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REVISION OF THREE APHIDS DESCRIBED FROM A RED-VEIN MAPLE ACER RUFINERVE IN JAPAN (HEMIPTERA: APHIDIDAE)

By SHUN'ICHIRO SUGIMOTO

Abstract

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Morphological study and rearing experiment of *Acer rufinerve*-infesting aphids collected at the Rokkô Mountains in Hyôgo Prefecture, western Japan showed that three aphids *Trichaitophorus koyaensis* Takahashi, *T. takahashii* Sorin and *Periphyllus montanus* Sorin are all the same species. Synonyms are listed under the valid name *T. koyaensis*. The fundatrix, oviparous female and male of *T. koyaensis* are described for the first time. Morphological variation of the apterous and alate viviparous females is added, and the life cycle is provided.

Author's address. Kôbe Plant Protection Station, 1–1 Hatoba-chô, Chûô-ku, Kôbe, 650–0042 Japan. (Present address: Yokohama Plant Protection Station, 5–57 Kitanakadôri, Naka-ku, Yokohama, 231–0003 Japan).

Introduction

There are the following three aphids known from the red-vein maple, *Acer rufinerve* (Aceraceae), in Japan: *Trichaitophorus koyaensis* Takahashi, 1961; *T. takahashii* Sorin, 2002; *Periphyllus montanus* Sorin, 1979. The genus *Trichaitophorus* is characterized by having head fused with pronotum and long thick, hollow setae only around margin of body (Blackman & Eastop, 2012). The two Japanese *Trichaitophorus* species *T. koyaensis* and *T. takahashii* are described based on apterous viviparous females (Takahashi, 1961; Sorin, 2002). They are distinguishable from each other by the first tarsal chaetotaxy (Sorin, 2002) and the relative length of the longest seta on hind tibiae to the middle width of the tibia (Blackman & Eastop, 2012). On the other hand, *P. montanus* is described based on apterous and alate viviparous females (Sorin, 1979). Although this species is placed under the genus *Periphyllus*, it is different from other Japanese *Periphyllus* species by having head fused with pronotum in the apterous viviparous female and shorter setae on the antennal segment in the apterous and alate viviparous females (Sorin, 1979). Sexual morphs and life cycle of these three species are unknown (Blackman & Eastop, 2012), except that the first instar larvae of *T. takahashii* have lamellate marginal setae (Sorin, 2002) as in the aestivating larvae of some *Periphyllus* species.

During my recent field observation on *A. rufinerve*-infesting aphids at the Rokkô Mountains in western Japan, I collected the apterous viviparous females each of *T. koyaensis* and *T. takahashii*, the apterous and alate viviparous females of *P. montanus*, and the fundatrices, oviparous females and males of a *Periphyllus*-like species. To clarify the taxonomic relationships of these species, I examined their morphology based on specimens from the field observation and by rearing colonies. Detailed examination showed that the nominal species, *T. koyaensis*, *T. takahashii* and *P. montanus*, and the *Periphyllus*-like species are all referable to the same species, and that apterous viviparous females seemingly with the characters of *T. koyaensis*, *T. takahashii* or *P. montanus* are morphological variants within the same morph. In the present paper, I describe and illustrate each morph of the *Acer rufinerve*-infesting aphids under the valid name *T. koyaensis*, and provide its life cycle.

Materials and Methods

Field observation and sampling. A field observation for *A. rufinerve*-infesting aphids was conducted at the Rokkô Mountains in Hyôgo Prefecture, western Japan, which include the type localities of *P. montanus* (Mt. Futatabi) and *T. takahashii* (Mt. Rokkô). To determine aphid species and its morph on *A. rufinerve*, larvae and adults were collected at several sites in the Rokkô from 2009 to 2012, and also monthly collected from a single *A. rufinerve* tree at Mt. Shakunage (located between Mt. Futatabi and Mt. Rokkô) from April to November 2012. The collected samples were preserved in 70% ethanol.

