

Description of two new species of *Syphacia* (Nematoda: Oxyuridae) collected from *Eropeplus canus* (Rodentia: Muridae), an endemic rat of Sulawesi, Indonesia, with proposal of new subgenera

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Abstract. Two new subgenera of the genus *Syphacia* (Nematoda: Oxyuridae) are proposed for two new species collected from the caecum of *Eropeplus canus*, an endemic murid of Sulawesi, Indonesia. *Syphacia* (*Rumbaisyphacia*) *kumis*, new subgenus and new species has setiferous apical margin of pharynx in both sexes, and *Syphacia* (*Segienamsyphacia*) *yunia*, new subgenus and new species has a hexagonal oral opening in female and an egg with an operculum located closer to equator, being readily distinguished from other congeners hitherto known. The peculiar morphology of these species suggests that they belong to different lineages from that of *Syphacia* spp. recorded so far from Sulawesi. They might have been introduced with an ancestral murid linking *Eropeplus* and *Lenothrix*, one of the most primitive rats on Sundaland, and coevolved in Sulawesi.

Key words. Indonesia, Sulawesi, *Syphacia*, new subgenus, *Eropeplus canus*

INTRODUCTION

The Sulawesi soft-furred rat, *Eropeplus canus* Miller & Hollister, 1921 (Rodentia: Muridae: Murinae), is one of the endemic murids of Sulawesi, Indonesia, and the sole member of the genus. This species is known only from a few mountainous localities and has been recorded between 1,800 and 2,300 m (Musser & Carleton, 2005). Because its extent of occurrence is less than 20,000 km², *E. canus* is now classified as vulnerable (IUCN, 2013).

Helminthological study on *E. canus* was only made during the medicozoological survey of Sulawesi in 1992: four individuals were examined, three new heligmonellid nematodes, i.e., *Hasanuddinina maxomyos* Hasegawa & Syafruddin, 1994, *Heligmonoides musseri* Hasegawa & Syafruddin, 1994, and *Paraheligmonelloides eropeplios* Hasegawa, Miyata & Syafruddin, 1999 were described, and one chabertiid, *Cyclodontostomum purvisi* Adams, 1933 was reported (Hasegawa & Syafruddin, 1994a, b; Hasegawa et al., 1999). Besides these nematodes, presence of *Syphacia* Seurat, 1916 species (Oxyuridae: Syphaciinae) in the caecum of them was noticed but further examination has not been made thereafter. Recently we re-examined the materials and

found two species with peculiar morphology concomitantly infected. They are described as new species herein.

MATERIAL AND METHODS

The host rats were purchased from a local farmer, who trapped them in Lambanan, South Sulawesi Administrative District, Indonesia, using traditional snap traps. The alimentary tracts were removed and fixed in 10% formalin solution. They were transported to the laboratory of the junior author (H. H.). Contents of the caecum were transferred to a petri dish, and observed for helminths under a stereomicroscope. The host identification was made based on skulls extracted. Pinworms were collected from the caecum of *E. canus*. Prior to examination specimens were cleared in glycerine + lactophenol + alcohol solution (4:1:4) and then studied under a compound Olympus BH-2 series microscope with a drawing tube as temporary wet mount. Freehand cross sections were made using small piece of razor blade. Measurements were made with an ocular micrometer. For SEM examination, specimens were post-fixed in glutaraldehyde, dehydrated through an ethanol series and vacuum-dried using TAITEC VC-96N, at least for 30 minutes. Dried specimens were then coated with gold at 5–8 mA for 5 min. After coated, specimens were studied using a JEOL JSM5310LV scanning electron microscope (SEM) at an accelerating voltage of 20 kV. Measurements were given in micrometres unless otherwise stated, and presented as holotype/allotype, the range of paratypes in the square brackets and followed by the mean in parentheses. Type specimens were deposited in Museum Zoologicum Bogoriense (MZB), Bogor, Indonesia.

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TAXONOMY

All of the four individuals of *E. canus* examined were infected with two species of *Syphacia*, especially numerous in number in one host. Both of the two species were easily distinguished by different body size under stereomicroscope.

Family Oxyruidae Cobbold, 1864

Genus *Syphacia* Seurat, 1916

Subgenus *Rumbaisyphacia*, new subgenus

Diagnosis. Cephalic plate round. Cephalic papillae pedunculated. Amphidial pores with porous patches laterally. Cephalic vesicle present. Cervical alae absent. Lateral alae vesicular. Pharynx with setiferous apical margin. Male with three mamelons. Gubernaculum with non-ornamented accessory piece. Parasites of murid rodents.

