



Chinese psyllids in the genus *Cacopsylla* (Hemiptera: Sternorrhyncha: Psylloidea) associated with *Spiraea* (Rosaceae)

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ABSTRACT

The Chinese *Cacopsylla* species associated with *Spiraea* are revised. Three new species (*Cacopsylla falcata* sp. nov., *C. nocturna* sp. nov. and *C. qilianensis* sp. nov.) are described, and two [*C. hyalinonemae* Li and Yang, 1989 and *C. spiraeicola* (Li, 2011) comb. nov.] are redescribed. A new combination is also proposed for *Cacopsylla tetrotaenialis* (Li and Yang, 1989) comb. nov. Among the five species, *C. falcata* and *C. qilianensis* are affirmed to develop on *Spiraea*, as fifth instar immatures were found. The host plants of the other species remain uncertain. Based on morphological grounds, it is suggested that *C. falcata* and *C. nocturna* are closely related, but that the five species associated with *Spiraea* do not constitute a monophyletic group.

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Introduction

Psyllids, or jumping plant-lice, are generally accepted common names for insects of Psylloidea, with regard to their phloem-sucking habit and strong dependence on host plants. The term 'host plant' is defined as the plant on which a psyllid species completes its life history, empirically requiring fifth instar immatures to be found (Burckhardt et al. 2014). Psyllids are rather strictly host specific. For most small- to medium-sized genera, they each develop on one certain plant genus or on several plant genera belonging to the same family. And, for most species, the range of host plant of each species is one single species or several species of the same genus. Nevertheless, in large genera like *Cacopsylla*, it is a much more sophisticated situation. *Cacopsylla* is currently the most diverse psyllid genus, with over 500 known species worldwide, distributed throughout the Holarctic Region, and spreading into the Oriental Region (Ouvrard 2015). The species are recorded on many plants, of which the most common host plant genera include: *Malus*, *Crataegus*, *Pyrus*, *Elaeagnus*, *Hippophae*, *Rhamnus*, *Salix*, *Viburnum* and *Acer*. Some of the species on the same host plant taxon, putatively at least, constitute one or several monophyletic groups based on resemblance in morphology, e.g., species on *Salix*, divided into the *abdominalis* group and the *saliceti* group (Lauterer and Burckhardt 1997); species on Elaeagnaceae (*Elaeagnus* and *Hippophae*), divided into the group with rather long and straight female terminalia and the group with relatively

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short and up-curving female terminalia (unpublished data). However, the species on pear are currently considered polygenous (Burckhardt and Hodkinson 1986; Luo et al. 2012).

Spiraea is a genus belonging to Rosaceae, Spiraeoideae, commonly seen in mountains, but not a common host plant for psyllids. Before the present research, only *Cyamophiliopsis* spp. are known to take *Spiraea* as the genuine host plant. As a small genus closely related to *Cacopsylla*, *Cyamophiliopsis* Li 2011 is undoubtedly considered monophyletic (Luo et al. 2015). Besides *Cyamophiliopsis*, the only species associated with *Spiraea* are *Euphaleropsis spiraeicola* Li, 2011 and *Homotoma spiraeae* Yang and Li, 1981. In the collections of the last few years, we discovered four more species of *Cacopsylla* associated with *Spiraea*, and discovered that *Euphaleropsis spiraeicola* is rather a *Cacopsylla* species. In the present paper, we seek to coordinate all of the species, define them, and discuss their phylogenetic relationships.

Materials and methods

All specimens were acquired from the collections of Entomological Museum, China Agricultural University.

Preparation of slides were made following this protocol: whole insect boiled in potassium hydroxide (KOH) solution for 10 minutes, naturally cooled down after heating stopped, then washed in distilled water, and finally mounted on a slide in glycerine. All drawings, examinations and photos were undertaken with an Olympus[®] BX41 microscope. In the drawings of fore wings (Figures 1(f), 3(f), 5(f), 6(f), 8(f)), thin dashed lines represent ranges of surface spinules (on the dorsal surface), while thick dashed lines (except the one marking the claval suture) represent ranges of radular spinules (on the ventral surface).

Measurements (Table 1) were taken with a Keyence[®] VHX-1000 digital microscope using its measuring function and are given in millimetres (mm). For adults: BL = total body length measured from anterior margin of head to tip of folded fore wing, HW = head width, AL = antennal length, TW = mesoscutum width, WL = fore wing length, TL = metatibial length. For fifth instar immatures: BL = total body length, HW = head width, FL = fore wing pad length, measured as the distance between transverse tangents of anterior angle and posterior margin.

Terminology mainly follows Vondráček (1957), Ouvrard et al. (2002) and Yang et al. (2009), for adult, and White and Hodkinson (1985) for immature.

For nomenclature of plants, we follow Lu and Alexander (2003).

Taxonomic accounts

Cacopsylla falcata sp. nov.

Figures 1(a–g), 2(a–c), 8a, 10(a–b)

Description

Adult.

Colouration (Figure 10(a–b)). Body orange in overall view. Vertex mostly orange, with inner-posterior angles white. Genal processes ochre. Compound eyes purple, ocelli orange. Occiput black. Antenna yellow, with black apices on segments III–XIII, and

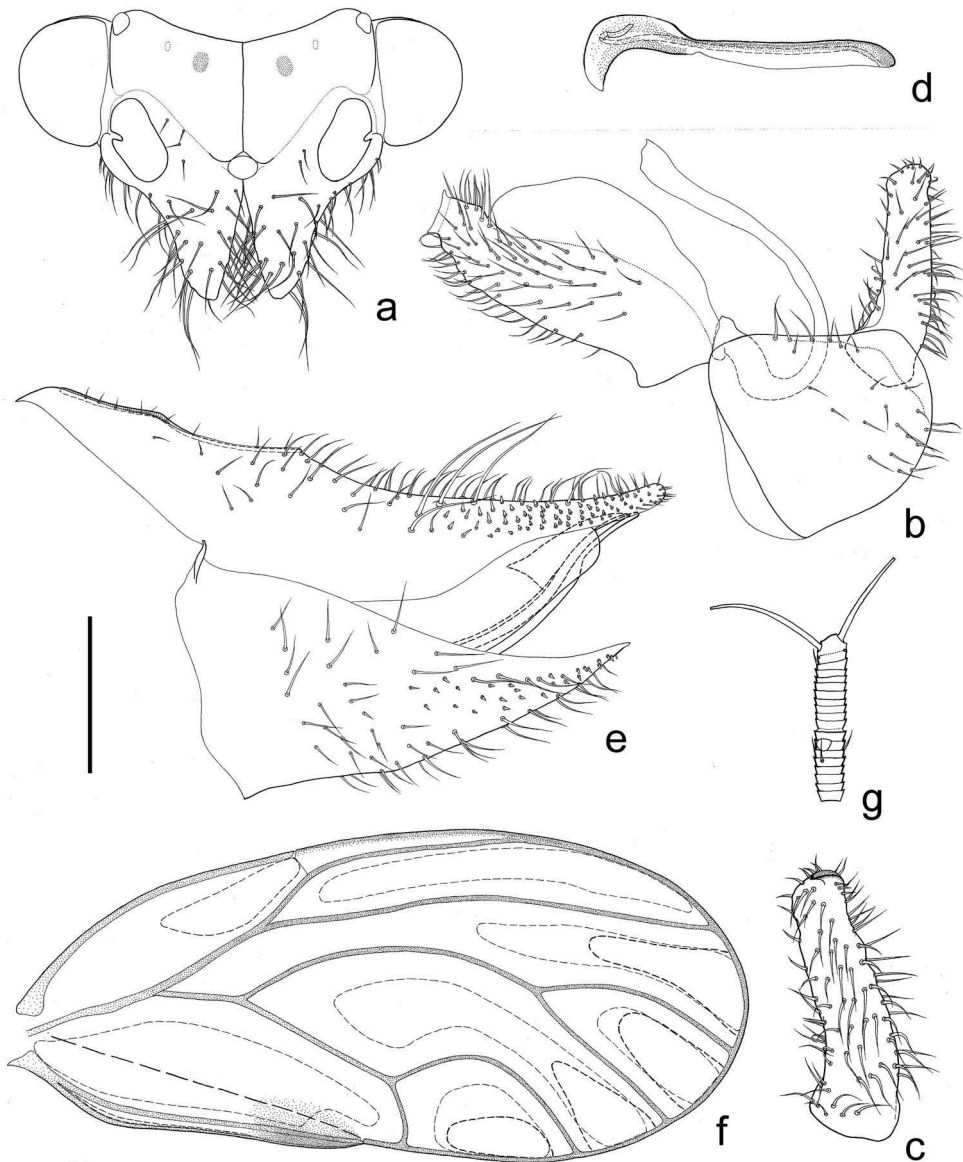


Figure 1. *Cacopsylla falcata* sp. nov., adult. (a) Head, front view, antennae removed; (b) male terminalia, in profile, ignoring distal segment of aedeagus and phallobase; (c) inner view of paramere; (d) distal segment of aedeagus; (e) female terminalia, in profile; (f) fore wing; (g) distal two segments of antenna. Scale bar: a = 0.25 mm; b, e = 0.155 mm; c, d, g = 0.124 mm; f = 0.625 mm.

segments IX–X entirely black. Thoracic dorsum yellow in ground, with the vast majority covered by orange stripes and patterns; anterior half of pronotum irregularly tainted orange; the two triangular patches in mesopraescutum almost covering the whole ground. Metapostnotum with two black patches bilaterally. Ventrums of mesothorax

Table 1. Measurements, in mm.