Rearing experiment. As a supplement to the above monthly sampling, a rearing experiment was conducted in the spring of 2012 using potted seedlings of *A. rufinerve* under the natural day length in the laboratory. For the rearing experiment, one fundatrix of a *Periphyllus*-like species was collected at Arima-onsen, the northern foot of the Rokkô on 14 April 2012. It was transferred onto one of the seedlings, and its offspring

were reared successively on the same seedlings as a rule. When the alatae emerged on the seedling, they were transferred to a new one. The experiment was conducted by July 2012. To identify aphids on the seedlings, some larvae, adults and larval exuvia were collected at random, and these samples were preserved in 70% ethanol.

Morphological examination. The samples preserved were mounted on microscope slides in balsam by Martin's (1987) methods. Among them, the specimens of apterous viviparous females and larvae were stained by acid fucshin before the dehydration by glacial acetic acid. Morphological inspections were based on mounted specimens prepared by me and the borrowed specimens. The former specimens are deposited in the Laboratory of Systematic Entomology, Hokkaido University (SEHU). The latter ones are the holotype of *T. koyaensis* and the authentic specimens identified as *T. koyaensis* by Dr. Ryoichi Takahashi in SEHU, and the paratypes of *T. takahashii* and the authentic specimens identified as *P. montanus* by Dr. Masato Sorin in the National Institute of Agro-Environmental Sciences (NIAES). In the usage of morphological terms in the following text, I followed Miyazaki (1987).

Descriptions

Trichaitophorus koyaensis Takahashi
[Japanese name: Urihadakaede-ke-aburamushi]

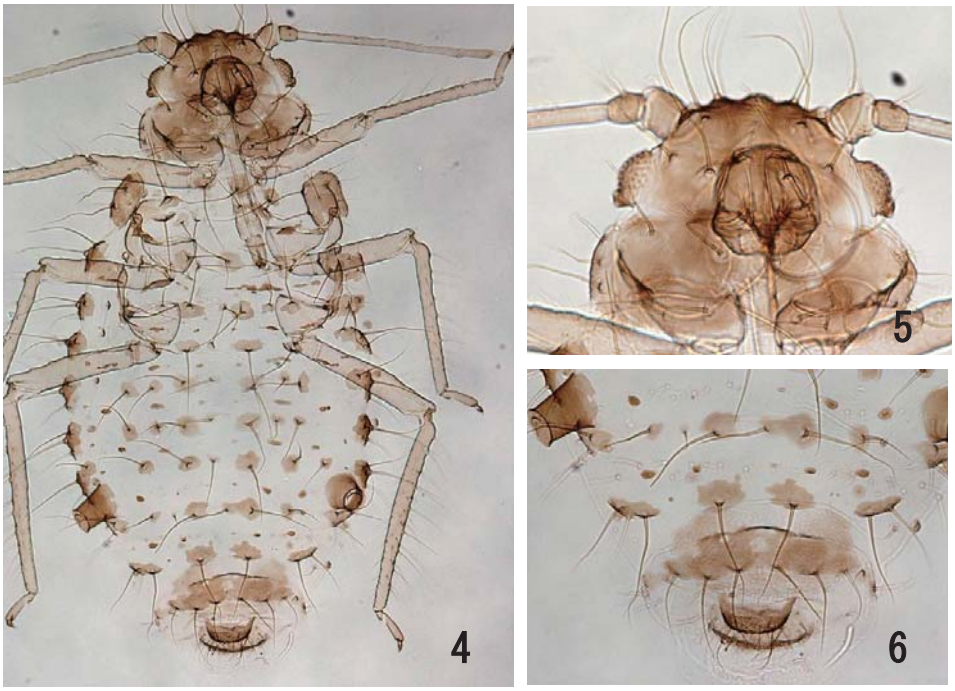
Trichaitophorus koyaensis Takahashi, 1961: 248.
Trichaitophorus koyaensis; Higuchi, 1972: 98; Sorin, 1977: 153; Togashi, 2002: 7.
Periphyllus montanus Sorin, 1979: 120. syn. nov.
Periphyllus montanus; Sorin, 1990: 799; Togashi, 2001: 25.
Trichaitophorus takahashii Sorin, 2002: 184. syn. nov.

This species has been known by apterous and alate viviparous females. The fundatrix, oviparous female and male are described for the first time.