Type and only species. *Syphacia (Rumbaisyphacia) kumis*, new species

Syphacia (Rumbaisyphacia) kumis, new species

(Figs. 1–18)

Material examined. Holotype male and allotype female (MZBNa 624), 10 males and 10 females paratypes (MZBNa 625), Lambanan, Sulawesi, Indonesia, coll. H. Hasegawa, 31 July 1992.

Description. General: Medium sized pinworm with subgeneric characteristics defined above. Cuticle with faint transverse striations. Oral aperture surrounded by three triangular lips, one dorsal and two subventral; anterior margin of pharynx setiferous; four large cephalic papillae pedunculated, situated squarely; amphids close to subventral cephalic papillae. Oesophagus of typical oxyuroid form with valved bulb. Nerve ring anterior to midlevel of oesophageal corpus. Cephalic vesicle extending to nerve ring level. Deirids not seen.

Male (holotype and 10 paratypes): Total length 1.61 [1.51–1.72] (1.65) mm, maximum width 119 [111–128] (125). Posterior body bent ventrally. Cephalic papillae situated trapezoidally with wider distance ventrally. Lateral alae large, vesicular. Total oesophagus 377 [352–393] (353) long: pharynx 18 [13–17] (16) long and 24 [17–24] (22) wide, corpus 292 [252–278] (273) long and 43 [34–39] (37) wide, isthmus 21 [16–25] (21) wide at narrowest level, and bulb 67 [52–70] (67) long by 67 [68–78] (71) wide. Nerve ring 128 [127–147] (132), and excretory pore far posterior to oesophago-intestinal junction, protruded, 612 [568–667] (617) from cephalic end. Three mamelons with prominent annulations developed at ventral posterior body; anterior mamelon 84 [72–103] (92) long, middle mamelon 102 [92–103] (97) long and posterior mamelon 72 [64–100] (80) long. Distance from cephalic end to anterior edges of anterior, middle and posterior mamelons 793 [820–926] (862), 0.98 [1.04–1.16] (1.07) mm and 1.23 [1.21–1.37] (1.29) mm, respectively. Spicule single, relatively short, thin, needle-

shaped, 88 [79–84] (83) long, [i.e., 5.5 [4.72–8.58] (5.0)% of total body length (TBL)]. Gubernaculum 40 [39–42] (41) long with thin, unornamented accessory piece of 10 [10–12] (11) long. Caudal papillae present in 3 pairs, 2 pairs small, near cloaca and 1 pair, large, protruding posterolaterally. Tail 130 [108–136] (121) long [i.e., 8.1 [6.4–8.1] (7.4)% of TBL].

Female (allotype and 10 paratypes): Body slender, relatively stout; length 4.36 [3.21–4.12] (3.60) mm, width 248 [192–279] (212). Cephalic papillae situated quadrangularly. Distance between amphids 37.7–39.2 (n=2). Lateral alae small, vesicular. Total oesophagus 547 [470–537] (500) long: pharynx 19 [17–21] (19) long and 38 [33–38] (36) wide, corpus 422 [369–404] (384) long and 61 [47–56] (50) wide, isthmus 15–21 (18) long, 42 [28–39] (34) wide at narrowest level, and bulb 106 [96–114] (98) long by 122 [97–117] (108) wide. Nerve ring 165 [161–181] (174), and excretory pore 863 [726–861] (795), from cephalic end. Vulva protruded, 1.21 [0.97–1.16] (1.08) mm from cephalic end; vagina and ovejector directed posteriorly. Distance between excretory pore and vulva 347 [228–295] (270) [i.e., 7.9 [6.7–8.3] (7.6)% of TBL]. Eggs ellipsoidal, asymmetrical with one side flattened, operculated in convex side, shell surface pitted, embryonated in uteri, 96–102 × 34–40. Uterus extending anteriorly from just posterior of oesophageal bulb and ending posteriorly near anus. Tail relatively long, tapering to pointed end, 688 [500–607] (552) long [i.e., 15.8 [14.6–16.3] (15.3)% of TBL].

Type host. *Eropeplus canus* Miller & Hollister, 1921 (Sulawesi soft-furred rat) (Rodentia: Muridae).