Adult		BL	AL	HW	TW	WL	TL
<i>Cacopsylla falcata</i>	Male (n = 5)	2.64–3.24	1.09–1.33	0.59–0.71	0.60–0.68	2.23–2.68	0.52–0.63
	Female (n = 5)	2.83–3.21	1.15–1.19	0.69–0.71	0.65–0.66	2.38–2.68	0.51–0.56
<i>Cacopsylla hyalinonemae</i>	Male (n = 5)	2.97–3.26	1.16–1.28	0.64–0.66	0.58–0.61	2.36–2.49	0.48–0.51
	Female (n = 5)	3.27–3.66	1.28–1.34	0.67–0.71	0.64–0.71	2.49–2.82	0.54–0.57
<i>Cacopsylla nocturna</i>	Male (n = 4)	2.71–3.12	1.06–1.07	0.60–0.67	0.51–0.57	2.37–2.71	0.46–0.47
	Female (n = 4)	2.92–3.28	1.02–1.19	0.62–0.64	0.56–0.58	2.55–2.91	0.45–0.53
<i>Cacopsylla qilianana</i>	Male (n = 4)	2.23–2.38	0.47–0.48	0.49–0.52	0.61–0.64	1.94–1.97	0.38–0.44
	Female (n = 2)	2.46–2.50	0.49–0.51	0.56–0.58	0.62–0.63	2.08–2.10	0.43–0.46
<i>Cacopsylla spiraeicola</i>	Male (n = 5)	2.45–2.76	0.75–0.80	0.53–0.57	0.50–0.53	2.02–2.16	0.45–0.48
	Female (n = 5)	2.64–2.94	0.69–0.70	0.57–0.59	0.59–0.67	2.20–2.54	0.46–0.48
Fifth instar immature		BL		HW		FL	
<i>Cacopsylla falcata</i> (n = 2)		1.04–1.12		0.54–0.57		0.56–0.57	
<i>Cacopsylla qilianana</i> (n = 3)		1.47–1.53		0.55–0.58		0.54–0.57	

BL: total body length; AL: antennal length; HW: head width; TW: mesoscutum length; WL: fore wing length; TL: metatibial length; FL: fore wing pad length.

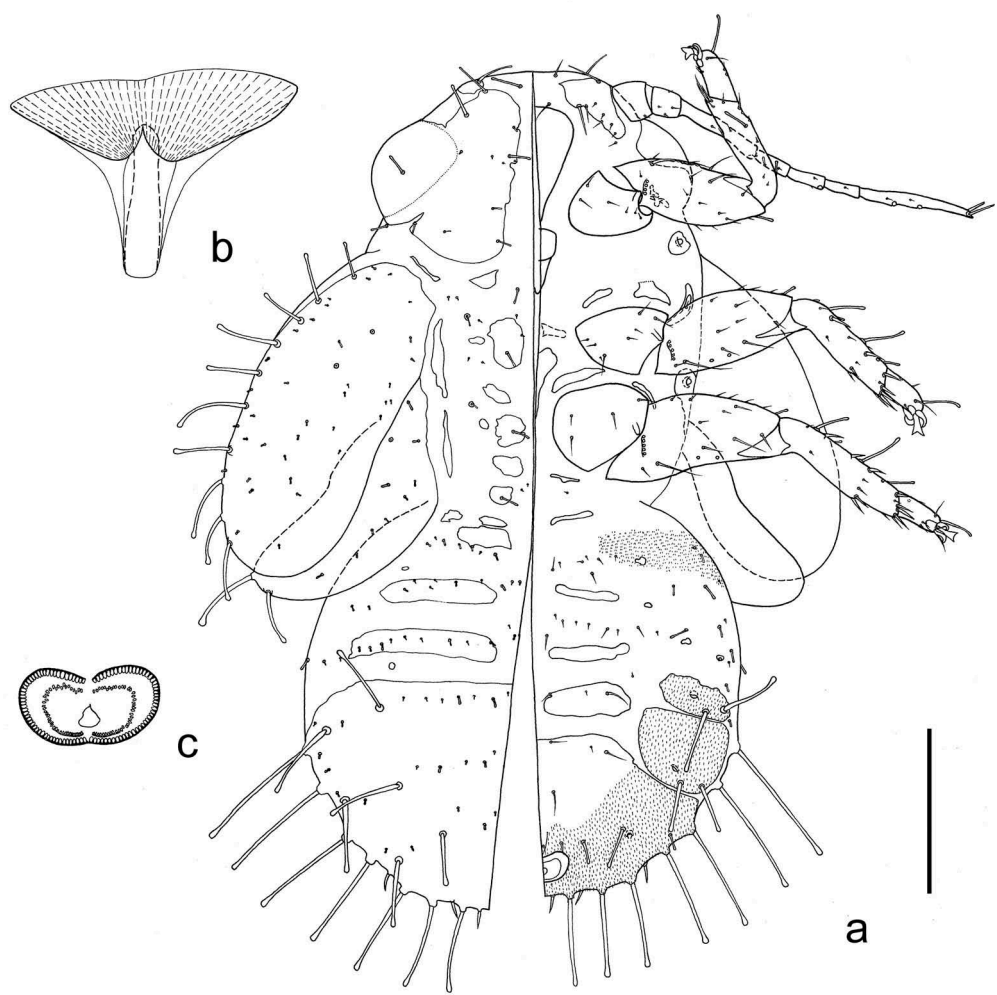


Figure 2. *Cacopsylla falcata* sp. nov., fifth instar immature. (a) Overall view, dorsal aspect on the left half, ventral aspect on the right half; (b) tarsal arolium; (c) anal pore field. Scale bar: a = 0.31 mm; b = 0.031 mm; c = 0.124 mm.

black except for a transverse narrow band in the middle. Legs yellow, with outer wall of metacoxa dark brown. Fore wing membrane (Figure 1(f)) hyaline, with a dark brown patch covering subapex of cell a_1 , expanding around as a light brown patch near anal break; veins brown. Abdominal terga yellow, with anterior margin of each segment blackish; abdominal sterna yellow in ground, with anterior half of segment III black, other segments with an indistinctly demarcated light brown patch in anterior margin near lateral margin, all segments with a small brown patch in posterior half near lateral margin. Male terminalia yellow, with ventral surface of subgenital plate lightly brownish. Female terminalia yellow, with apex brownish.

Structures. Head (Figure 1(a)) inclined from longitudinal body axis by 80–90°, slightly narrower than mesoscutum transversely. Lateral parts of vertex rather short longitudinally; anterior margin and base of lateral ocelli strongly convex, appearing distinctly contrasted from the inner-posterior angles; boundary between vertex and gena clear. Surface of vertex finely sculptured with scaly microstructures and microscopic setae that gradually grow longer in the antero-inner angles, exceeding the length of the setae around antennal insertion. Gena processes long, gradually growing divergent, with apices subacute; outer margin relatively smoothly curved; genal whip setae relatively widely spaced. Antenna longer than HW; the more distally situated terminal seta only slightly shorter than the more proximally situated terminal seta (Figure 1(g)).

Mesopraescutum strongly produced forward, pressing pronotum to be strongly arched. Metatibia with well developed genual spine, apical spurs arranged in 1 + 1 + 2 + 1. Fore wing (Figure 1(f)) oblong oval, strongly widening until apical 1/3; posterior margin nearly straight; height of cell cu_1 distinctly longer than length of vein Cu_{1b} ; fields of surface spinules relatively small, slightly contracted at margins of cells; fields of radular spinules as shown in Figure 1(f).

Male terminalia: Proctiger (Figure 1(b)) without posterior lobe, gently arched, with anterior surface waved near apex; apical 4/5 of anterior surface setosed. Paramere (Figures 1(b–c)) slightly curved forward, with apex curved backwards; apical tooth curved inwards, with tip subacute and pointed forward; anterior margin expanded into a small rounded lobe at subapex; inner surface with large numbers of long setae curving downwards, posterior margin also with large numbers of long setae. Distal segment of aedeagus (Figure 1(d)) relatively long and slender; apical dilatation sickle-shaped; sclerotised end tube of ductus ejaculatorius projected backwards, and gently curved upwards. Subgenital plate (Figure 1(b)) near square in profile, except for the finely rounded ventral surface; weakly sclerotised anterior lobe present.

Female terminalia (Figure 1(e)): Relatively long and simple. Anal ring covering about 2/5 of the total length of proctiger; proctiger slightly curved upwards; longitudinal row of rather long setae in dorsum of apical process formed of: four longest in the base, forming a strongly curved line, one short seta in apical 1/3, and one shortest in apical 1/5; fields of peg setae large, almost touching in the middle. Subgenital plate relatively long and narrow in profile, field of peg setae in subgenital plate covering apical 1/2. Valvulae dorsalis and ventralis gently curved upwards, stretching into the cavity beneath proctiger; valvulae lateralis rather narrow.

