess, and has been illustrated as close as possible to what is seen in the specimens. Chaetotaxy of subgenital plate and vulval margin as in Fig. 4e, more or less similar between the two specimens, but setae in oblique rows differ in numbers (3–5) between specimens. Measurements as in Table 2.

Specimens examined. 4♂, 2♀, Jinshanyakuo, elev. 2360 m, Zhenyuan County, Yunnan Province, China, 11 Sep 2018, leg. D.R. Gustafsson & L. Lei, bird ID J-3793, louse IDs GD-PHTH-00014–19.

Remarks. To our knowledge, this is only the second report of *Quadraceps sinensis*, the first being its original description by Timmermann (1954a). Moreover, despite its name, this is the first record from China, as the original description was based on specimens collected in Nepal and Japan. Timmermann (1954a) did not examine any females of this species, which is here illustrated for the first time.

DISCUSSION

Accurate assessments of population status and host associations

Table 3. Host associations of lice in the genera *Actornithophilus* and *Quadraceps* on lapwings. For simplicity, host subspecies are not listed. Abbreviations used: *A.* = *Actornithophilus*; *Q.* = *Quadraceps*; *V.* = *Vanellus*. No lice of these two genera are known from hosts marked with dashes (–).

Host species	Louse species
White-headed Lapwing *V. albiceps*	*A. hoplopteri* (Mjöberg, 1910) *Q. eggelingi* Timmermann, 1954a
Blacksmith Lapwing *V. armatus*	*A. hoplopteri* (Mjöberg, 1910) *Q. chorleyi* Timmermann, 1954a *Q. geminus* Timmermann, 1958
Pied Lapwing *V. cayanus*	*Q. hasei* Timmermann, 1954a
Southern Lapwing *V. chilensis*	*A. gracilis* (Piaget, 1880) *Q. guimaraesi* Timmermann, 1954a
Grey-headed Lapwing *V. cinereus*	*A. hoplopteri* (Mjöberg, 1910) *Q, sinensis* Timmermann, 1954a
Crowned Lapwing *V. coronatus*	*A. crinitus* Clay, 1962 *Q. kilimandjarensis* (Kellogg, 1910)
Long-toed Lapwing *V. crassirostris*	*A. hoplopteri* (Mjöberg, 1910) *Q. hancocki* Timmermann, 1954a
River Lapwing *V. duvaucelii*	*A. hoplopteri* (Mjöberg, 1910) *Q. hoplopteri* (Mjöberg, 1910)
Sociable Lapwing *V. gregarius*	*A. ochraceus* (Nitzsch, 1818) *Q. kilimandjarensis* (Kellogg, 1910)
Red-wattled Lapwing *V. indicus*	*A. hoplopteri* (Mjöberg, 1910) *Q. dasi* Tandan, 1952
White-tailed Lapwing *V. leucurus*	*A. hoplopteri* (Mjöberg, 1910) *Q. grallarius* Timmermann, 1954a
Senegal Lapwing *V. lugubris*	*Q. kilimandjarensis* (Kellogg, 1910)
Javan Lapwing *V. macropterus*	–
Yellow-wattled Lapwing *V. malabaricus*	–
Spot-breasted Lapwing *V. melanocephalus*	–
Black-winged Lapwing *V. melanopterus*	*A. hoplopteri* (Mjöberg, 1910) *Q. kilimandjarensis* (Kellogg, 1910)
Masked Lapwing *V. miles*	*A. hoplopteri* (Mjöberg, 1910) *Q. renschi* Timmermann, 1954a *Q. rheinwaldi* Timmermann, 1969
Andean Lapwing *V. resplendens*	*A. hoplopteri* (Mjöberg, 1910) *Q. incai* Timmermann, 1954a *Q. parabolicus* (Eichler [in Niethammer], 1953)
Wattled Lapwing *V. senegallus*	*A. hoplopteri* (Mjöberg, 1910) *Q. kilimandjarensis* (Kellogg, 1910)
Spur-winged Lapwing *V. spinosus*	*A. hoplopteri* (Mjöberg, 1910) *Q. hoplopteri* (Mjöberg, 1910)
Brown-chested Lapwing *V. superciliosus*	–
Black-headed Lapwing *V. tectus*	*Q. kilimandjarensis* (Kellogg, 1910)
Banded Lapwing *V. tricolor*	*A. hoplopteri* (Mjöberg, 1910) *Q. australis* Emerson & Price, 1986
Northern Lapwing *V. vanellus*	*A. gracilis* (Piaget, 1880) *Q. junceus* (Scopoli, 1763)

of parasites require adequate descriptions and illustrations so that specimens can be identified with confidence. Unfortunately, for many species of lice parasitizing shorebirds, only partial illustrations have been published, typically including only the male genitalia. Females and males with destroyed or obscured genitalia are therefore difficult to identify without direct comparison with type material. The majority of the louse species known from shorebirds are in need of better, more detailed redescriptions. In many cases fresh collections are needed to properly assess species limits.

This is not least the case with species like *A. hoplopteri*, which purportedly occur on multiple host species across the world (Price *et al.* 2003; Table 3). Clay (1962) noted that there are some morphological differences between specimens of this species taken from different hosts, and Carriker (1963) described two Neotropical populations as distinct subspecies. More specimens are needed to assess these different viewpoints. We would gladly receive louse specimens from other lapwing species. Both louse species redescribed here, as well as head lice in the genus *Saemundssonia* that are also known from lapwings, can be collected manually from the host, using forceps. However, *Actornithophilus* lice can move rather quickly, and collection of lice in this genus will require some training. Lice in the genus *Actornithophilus* have sometimes been found on the eggs of active nests, including nests of lapwings (Thompson 1936).