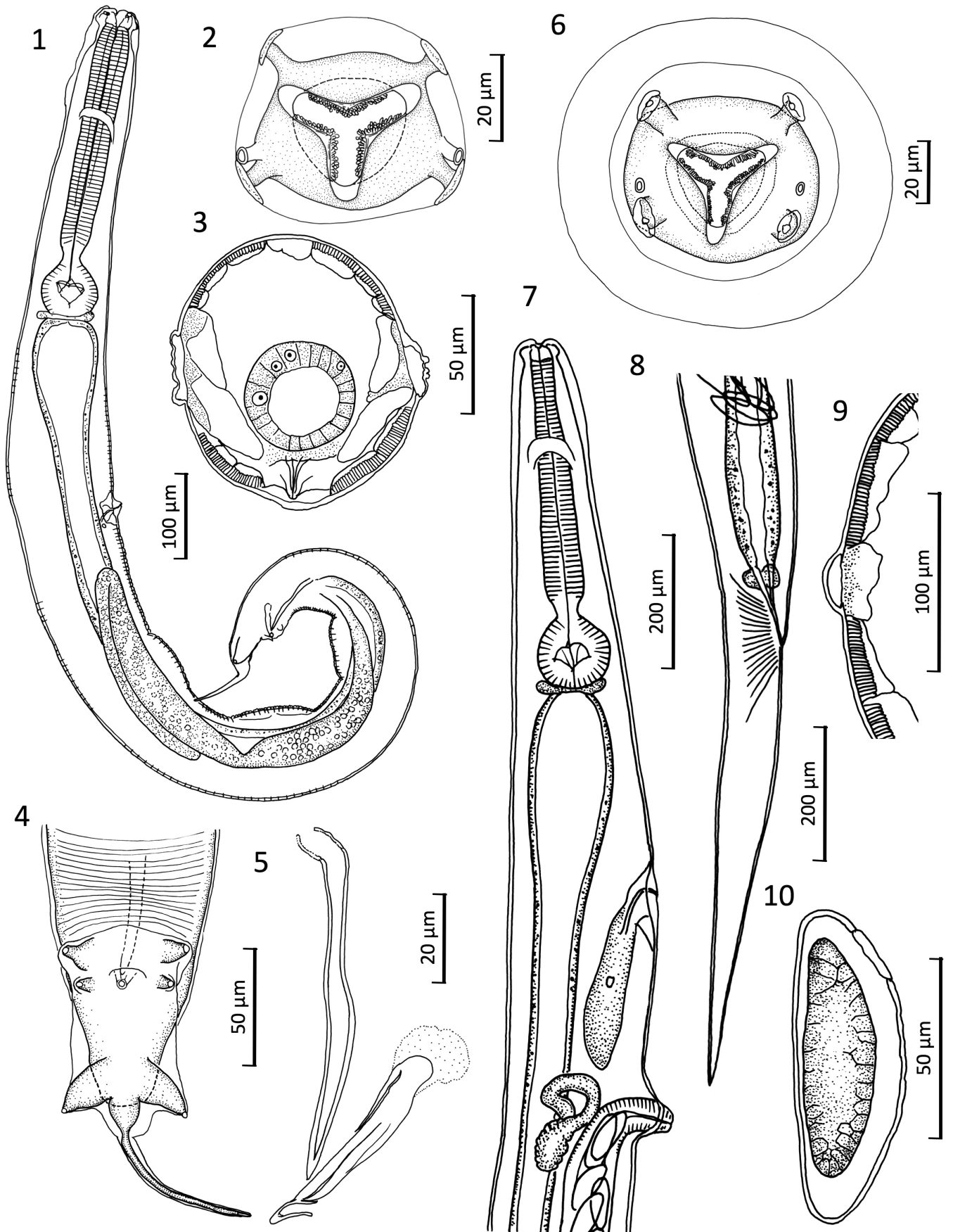
Symbiotype. The type host was deposited to the American Museum of Natural History with accession number M-267755.

Site of infection. Caecum.

Etymology. The subgeneric name was created by combining an Indonesian word ‘rumbai’, meaning fringe, and *Syphacia*, and the species epithet was derived from an Indonesian word ‘kumis’, which means moustach. Both words were adopted as the setiferous apical margin of pharynx reminds of fringed edge and moustach.

Remarks. This is a typical member of the genus *Syphacia* Seurat, 1916 by having three mamelons in males (Petter & Quentin, 1971; Hugot, 1988). Three subgenera have been recognised: *Syphacia* Seurat, 1916, *Cricetoxoyuris* Hugot, 1988, and *Sueratoxyuris* Hugot, 1988 (Hugot, 1988). By lacking cervical alae, developed deirids, and by having an unornamented accessory piece of gubernaculum, and vesicular lateral alae, it resembles subgenus *Syphacia* (Hugot, 1988). Pedunculated cephalic papillae arranged quadrangularly are also seen in *Syphacia (Syphacia) muris* (Yamaguti, 1935) (Quentin, 1971). However, setiferous apical margin of pharynx is a quite peculiar characteristic. A comparable structure has been known only in *Oxyuris* (Schrank, 1788) among the oxyuroids of vertebrates (Petter & Quentin, 1976; Gibbons, 2010). A new subgenus is hence proposed.