Fifth instar immature.

Colouration. Generally yellow. Compound eyes red. Apical 2/3 of antenna black.

Structures. Dorsum completely covered with minute to long capitate setae, including ocular and postocular setae (Figure 2(a)). Antenna (Figure 2(a)) 7-segmented, with one rhinarium on apex of segments 3 and 5 each, and two rhinaria on segment 7. Wing pads (Figure 2(a)) large; fore wing pad oval, with about 10 long capitate setae on outer margin, anterior half with two pores; hind wing pad knife-shaped, with two long capitate setae on apex, anterior angle with one pore. Dorsum of fore tibialtarsus with one long capitate seta, dorsum of mid and hind tibialtarsus with two long capitate setae (Figure 2(a)). Tarsal arolium (Figure 2(b)) wide fishtail-shaped, with expanded areas rather coarse, with relatively short pedicel gradually growing narrow basally, and with well-developed unguitractor. Third pair of sclerites with spiracle in abdominal ventrum completely fused with anal plate (Figure 2(a)). Abdominal ventrum (Figure 2(a)) with long or short capitate setae near the margin, other parts with long or short simple setae. Abdominal margin (Figure 2(a)) with 7 + 7 rather long capitate setae, gradually growing shorter medially, and with 3 + 3 setae close to the lanceolate type (sensu White and Hodkinson 1985). Circum anal pore field (Figure 2(c)) ventral and small, composed of a complete outer ring of single row of slit-shaped pores, and a complete inner ring of jagged single row of oval pores. 1 + 1 setae near the lanceolate type present anterior to anal pore field.

Material examined

Holotype: male, dry mounted, Jinzhai Village, Yongshan, Yunnan, China, 28°0'54"N, 103°32'17"E, 23 April 2014, Luo Xinyu, on *Spiraea* ? *teniana*. Paratypes: 11 males, 12 females, dry mounted, 1 male, 1 female, slide mounted, 8 males, 9 females, 3 fifth instar immatures, preserved in absolute ethanol, same data as holotype.

Host plant

Spiraea ? *teniana*.

Etymology

Named after the sickle-shaped apical dilatation of aedeagus, Latin 'falx' = 'sickle'.

***Cacopsylla hyalinonemae* Li and Yang, 1989**

Figures 3(a–h), 8(b), 10(c–d)

Cacopsylla hyalinonemae Li and Yang, 1989: 70; Li, 2011: 820.

Redescription**Adult.**

Colouration (Figures 10(c–d)). Body light brown in overall view. Vertex pale yellow in ground, with two longitudinal ochreous stripes consistent with those on thoracic dorsum, along with two narrow ochreous stripes beside. Antennal base ochreous except for margin of antennal insertion. Dorsal aspect of genal processes pale yellow in ground, with two longitudinal red stripes; ventral aspect of genal processes brown. Compound

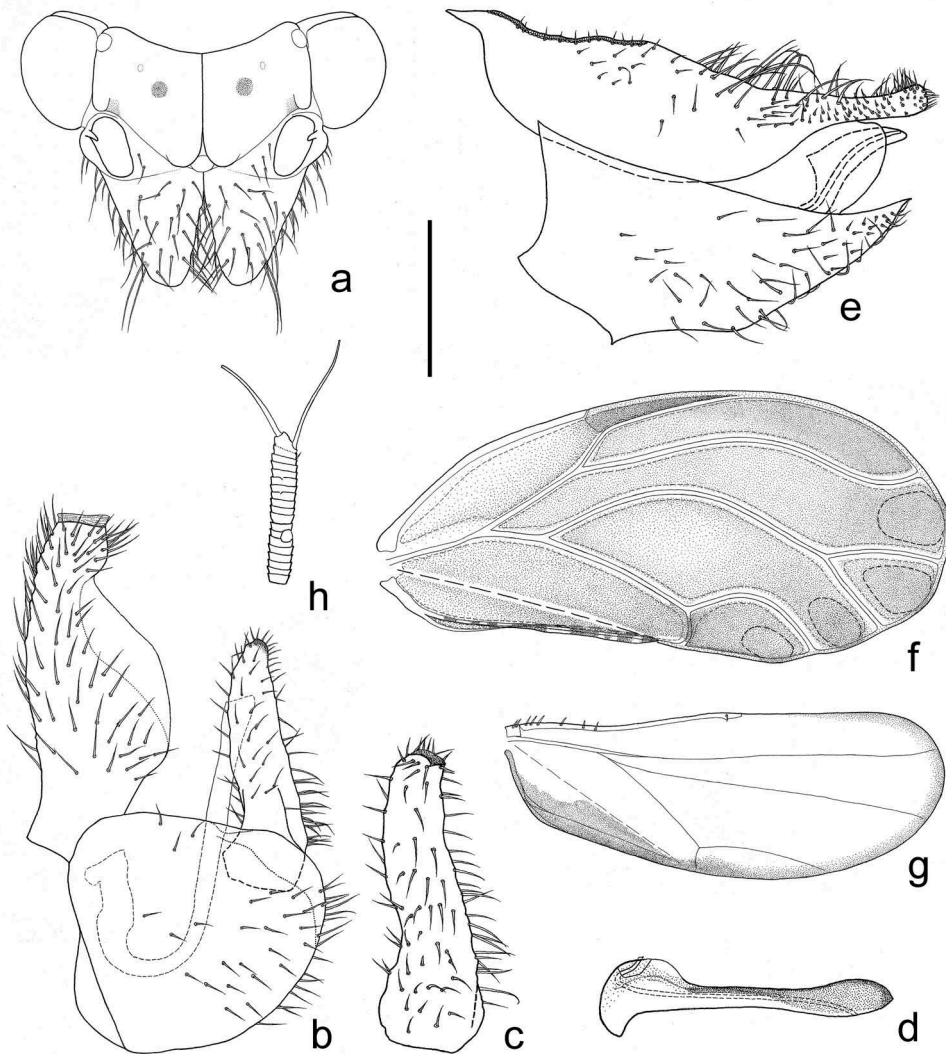


Figure 3. *Cacopsylla hyalinonemae* Li and Yang, 1989, adult. (a) Head, front view, antennae removed; (b) male terminalia, in profile, ignoring distal segment of aedeagus and phallobase; (c) inner view of paramere; (d) distal segment of aedeagus; (e) female terminalia, in profile; (f) fore wing; (g) hind wing; (h) distal two segments of antenna. Scale bar: a = 0.286 mm; b = 0.155 mm; c, d, h = 0.124 mm; e = 0.167 mm; f, g = 0.714 mm.

eyes red, ocelli orange. Antenna pale yellow, with black apices on segments III–VIII, and segments IX–X entirely black. Thoracic dorsum pale yellow in ground, with ochreous stripes; two longitudinal stripes present through pronotum and mesopraescutum, consistent with the stripes on vertex; lateral stripes on mesoscutum with conspicuous dark brown outlines. Thoracic pleurites mostly brown, dorsal bulge of mesopleuron pale yellow. Legs yellow, coxae black, femora more or less darkened. Fore wing membrane (Figure 3(f)) golden yellow and hyaline, leaving colourless bands along veins; margin

brown, gradually lightening basally; pterostigma dark brown; veins mostly colourless, marginal vein yellow; vein A_1 with several black sections varying in length. Hind wing membrane (Figure 3(g)) hyaline, outer and caudal margin, and part of cell cu_2 black. Abdomen dark brown, tergum of segment III ochreous. Male terminalia ochreous, apical tube of proctiger dark brown, subgenital plate more or less blackish. Female proctiger ochreous, subgenital plate dark brown.

Structures. Head (Figure 3(a)) inclined from longitudinal body axis by about 45° , slightly wider than mesoscutum transversely. Antero-outer and antero-inner angles of vertex protruding as round tubercles; boundary between vertex and gena clear. Surface of vertex finely sculptured with scaly microstructures and microscopic setae. Genal processes long and rather robust, slightly tilted upwards, gradually growing divergent, apices rounded. Demarcation between antennal base and genal process rather distinct as a crease. Antenna relatively slender, more distally situated terminal seta about $2/3$ as long as the more proximally situated terminal seta (Figure 3(h)).

Mesopraescutum moderately produced forward, pressing pronotum to be gently arched. Metatibia with well developed genual spine, apical spurs arranged in $1 + 3 + 1$. Fore wing (Figure 3(f)) oblong oval, strongly widening until apical $1/4$; posterior margin nearly straight; height of cell cu_1 distinctly longer than length of vein Cu_{1b} ; vein A_1 with narrow flag expanded outwards; fields of surface spinules relatively large, contracted at apices of cells; fields of radular spinules as shown in Figure 3(f).