Prevalence of lice on Grey-headed Lapwing

We obtained lice in the genus *Actornithophilus* from four of our seven birds (57%), which is similar to the prevalence reported by Özkan *et al.* (2016) from Spur-winged Lapwing *Vanellus spinosus* in Turkey ("about half" of 20 birds). González-Acuña *et al.* (2008) reported a higher prevalence (72%) of *Actornithophilus gracilis* (Piaget, 1880) on Southern Lapwing *Vanellus chilensis* in Chile. However, in all cases species in the genus *Actornithophilus* appear to be rather common on lapwings.

By contrast, we only obtained lice in the genus *Quadraceps* from a single bird (14%), which is much lower than that reported for *Quadraceps guimaraesi* Timmermann, 1954a, on Southern Lapwing (64%; González-Acuña *et al.* 2008). However, González-Acuña *et al.* (2008) examined dead birds and could thus more easily collect all lice living on these host specimens. The differences between their results and ours could therefore partially be due to collection method. Notably, Özkan *et al.* (2016) did not report any species of *Quadraceps* in their samples.

A third species of chewing louse is known from Grey-headed Lapwing: *Saemundssonia africana* Timmermann, 1951. Lice in this genus are normally found on the heads of shorebirds. We examined the heads of all our lapwings but did not recover any specimens of *Saemundssonia*. González-Acuña *et al.* (2008) and Özkan *et al.* (2016) also did not report any specimens of any species of *Saemundssonia*. Mitchell & Dick (1977) reported a prevalence of 25% for *Saemundssonia africana* on Red-wattled Lapwing *Vanellus indicus*. This appears to be the only published prevalence for any species of *Saemundssonia* on lapwings. However, both Ash (1960) and Cabot (1975) have reported prevalences of 20% for *Saemundssonia* sp. on Ringed Plover *Charadrius hiaticula*. This may suggest that lice in the genus *Saemundssonia* are generally rare on charadriid hosts.

Our sample size here is small. However, if the infestation rates we found will hold up when more hosts will be examined, it may suggest that only a minority of the lapwings are parasitized by *Q. sinensis*. The Grey-headed Lapwing is listed as 'Least Concern' but decreasing in the IUCN Red List (BirdLife International 2016). *Actornithophilus hoplopteri*, as currently defined, occurs on a variety of lapwing species across the world (Table 3). Therefore, this species is likely not threatened even if some of its hosts may be. However, a revision of *Actornithophilus* on lapwings may indicate that *A. hoplopteri* comprises a complex of species with more restricted host ranges. If so, some of these may be at least as threatened as their hosts.

Quadraceps sinensis is not known to occur on any other host species than Grey-headed Lapwing. If the populations of *V. cinereus* continue to decline and its conservation status needs to be changed, this probably applies also to *Q. sinensis*. Little is known about the chewing lice of rare hosts, but Bush *et al.* (2013) found that the diversity of chewing lice decreased in fragmented habitats even if the hosts remained common. Chewing lice may thus be more vulnerable than their hosts to local or global extinction; several co-endangered and co-extinct species of chewing lice are known (Rózsa & Vas 2015).

Microhabitat preference

Some species of lice in the genus *Actornithophilus* are known to be quill-boring (*e.g.* Paterson 1954, Clay 1962, Price & Leibovitz 1969), but this has never been confirmed for *A. hoplopteri*. Lice inside quills are accessible only by removing the feathers and cutting them open; this was not done in Jinshanyakou. The entrance holes of *Actornithophilus* are reported to be easily visible towards the base of the quills (Paterson 1954). However, as collection of lice was done at night under suboptimal light conditions, we were unable to confirm whether or not *A. hoplopteri* is quill-boring.

However, adult specimens of *A. hoplopteri* were seen by us running through the host's plumage. Apart from specimens collected through fumigation, all specimens of *Actornithophilus* collected by us were taken with forceps from the ventral side of the primaries or outer secondaries. This is in line with previous reports (*e.g.* Price & Leibovitz 1969) that *Actornithophilus* species occur in, or on, the quills of their hosts. On one bird, *Actornithophilus* were also collected on the back. However, louse collection on this bird had been delayed for some time, and the lice may have moved to the back from the wings while the bird was caught. Paterson (1954) found that the quill-boring *Colpocephalum scopinum* Mjöberg 1910b would emerge from the quills if these were gently warmed. Our collections of *A. hoplopteri* from the plumage of the hosts may thus be a result of handling of the birds.

The microhabitat preferences of lice in the genus *Quadraceps* are poorly known. Johnson *et al.* (2012) included *Quadraceps*

in the 'generalist' category, but the microhabitat choice likely differs between different species of *Quadraceps*. This may particularly be the case in hosts such as some *Charadrius* plovers or *Recurvirostra* avocets that are parasitized by more than one species of *Quadraceps sensu lato* (Timmermann 1953a, Price *et al*. 2003). The *Q. sinensis* collected by us were all taken from the upper rump and back of the bird. None were found on the flanks or chest of the bird. As *Q. sinensis* was only found on one of the birds we examined, little can be said about the habitat preferences of this species based on our data.

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