Distribution. Lambanan, Sulawesi, Indonesia (present study)



Figs. 1–10. *Syphacia (Rumbaisyphacia) kumis*, new species from *Eropeplus canus* in south Sulawesi, Indonesia. 1, male, holotype, lateral view; 2, cephalic end of male, apical view; 3, midbody in cross section of male; 4, posterior end of male, ventral view; 5, spicule and gubernaculum, lateral view; 6, cephalic end of female, apical view; 7, anterior portion of female, lateral view; 8, Posterior portion of female; 9, midbody in cross section of female; 10, egg.

Family Oxyruidae Cobbold, 1864

Genus *Syphacia* Seurat, 1916

Subgenus *Segienamsyphacia*, new subgenus

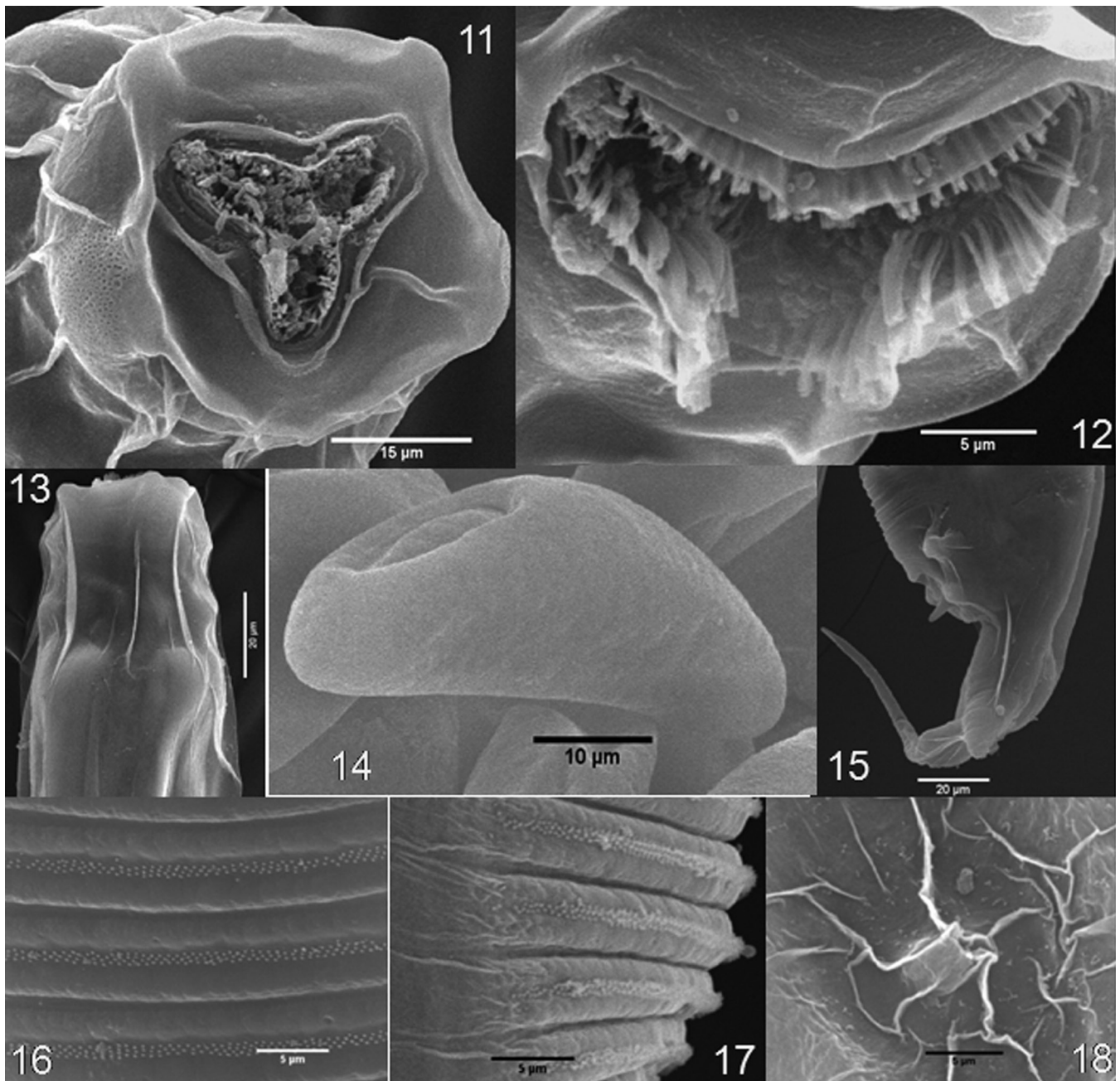
Diagnosis. Cephalic plate round. Cephalic papillae and amphidial pores forming circle. Amphidial pores with porous patches laterally. Cephalic vesicle present. Oral aperture triradiate, surrounded by 3 lips in male, hexagonal in female. Cervical alae absent. Lateral alae vesicular in male. Male with three mamelons. Accessory piece of gubernaculum unornamented. Parasites of murid rodents.