Male terminalia: Proctiger (Figure 3(b)) without posterior lobe, gently arched, with nearly evenly spaced setae; posterior margin moderately produced. Paramere (Figure 3(b–c)) slightly curved forward, outer surface with two ridges basally; apical tooth curved inwards, with tip subacute and pointed forward; inner surface with lots of long setae pointing downwards, posterior margin also with lots of long setae. Distal segment of aedeagus (Figure 3(d)) relatively long, nearly straight; apical dilatation short and stout, slightly hooked apically; sclerotised end tube of ductus ejaculatorius projected backwards, and gently curved upwards. Subgenital plate (Figure 3(b)) nearly round in profile.

Female terminalia (Figure 3(e)): Relatively short. Anal ring covering about $1/3$ of the total length of proctiger; longitudinal row of rather long setae in dorsum of apical process not clearly recognisable; setae in bilateral sides of apical process of proctiger gradually turn from short setae basally into peg setae apically. Subgenital plate relatively long and narrow in profile, peg setae present only near apex. Valvulae dorsalis and ventralis gently curved upwards.

Material examined

Holotype: female, slide mounted, Mountain Hua, Huayin, Shaanxi, China, 22 August 1962, Yang Chikun. Non-type specimens: 1 male, 1 female, dry mounted, Mountain Liupan, Jingyuan, Ningxia, China, altitude 2100 m, 30 July 1992, Li Fasheng; 2 males, 2 females, dry mounted, Mountain Kongtong, Pingliang, Gansu, China, altitude 1400–2000 m, 29 July 1992, Li Fasheng; 3 males, 5 females, dry mounted, Erlong river forestry farm, Jingyuan, Ningxia, China, altitude 2050 m, $35^\circ 19' 17''N$, $106^\circ 21' 24''E$, 29 July 2012, Luo Xinyu, on *Spiraea* sp.; 1 female, dry mounted, Dongshanpo forestry farm, Jingyuan, Ningxia, China, $35^\circ 36' 32''N$, $106^\circ 14' 38''E$, 10 August 2012, Luo Xinyu; 1 male, 1 female,

slide mounted, 3 males, 4 females, preserved in absolute ethanol, Laolongtan, Jingyuan, Ningxia, China, altitude 1900 m, 35°32'38"N, 106°20'21"E, 3 August 2012, Luo Xinyu, on *Spiraea* sp.

Host plant

Probably *Spiraea* sp., as although there were only a few adults collected on the plant, no adult was collected from the surrounding plants. Li (2011) listed *Syrina oblata* as the host plant, but it is most probably a shelter plant or food plant.

Remarks

This species is rather unique within the genus, attributed to the longitudinal stripes through the vertex to mesopraescutum, the red stripes on the genal processes, the less inclined head, and the protruding anterior angles of the vertex. *Psylla tetrotaenialis* Li and Yang, 1989 is another species with such characters; we regard it as a closely related species to *C. hyalinonemae*, and hereby assign it to *Cacopsylla* as *Cacopsylla tetrotaenialis* (Li and Yang, 1989) comb. nov.

Cacopsylla nocturna sp. nov.

Figures 4(a–g), 8(c), 10(e–f)

Description

Adult.

Colouration (Figure 10(e–f)). Body dark brown to black in overall view. Vertex white in ground, mostly covered by brown markings except for antero-inner angles, antero-outer angles and postero-inner angles; discal foveae dark brown. Genal processes ochre, with apical half brown. Compound eyes black; lateral ocelli orange, medial ocellus brown. Occiput black; postocular sclerites black, with margin entirely white. Antenna brown, with black apices on segments III–XIII, and segments IX–X entirely black. Thoracic dorsum mostly orange, with brown to dark brown stripes and patterns; pronotum with three brown markings in the middle; the two triangular patches in mesopraescutum almost covering the whole ground. Metapostnotum entirely black. Thoracic pleurites almost completely black, except for the antero-dorsal bulging of mesopleuron. Legs yellow, with pro- and mesocoxae black, metacoxa irregularly blackish; all femora black. Fore wing (Figure 4(f)) membrane hyaline, with a black marking near anal break; veins yellow, gradually turning brown apically, with C + Sc, base of A₂, and outer margin before anal break brown. Abdomen black, with a longitudinal white band across the lateral aspect of terga of segments III–VI. Male and female terminalia black.

Structures. Head (Figure 4(a)) inclined from longitudinal body axis by 90°, slightly wider than mesoscutum transversely. Lateral parts of vertex rather short longitudinally; anterior margin and base of lateral ocelli strongly convex, appearing distinctly contrasted from the inner-posterior angles; antero-outer angles distinctly bulging; boundary between vertex and gena clear. Surface of vertex finely sculptured with scaly microstructures and microscopic setae. Gena processes long and slender, gradually growing divergent, with apices subacute; outer margin strongly emarginated; genal whip setae

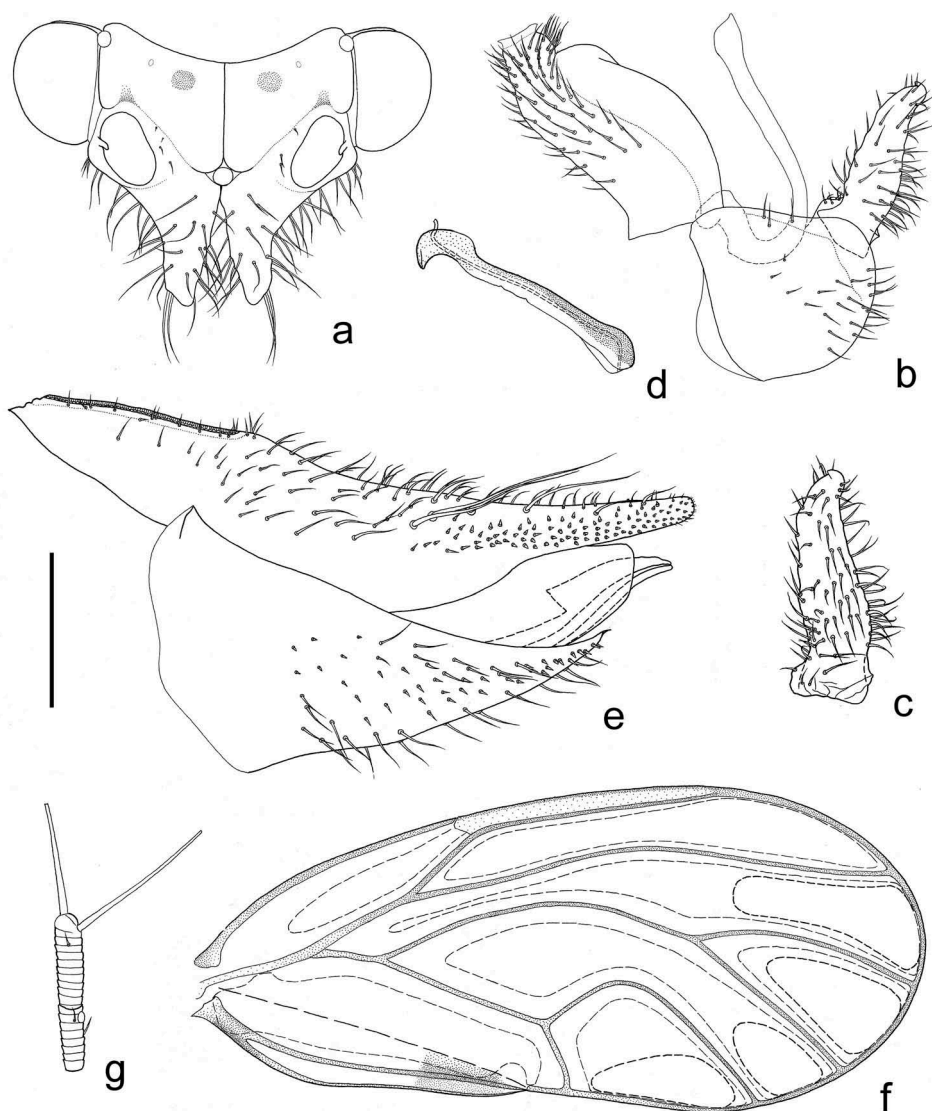


Figure 4. *Cacopsylla nocturna* sp. nov., adult. (a) Head, front view, antennae removed; (b) male terminalia, in profile, ignoring distal segment of aedeagus and phallobase; (c) inner view of paramere; (d) distal segment of aedeagus; (e) female terminalia, in profile; (f) fore wing; (g) distal two segments of antenna. Scale bar: a = 0.25 mm; b = 0.155 mm; c, d, g = 0.124 mm; e = 0.138 mm; f = 0.556 mm.

relatively narrowly spaced. Antenna longer than HW; terminal setae rather long, the more distally situated one about $3/4$ as long as the more proximally situated one (Figure 4(g)).

Mesopraescutum strongly produced forward, pressing pronotum to be strongly arched. Metatibia with well developed genual spine, apical spurs arranged in $1 + 1 + 2 + 1$. Fore wing (Figure 4(f)) oblong oval, strongly widening until apical $1/3$; posterior margin nearly straight; height of cell cu_1 distinctly longer than length of vein

Cu_{1b}; fields of surface spinules relatively large, leaving spinule-free bands narrowing along veins; fields of radular spinules as shown in Figure 4(f).

Male terminalia: Proctiger (Figure 4(b)) without posterior lobe, gently arched, with nearly evenly spaced short setae. Paramere (Figure 4(b–c)) slightly curved forward, with apex curved backwards; apical tooth relatively small, curved inwards, with tip subacute and pointed forward; base better expanded, near rectangular; inner surface with large amounts of long setae curving downwards, posterior margin also with large numbers of long setae. Distal segment of aedeagus (Figure 4(d)) relatively long, robust basally, smoothly growing slender apically until apical dilatation; apical dilatation rather small, strongly hooked; sclerotised end tube of ductus ejaculatorius projected upwards, and gently curved forward. Subgenital plate (Figure 4(b)) rather small, with weakly sclerotised anterior lobe.

Female terminalia (Figure 4(e)): Relatively long and simple. Anal ring covering less than 1/3 of the total length of proctiger; longitudinal row of rather long setae in dorsum of apical process formed of: four longest in the base, forming a weakly curved line, one short seta in apical 2/5, and one shortest in apical 1/5; fields of peg setae barely touching in the middle. Subgenital plate relatively long and narrow in profile, field of peg setae in subgenital plate covering apical 2/3. Valvulae dorsalis and ventralis gently curved upwards.

Material examined

Holotype: male, dry mounted, Xishaxiang, Yongshan, Yunnan, China, 28°17'56"N, 103°58'52"E, 23 April 2014, Luo Xinyu, by light trap. Paratypes: 4 males, 4 females, dry mounted, 1 female, slide mounted, same data as holotype; 1 male, dry mounted, 1 male, slide mounted, same location as holotype, 24 April 2014, Luo Xinyu, on *Spiraea teniana*.

Host plant

Probably *Spiraea teniana*. Before the light trap, we also observed several adults on the plant at dusk.

Etymology

Named after the time the type series was collected, 'nocturnus' = 'night'.

Cacopsylla qilianensis sp. nov.

Figures 5(a–g), 6(a–c), 8(d), 10(g–h)

Description

Adult.

Colouration (Figure 10(g–h)). Body orange in overall view. Vertex orange. Genal processes yellow. Compound eyes brown, ocelli orange. Antenna yellow, with black apex on segment VIII, and segments IX–X entirely black. Thoracic dorsum pale grey, with reddish orange stripes. Thoracic pleurites mostly orange, trochantin of metathorax more or less blackish. Ventral aspect of mesothorax black, except for a transverse narrow band in the middle. Legs yellow; metacoxa blackish; dorsal surface of femora blackish. Fore wing

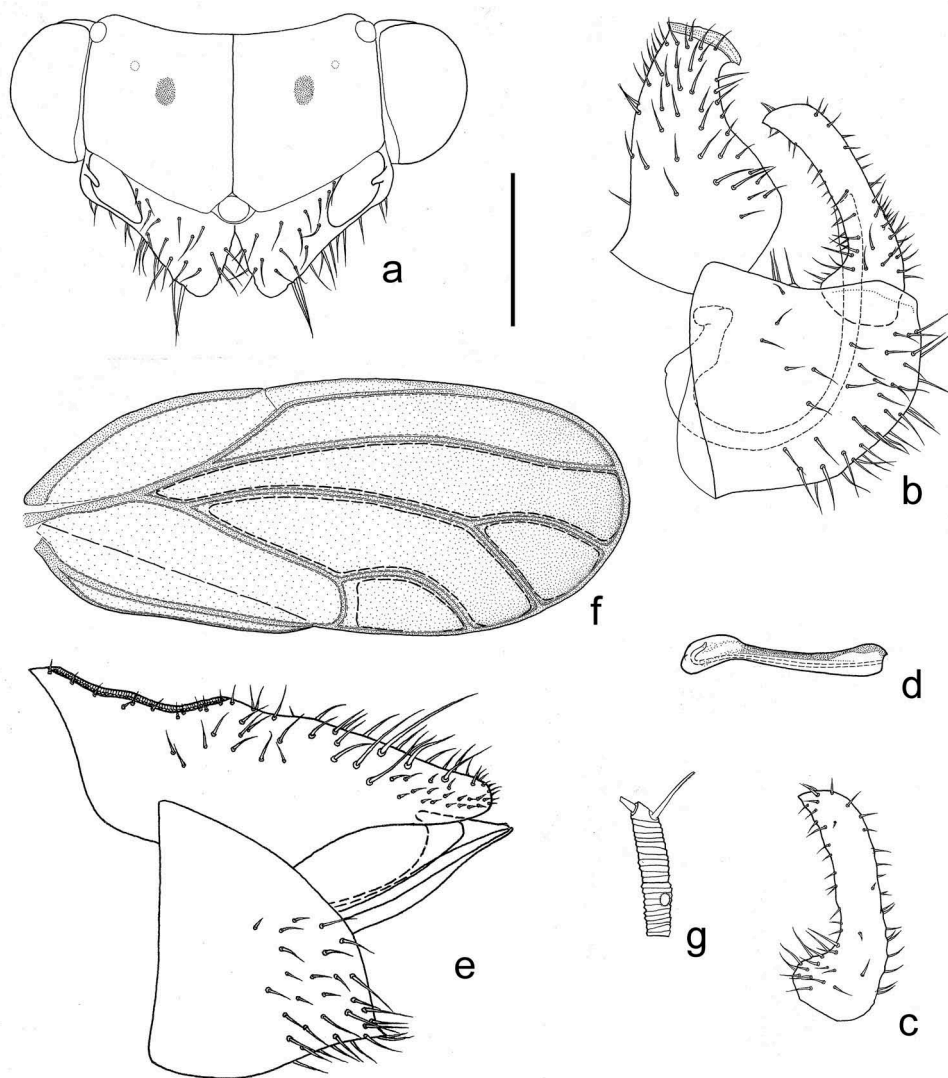


Figure 5. *Cacopsylla qilianensis* sp. nov., adult. (a) Head, front view, antennae removed; (b) male terminalia, in profile, ignoring distal segment of aedeagus and phallobase; (c) inner view of paramere; (d) distal segment of aedeagus; (e) female terminalia, in profile; (f) fore wing; (g) distal two segments of antenna. Scale bar: a = 0.2 mm; b–d, g = 0.124 mm; e = 0.133; f = 0.556 mm.

(Figure 5(f)) membrane translucent, grey, darker in apical margin, gradually turning light basally; veins slightly darker than membrane. Abdomen orange; lateral end of anterior margin of terga of segments III–VII light brown to black, darkest in segment III, gradually lightening by each segment; ventral surface with two longitudinal brown bands. Male and female terminalia orange.

Structures. Head (Figure 5(a)) inclined from longitudinal body axis by 90°, slightly narrower than mesoscutum transversely. Boundary between vertex and gena clear and

nearly straight, antero-outer angles nearly rounded; plane of vertex distinctly higher than that of genal processes; discal foveae relatively shallow. Surface of vertex finely sculptured with scaly microstructures and microscopic setae. Gena processes about half as long as median suture of vertex, moderately divergent apically, with apices blunt. Antenna about as long as HW; terminal setae relatively short, the more distally situated one about 1/3 as long as the more proximally situated one (Figure 5(g)).

Mesopraescutum moderately produced forward, pressing pronotum to be moderately arched. Metatibia without genual spine, with five apical spurs (in one case six), midial ones irregularly grouped. Fore wing (Figure 5(f)) oblong oval, widest in apical 1/3; height of cell cu_1 indistinctly longer than length of vein Cu_{1b} ; surface spinules small and dense, completely covering the whole fore wing membrane; fields of radular spinules as shown in Figure 5(f).

Male terminalia: Proctiger (Figure 5(b)) relatively short and thick, with produced posterior margin, gently arched, covered with nearly evenly spaced short setae. Paramere (Figure 5(b–c)) blade-shaped in profile, strongly curved forward, without distinct apical tooth; inner surface with rather few setae; anterior half of the base with relatively dense setae. Distal segment of aedeagus (Figure 5(d)) relatively short; apical dilatation near oval, slightly inclined downwards, not hooked; sclerotised end tube of ductus ejaculatorius projected obliquely backwards, and gently curved upwards. Subgenital plate (Figure 5(b)) near square in profile, dorsal margin slightly folded inwards; ventral surface with relatively dense setae.

Female terminalia (Figure 5(e)): Rather short. Longitudinal row of rather long setae in dorsum of apical process not clearly recognisable; bilateral sides of apical process of proctiger without peg setae, short and slender setae present instead. Subgenital plate rather short, forming a wide opening with proctiger, without peg setae. Valvulae dorsalis and ventralis stretching obliquely upwards, partly hidden beneath the cavity of proctiger.

Fifth instar immature.

Colouration. Membranous parts orange. All sclerites dark brown. Antenna yellow, with apical three segments black. Compound eyes reddish brown.