Type and only species. *Syphacia (Segienamsyphacia) yuniae* sp. n.

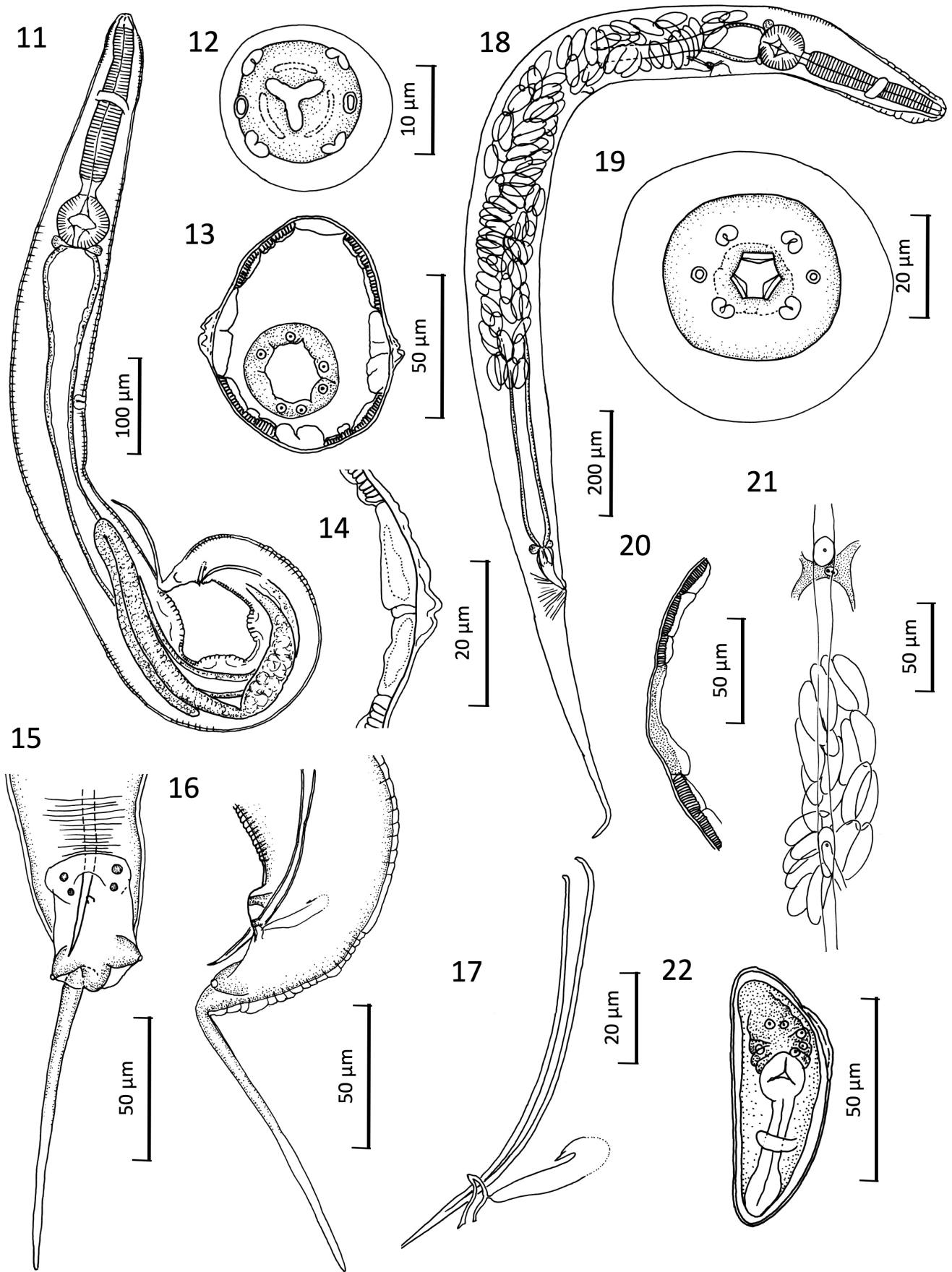
Syphacia (Segienamsyphacia) yuniae, new species
(Figs. 19–36)