Structures. Dorsum completely covered with a type of specialised simple setae (awl-shaped, termed conical seta below), including ocular and postocular setae (Figure 6(a)). All bases of setae strongly sclerotised (Figure 6(a)), following the colour of normal sclerites. Antenna (Figure 6(a)) 7-segmented, with one rhinarium on apex of segments 3 and 5 each, and two rhinaria on segment 7; segment 7 relatively short, with the two rhinaria relatively close. Wing pads (Figure 6(a)) large; fore wing pad oval, outer margin decorated with dense conical setae varying in length, anterior half with one pore; hind wing pad knife-shaped, with two long conical setae on apex. Dorsum of mid and hind tibialtarsus with two long capitate setae (Figure 6(a)). Tarsal arolium (Figure 6(b)) fishtail-shaped, with expanded areas rather coarse, with relatively long pedicel gradually growing narrow basally, and with well-developed unguitractor. Third pair of sclerites with spiracle in abdominal ventrum completely free from anal plate (Figure 6(a)). Abdominal ventrum (Figure 6(a)) with long or short conical setae near the margin, other parts with long or short simple setae. Abdominal margin (Figure 6(a)) with 7 + 7 rather long conical setae, innermost pair relatively short; and with 2 + 2 sectasetae. Circum anal pore field

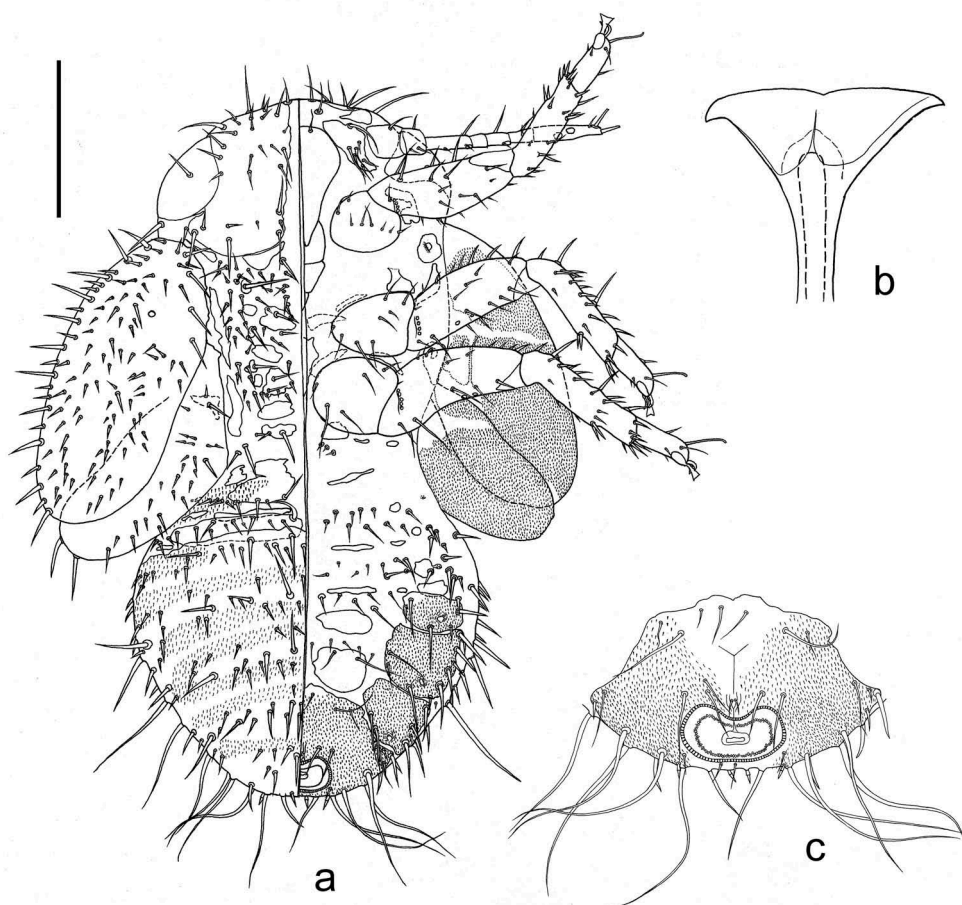


Figure 6. *Cacopsylla qilianensis* sp. nov., fifth instar immature. (a) Overall view, dorsal aspect on the left half, ventral aspect on the right half; (b) tarsal arolium; (c) ventral aspect of anal plate. Scale bar: a = 0.31 mm; b = 0.031 mm; c = 0.124 mm.

(Figure 6(c)) ventral, composed of a complete outer ring of single row of slit-shaped pores, and a complete inner ring of jagged single row of oval pores.

Materials examined

Holotype: male, dry mounted, Sidalong forestry farm, Sunan, Gansu, China, altitude 2410 m, 38°28'26"N, 99°58'2"E, 4 August 2013, Luo Xinyu, on *Spiraea myrtilloides*. Paratypes: 3 males, 2 females, dry mounted, 2 males, 2 females, preserved in absolute ethanol, 1 male, 1 female, slide mounted, 6 fifth instar immatures, preserved in absolute ethanol, same data as holotype; 3 males, 4 females, preserved in absolute ethanol, Kangle forestry farm, Sunan, Gansu, China, altitude 2675 m, 38°50'6"N, 99°41'54"E, 6 August 2013, Luo Xinyu, on *Spiraea* sp.

Host plant

Spiraea myrtilloides.

Etymology

Named after the type locality, the Qilian Mountains.

Cacopsylla spiraeicola (Li, 2011) comb. nov.

Figures 7(a–g), 8(e), 10(i–j)

Euphaleropsis spiraeicola Li, 2011: 492.

Redescription

Adult.

Colouration (Figure 10(i–j)). Body brown in overall view. Vertex brown, discal foveae moderately darker. Genal processes slightly darker than vertex. Compound eyes black; lateral ocelli brown, medial ocellus orange. Antenna generally brown to dark brown, with basal half of segments III–V lighter. Thoracic dorsum with dark brown stripes and patterns. Thoracic pleurites generally brown, irregularly darkened along pleural sulci. Legs yellowish brown; pro- and mesocoxae dark brown, metacoxa irregularly darkened; trochanters dark brown; femora more or less darkened. Fore wing (Figure 7(f)) membrane hyaline, with brown to dark brown clouding, leaving breaches at apices of cells r_2 , m_1 , m_2 and cu_1 ; most veins brown, costal margin yellow. Hind wing membrane hyaline, more or less brownish along veins; veins light brown to brown. Abdomen and male and female terminalia dark brown to black.

Structures. Head (Figure 7(a)) inclined from longitudinal body axis by 45° , slightly narrower than mesoscutum transversely. Boundary between vertex and gena clear, without outstanding antero-outer angles; discal foveae relatively shallow, secondary foveae slightly concave. Surface of vertex finely sculptured with scaly microstructures and microscopic setae that gradually grow longer on antero-inner angles, exceeding length of setae around antennal insertion. Plane of genal processes inclined from that of vertex by about 45° . Gena processes about half as long as median suture of vertex, widely divergent apically, with apices nearly rounded. Antenna longer than HW, relatively thick; terminal setae rather short, the more distally situated one about $1/3$ as long as the more proximally situated one (Figure 7(g)).

Mesopraescutum moderately produced forward, pressing pronotum to be moderately arched. Metatibia without genual spine, with four apical spurs, arranged in $1 + 2 + 1$. Fore wing (Figure 7(f)) oblong oval, widest in the middle; veins relatively thick; height of cell cu_1 indistinctly longer than length of vein Cu_{1b} ; surface spinules (in dorsal surface) and radular spinules (in ventral surface) completely covering the whole fore wing membrane.

Male terminalia: Proctiger (Figure 7(b)) without posterior lobe, gently arched, covered with nearly evenly spaced short setae. Paramere (Figures 7(b–c)) strongly curved forward at basal $1/4$, then gently curved backwards; apical tooth finely congruent with the main part, moderately curved inwards, with tip acute and pointed forward; inner surface with dozens of erect short setae. Distal segment of aedeagus (Figure 7(d)) gently curved downwards; apical dilatation near oval, not hooked; ductus ejaculatorius relatively thick,

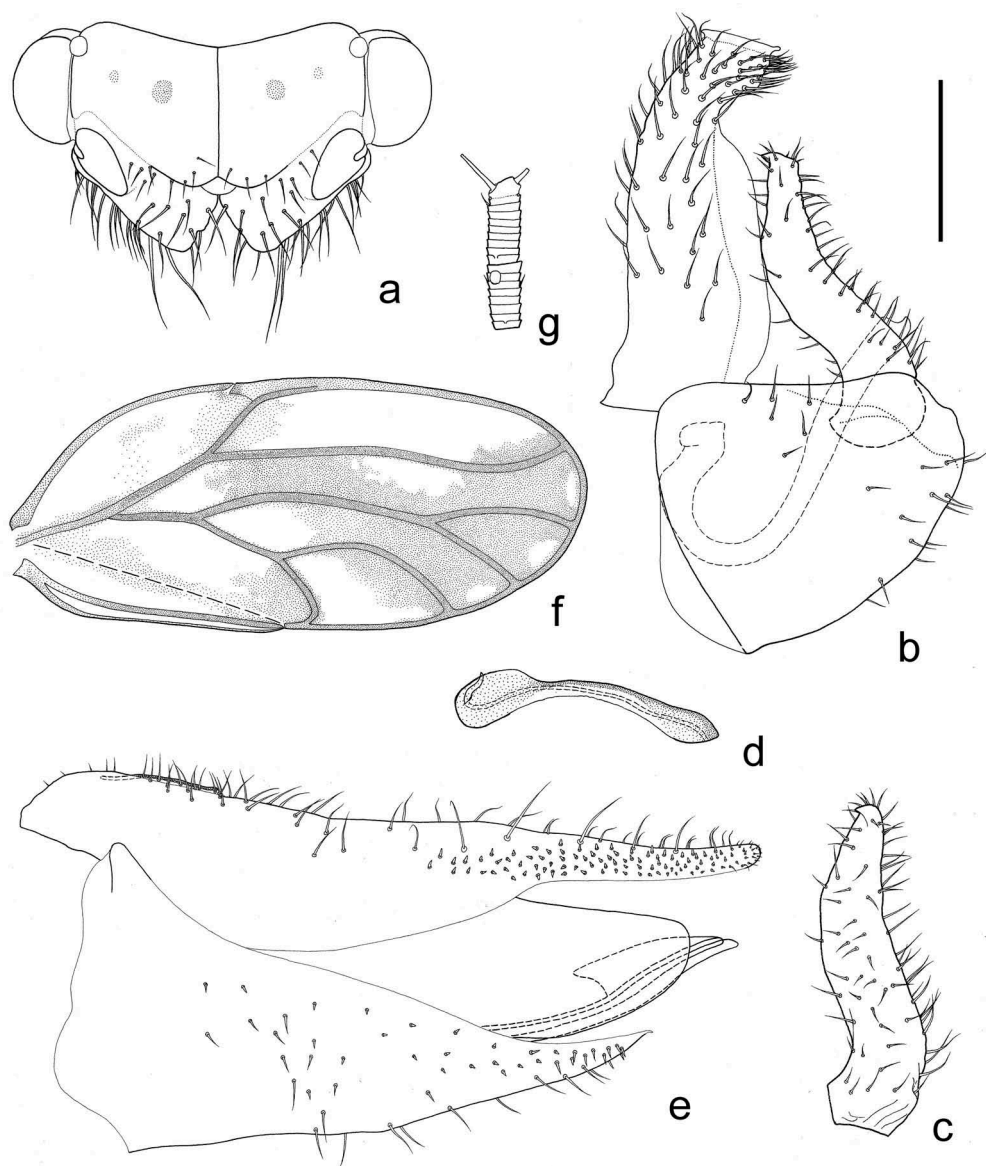


Figure 7. *Cacopsylla spiraeicola* (Li, 2011), adult. (a) Head, front view, antennae removed; (b) male terminalia, in profile, ignoring distal segment of aedeagus and phallobase; (c) inner view of paramere; (d) distal segment of aedeagus; (e) female terminalia, in profile; (f) fore wing; (g) distal two segments of antenna. Scale bar: a = 0.222 mm; b–d, g = 0.124 mm; e = 0.155 mm; f = 0.625 mm.

sclerotised end tube projected obliquely backwards, and gently curved upwards. Subgenital plate (Figure 7(b)) with small anterior lobe, ventral surface waved in profile.

Female terminalia (Figure 7(e)): Relatively long and simple. Anal ring rather small; dorsal surface of proctiger smoothly convex near base of apical process; longitudinal row of rather long setae in dorsum of apical process formed of nearly evenly

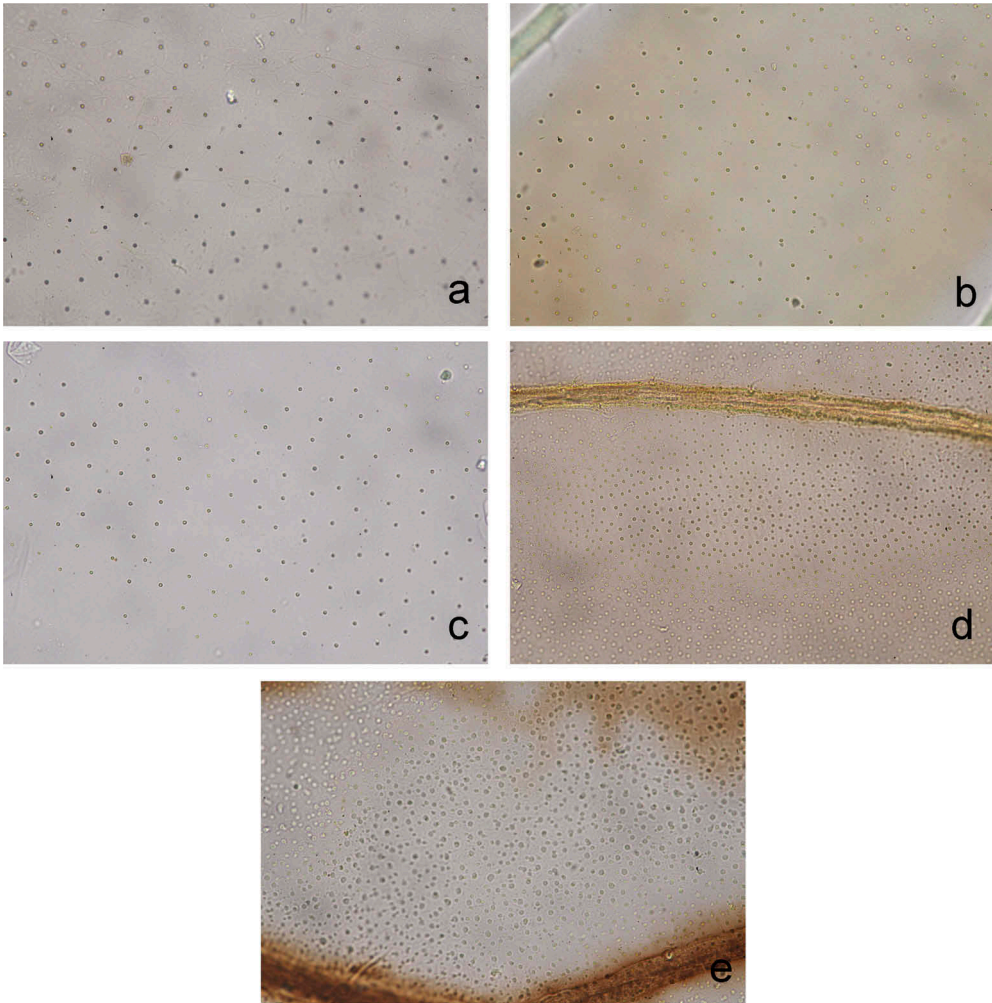


Figure 8. Microscopic photograph of fore wing membrane of *Cacopsylla* spp., showing texture of surface spinules. (a) *C. falcata* sp. nov.; (b) *C. hyalinonemae* Li and Yang, 1989; (c) *C. nocturna* sp. nov.; (d) *C. qilianensis* sp. nov.; (e) *C. spiraeicola* (Li, 2011).

spaced setae. Subgenital plate relatively long and narrow in profile, without relatively long setae near dorsal margin. Valvulae dorsalis and ventralis slightly curved upwards.

Material examined

Holotype: male, dry mounted, Mountain Lv, Beizhen, Liaoning, China, April 1992, Guan Shuwei, on *Spiraea salicifolia*. Paratypes: 5 males, 6 females, dry mounted, 2 males, 2 females, slide mounted, 5 males, 5 females, preserved in absolute ethanol, same data as holotype. Non-type material: 1 male, 1 female, slide mounted, 5 males, 8 females, dry