Material examined. Holotype male and allotype female (MZBNa 626), 10 males and 10 females paratypes (MZBNa 627), Lambanan, Sulawesi, Indonesia, coll. H. Hasegawa, 31 July 1992.

Description. General: With subgeneric characteristics defined above. Small sized worms with cuticle striated transversely. Cephalic vesicle weakly developed. Amphidial pores slightly closer to subventral cephalic papillae than to subdorsal ones.



Figs. 11–18. SEM *Syphacia (Rumbaisyphacia) kumis*, new species from *Eropeplus canus* in south Sulawesi, Indonesia. 11, cephalic end, apical view; 12, mouth opening showing setiferous apical margin of pharynx; 13, anterior end, lateral view; 14, egg; 15, posterior end; 16, mamelon, ventral view; 17, mamelon (lateral view); 18, protruded vulva



Figs. 19–30. *Syphacia (Segienamsyphacia) yuniae*, new species from *Eropeplus canus* in south Sulawesi, Indonesia. 19, male, holotype, lateral view; 20, cephalic end of male, apical view; 21, midbody in cross section of male; 22, midbody in cross section of male, higher magnification; 23, posterior portion of male, ventral view; 24, posterior portion of male; lateral view; 25, spicule and gubernaculum, lateral view; 26, female, lateral view; 27, cephalic end of female, apical view; 28, midbody in cross section of female; 29, egg; 30, excretory pore and vulva, showing poorly developed vagina

Oesophagus with corpus, distinct isthmus and terminating in spherical bulb. Nerve ring at middle of oesophageal corpus. Deirid not seen.

Male (holotype and 10 paratypes): Posterior body bent ventrally; length 1.20 [1.00–1.25] (1.14) mm, maximum width 88 [70–86] (81). Mouth triradiate, surrounded by three lips; distance between amphidial pores 8.2–11.5 (n=2); lateral alae large; total oesophagus including pharynx, corpus and bulb 248 [247–277] (254) long: pharynx 10 [9–11] (10) long and 13 [10–13] (11) wide, corpus 182 [170–200] (179) long and 32 [24–29] (26) wide, isthmus [13–15] (13) long and 16 [13–15] (14) wide at narrowest level, bulb 57 [47–56] (52) long by 61 [50–55] (54) wide; nerve ring and excretory pore 88 [100–107] (109) and 412 [376–435] (404) from anterior end, respectively; three mamelons on ventral surface of body provided with many transverse bands, each with central rows of spinules: anterior mamelon 72 [60–77] (64) long, middle mamelon [35–54] (46) long and posterior mamelon 35 [24–38] (32) long; distance from cephalic end to anterior edges of anterior, middle and posterior mamelons 642 [592–726] (652), 756 [661–857] (758) and 907 [769–962] (867), respectively; spicule single, thin, needle-shaped, relatively long, 83 [64–82] (73) long [i.e. 6.9 [5.5–7.5] (6)% of TBL]; gubernaculum 24 [22–28] (25) long; accessory piece of gubernaculum unornamented, protruded from body 10 [9–12] (10); caudal papillae present in 3 pairs, 2 pairs small, near cloaca, and 1 pair large, post-cloacal, protruding posterolaterally; tail 158 [126–157] (149) long including whip-like process [i.e., 13.2 [10.2–14.3] (13)% of TBL].

Female (allotype and 10 paratypes): Length 2.35 [2.34–2.56] (2.45) mm, width 154 [155–200] (181). Cephalic vesicle present, extending posteriorly to nerve ring. Oral aperture hexagonal. Distance between amphidial pores 16.2–17.8 (n=2). Lateral alae absent; total oesophagus including