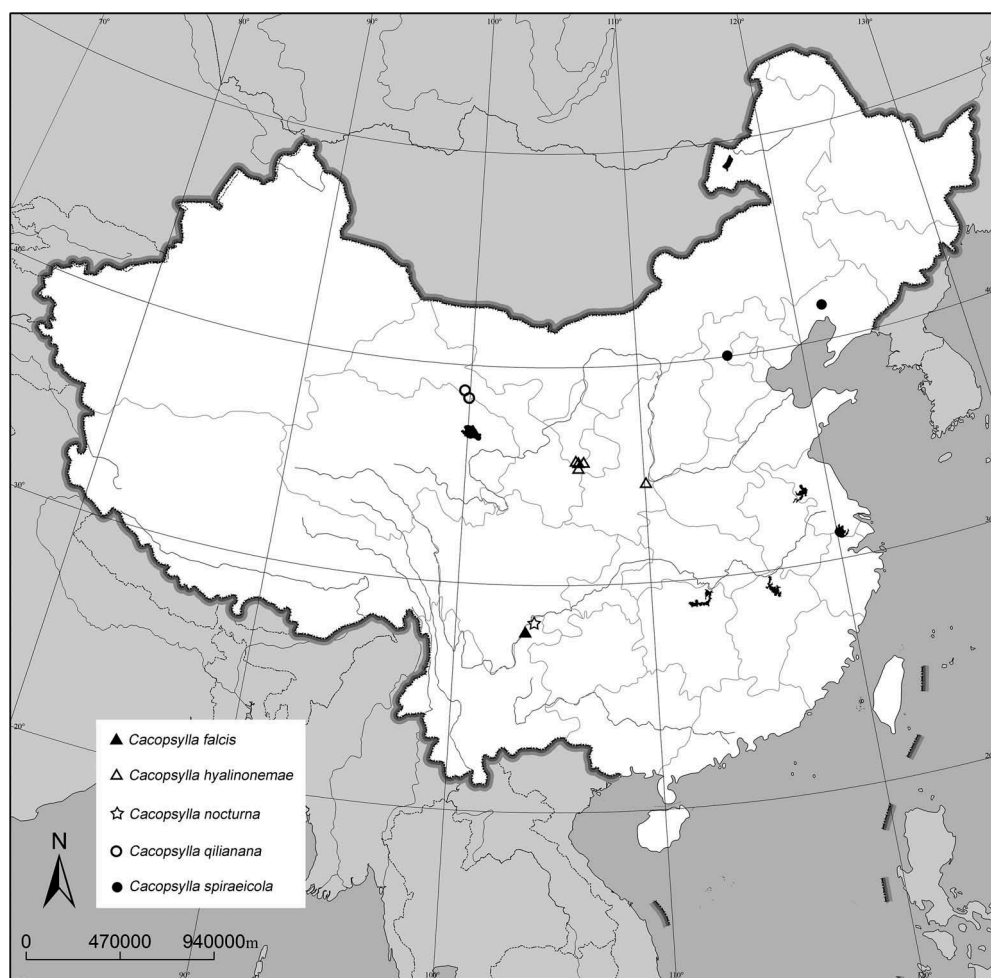


Figure 9. Distribution map of *Cacopsylla* spp. associated with *Spiraea* in China.

mounted, Lingshan, Mentougou, Beijing, China, 16 April 2012, Luo Xinyu, on *Spiraea trilobata* L.

Host plant

Unknown. In April of Liaoning province and Beijing, all psyllids are still in hibernation. *Spiraea* spp. recorded here are probably shelter plants.

Discussion

Due to their conspicuous diversity in morphology, the five species involved in this article do not constitute a monophyletic group. However, *Cacopsylla falcata* sp. nov. and *Cacopsylla nocturna* sp. nov. display great resemblance in: female not conspicuously larger than male in size, vertex rather short longitudinally in lateral aspect and with strongly bulging anterior portion, long and slender genal processes, oval fore wing

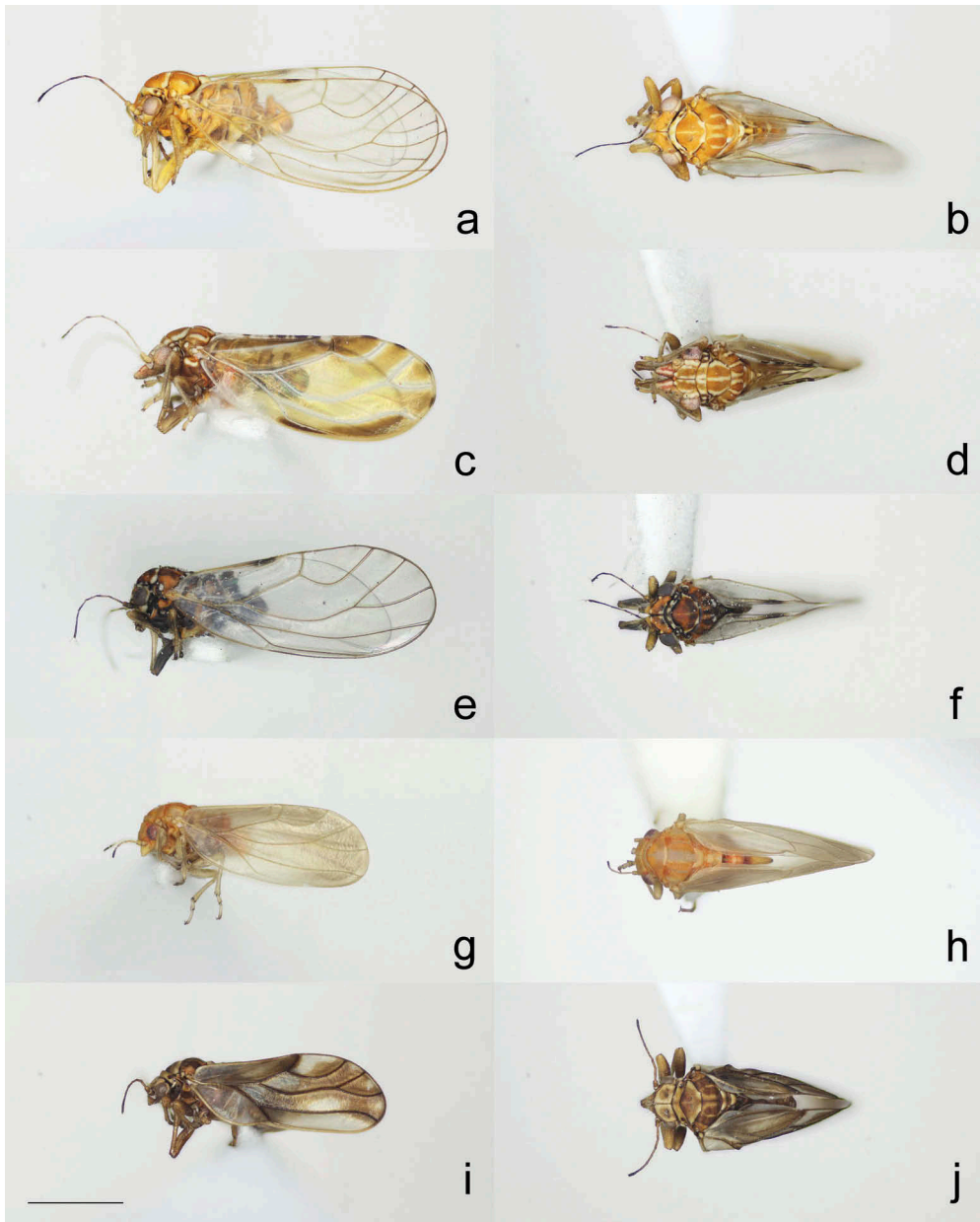


Figure 10. Photographs of dried specimens of *Cacopsylla* spp., adult. (a–b) *C. falcata* sp. nov.; (c–d) *C. hyalinonemae* Li and Yang, 1989; (e–f) *C. nocturna* sp. nov.; (g–h) *C. qilianensis* sp. nov.; (i–j) *C. spiraeicola* (Li, 2011). a, c, e, g, i. lateral view; b, d, f, h, j. dorsal view. Scale bar = 1 mm.

widest at apical 1/3, brown marking near anal break of fore wing, and rather long setae on apical process of female proctiger arranged in transverse rows. These characters define the two species as close relatives. Taking the immature characters of *C. falcata* (long capitates setae on body margin, 3 + 3 setae close to the lanceolate type on abdominal margin) into account, they are relatively more typical *Cacopsylla* members.

Although *C. spiraeicola* lacks genual spine on metatibia, possesses only four apical spurs, and bears rather dense surface spinules and radular spinules covering entire fore wing membrane, these characters are not crucial for *Cacopsylla*. The patterns on fore wing superficially resemble some *Elaeagnus*-feeding species such as *Cacopsylla gossypinmaculosa* Li 2011, but are intrinsically different from the latter. Patterns of *C. spiraeicola* leave breaches at the middle of cells, whereas that of the *Elaeagnus* feeders leave breaches around the apex of veins. We provisionally assign the species to *Cacopsylla* as it still resembles *Cacopsylla* more than it does *Euphaleropsis*, as the latter is an *Indigofera*-feeding genus of Macrocorsinae, mainly distributed in the Oriental Region, characterised as possessing black spots on the veins of the fore wing.

Cacopsylla qilianensis sp. nov. is another unique species that currently cannot be grouped with any other species. It possesses a rather distinctly outlined vertex whose plane is conspicuously above that of the gena and postocular sclerite, rather dense surface spinules covering the entire fore wing membrane, uniform radular spinules covering rather large areas on the fore wing, posteriorly produced male proctiger, paramere lacking conspicuously sclerotised apical tooth, female proctiger lacking peg setae and rows of long setae on apical process, and conical seta on dorsum of immature. These characters cannot be found in any other *Cacopsylla* species. Further findings are needed to determine the particular systematic position of *C. qilianensis* sp. nov.

Both *Cacopsylla falcata* sp. nov. and *C. nocturna* sp. nov. were collected in the mountainous areas in northern Zhaotong, a city in north-eastern Yunnan province, lying south of the Yangtze River (Figure 9). The physiognomy of forest above 1000 m in this area appears much more temperate than tropical, presenting us many undescribed Rosaceae-feeding *Cacopsylla* species, most of which follow the similarity of morphology stated above, and develop on host plants never recorded for psyllids. Our expedition in 2014 was very whistle-stop, and some further species around these two in future collections in this area can be expected.

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Disclosure statement

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