pharynx, corpus and bulb 378 [273–399] (381) long: pharynx 18 [16–22] (21) long and 28 [18–28] (20) wide, corpus 262 [245–287] (266) long and 50 [44–50] (47) wide, isthmus 24 [18–28] (22) wide at narrowest level, bulb 85 [72–85] (81) long by 91 [83–95] (87) wide; nerve ring 141 [112–148] (141), excretory pore 472 [471–570] (501) from cephalic end; vulva not protruding, 755 [753–853] (811) from cephalic end; vagina and ovejector weakly developed, directed posteriorly; distance between excretory pore and vulva 283 [201–324] (269) [i.e. 12.0 [8.1–12.8] (10.9)% of TBL]. Eggs asymmetrical with one side flattened, having operculum on convex side, closer to equator of egg, shell surface densely pitted, containing embryo with visible oesophagus in uterus, 68–74 (71.5) × 24–28 (25.7); uterus occupying in the middle of body, extending from level of excretory pore to near posterior end of middle 1/3 of body; tail long conical with pointed end, relatively long, 519 [469–540] (520) [i.e., 22.1 [19.4–23.1] (21.1)% of TBL].

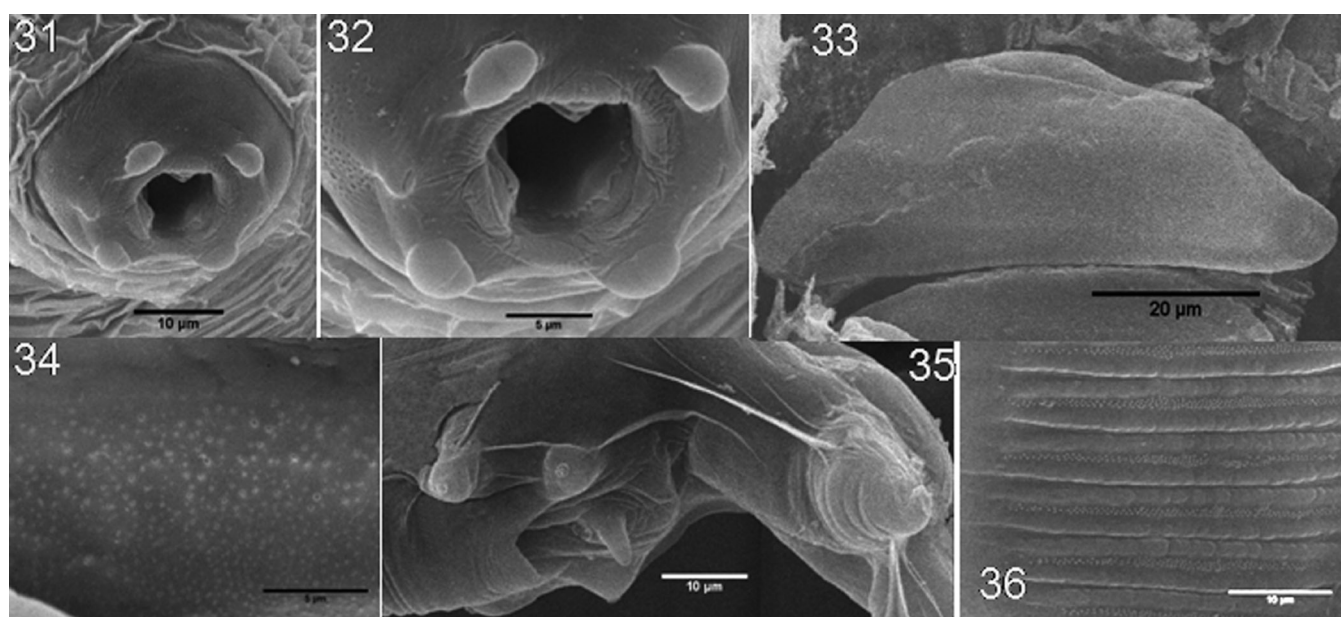
Type host. *Eropeplus canus* Miller & Hollister, 1921 (Sulawesi soft-furred rat) (Rodentia: Muridae).

Symbiotype. The type host was deposited to the American Museum of Natural History with accession number M-267755.

Site of infection. Caecum.

Etymology. Subgeneric name was created by combining Indonesian word 'Segi enam' meaning hexagonal, symbolising hexagonal oral shape in female, and *Syphacia*. Species epithet is dedicated to Ms. Yuni Apriyanti, to whom we are greatly indebted on preparation of specimen for SEM observation.

Remarks. This is also a typical member of the genus *Syphacia* Seurat, 1916 by having three mamelons in males (Petter & Quentin, 1971; Hugot, 1988). Among the three



Figs. 31–36. SEM *Syphacia* (*Segienamsyphacia*) *yuniae*, new species from *Eropeplus canus* in south Sulawesi, Indonesia. 31, cephalic end of female, apical view; 32, cephalic end of female, apical view, higher magnification; 33, egg; 34, enlarged view of eggshell surface; 35, caudal papilla of male, lateral view; 36, mamelon, ventral view.

subgenera recognised, it is close to the subgenus *Syphacia* by lacking cervical alae and developed deirids, and by having an unornamented accessory piece of the gubernaculum and vesicular lateral alae (Hugot, 1988). However, the hexagonal oral shape in the female has not been known for other members of the subgenus *Syphacia* species and other two subgenera. Hence new subgenus is proposed. Similar oral shape has been known in *Oxyuris*, *Brasilnema* Moravec et al., 1992, *Paraustroxyuris* Mawson, 1964, *Petronema* Hugot, 1983, *Royandersonia* Moravec & Van As, 2004 among the oxyuroids parasitic in vertebrates (Petter & Quentin, 1976; Gibbons, 2010). The egg operculum position is also characteristic because most congeners of *Syphacia* have an egg operculum closer to pole (Quentin, 1971; Petter & Quentin, 1976; Hugot, 1988).

Distribution. Lambanan, Sulawesi, Indonesia (present study)

DISCUSSION

The pinworms of the genus *Syphacia* seem to have rather strict host-specificity, and are believed to have co-evolutionary relationship with their hosts, though some host switching could be also possible (cf. Hugot, 1988). In Indonesia, six species have been described besides the cosmopolitan species, *S. muris*, in *Rattus* spp.; four *Syphacia* species from endemic murids in Sulawesi, namely, *S. sulawesiensis* Hasegawa & Tarore, 1996 in *Rattus xanthurus* (Gray, 1867), *S. rifaii* Dewi & Hasegawa, 2010 in *Bunomys* spp., *S. taeromyos* Dewi & Hasegawa, 2012 in *Taeromys celebensis* (Gray, 1867), and *S. paruromyos* Dewi & Hasegawa, 2012 in *Paruromys dominator* (Thomas, 1921); one species, *S. longaecauda* Smales, 2001, in *Melomys monktoni* Thomas, 1904 from Papua; *S. semiadii* Dewi, Asakawa & Fitriana, 2014 from *Halmaheramys bokimekot* Fabre et al., 2013 from Halmahera Island (Hasegawa & Tarore, 1996; Smales, 2001; Dewi & Hasegawa, 2010, 2012; Dewi et al., 2014).

The present two new species assigned to new subgenera share some of common features with all hitherto-known *Syphacia* species recorded from Sulawesi, e.g., cephalic plate is not elongated laterally or lacks dorsoventral constriction laterally, lateral alae are more or less vesicular, accessory piece of gubernaculum is simple, lacking ornamentation, in males (Hasegawa & Tarore, 1996; Dewi & Hasegawa, 2010, 2012; our unpublished observation on *S. muris*). It is hence surmised that they have derived from the same origin, and specialised. The host rat of the present new species is considered to have a close phylogenetic relationship with *Lenothrix* on the Sunda shelf (Musser & Newcomb, 1983; Musser, 1987). *Lenothrix* has been regarded to be a member of the earliest group, which have derived from the core murine lineage in Sundaland (Musser & Carleton, 2005). Hence it is of special interest to know whether *Lenothrix* harbors *Syphacia* species comparable to those in *Eropeplus*. It is also necessary to know whether these pinworms are really parasitic only in *E. canus* or are shared by some sympatric murids.

Concomitant infection with plural *Syphacia* species in a host is not a common feature. For example, Hasegawa &

Tarore (1996) found *S. sulawesiensis* and *S. muris* from *R. xanthurus* in North Sulawesi, but mixed infection was not proved. Weaver & Smales (2008) reported five *Syphacia* species from *Pseudomys hermannsburgensis* (Waite, 1896), but concomitant infection was also not noted. *Syphacia emileromani* Chabaud et al., 1963 and *S. frederici* Roman, 1945 are commonly parasitic in *Apodemus speciosus* (Temminck, 1844) and *A. argenteus* (Temminck, 1844) in Japan, but concomitant infection with them is very rare (junior authors' unpublished observation). Apparently, the ecological principle that plural species cannot occupy the same niche is acting. Although mixed infection of the golden hamster with three *Syphacia* species has been reported, it may be an exceptional case occurred in captive condition (Hasegawa et al., 2008). It is hence interesting that the present four hosts all harbored both pinworm species. In such a mixed infection, there might be some segregation in microhabitat or nutrient demand. Although the present two pinworm species use the same habitat, it is suggested that they may take different food material as the setiferous anterior margin of pharynx of *S. (R.) kumis* could serve a role as a strainer.

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