Fundatrix (Figs 1–3). Apterous. Color in life specimen: body brownish green. In mounted specimen: body membranous and not pigmented. The following characters dark brown; head, pronotum, marginal sclerites and dorsal scleroites on mesonotum to abdominal segment VII, sclerotic band on abdominal segment VIII, siphunculi and cauda.

Body oval, 2.65–3.80 mm long, with numerous dorsal hair-like setae which differ in length and thickness. Head smooth dorsally, sparsely spinulated ventrally, in some individuals fused with pronotum on spinal area, with 26–36 dorsal setae, of which the longest one is 6.9–10.0 times as long as the basal width of antennal segment III; frons produced forward, not surpassing apex of antennal segment I. Antennae 6-segmented, 0.33–0.42 times as long as body; segments I and II smooth, with 3–5, 2–3 setae, respectively; segments III to VI imbricated, with 2–6 setae on III, of which the longest one is 1.4–2.3 times as long as the basal width of III; processus terminalis 1.2–1.6 times as long as basal part of terminal segment; primary rhinaria with minute cilia. Rostrum reaching middle coxae; ultimate segment 0.9–1.0 times as long as segment II of hind tarsus, with 2–4 secondary setae. Tibiae almost smooth with only a few inconspicuous spinules on distal part of middle and hind tibiae, with numerous setae, of which the longest one is 2.7–3.4 times as long as the middle width of hind tibia. First tarsal

Figs 1–3. Fundatrix. 1: general aspect; 2: head; 3: posterior part of abdomen.



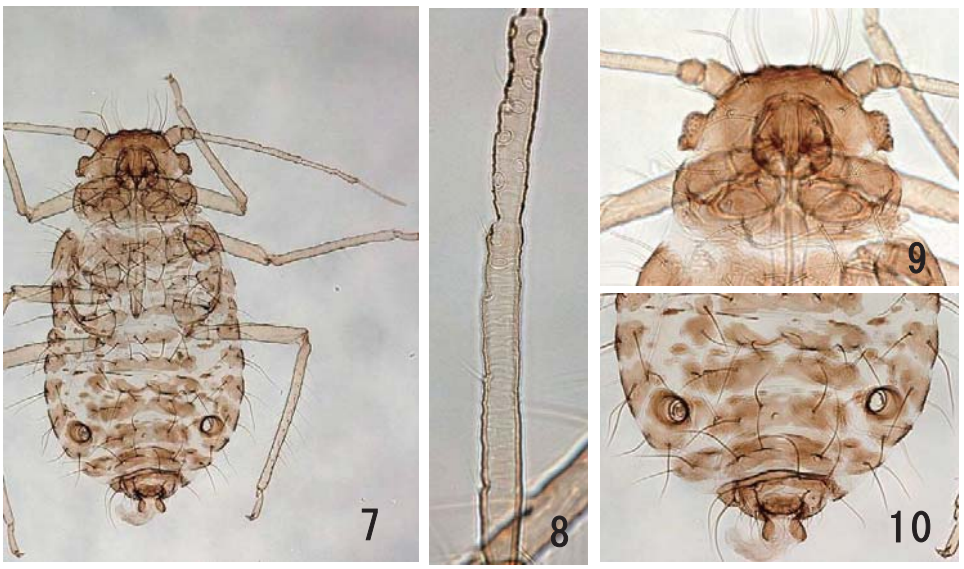
Figs 4–6. Oviparous female. 4: general aspect; 5: head; 6: posterior part of abdomen.

chaetotaxy 5:5:5. Abdomen with dorsal setae arranged in somewhat double or triple transverse rows on each tergite; a pair of spinal setae on each tergite longer and stouter than other dorsal setae; the longest seta of dorsal ones 6.9–10.0 times as long as basal width of antennal segment III; tergite VIII with 8–13 setae on sclerotic band; marginal sclerites on segments I to VII each with 5–12 setae, of which the longest one is the same length and thickness as spinal ones. Siphunculi truncate and smooth, with a flange, weakly reticulated at apex. Cauda broadly rounded, with 12–16 setae.

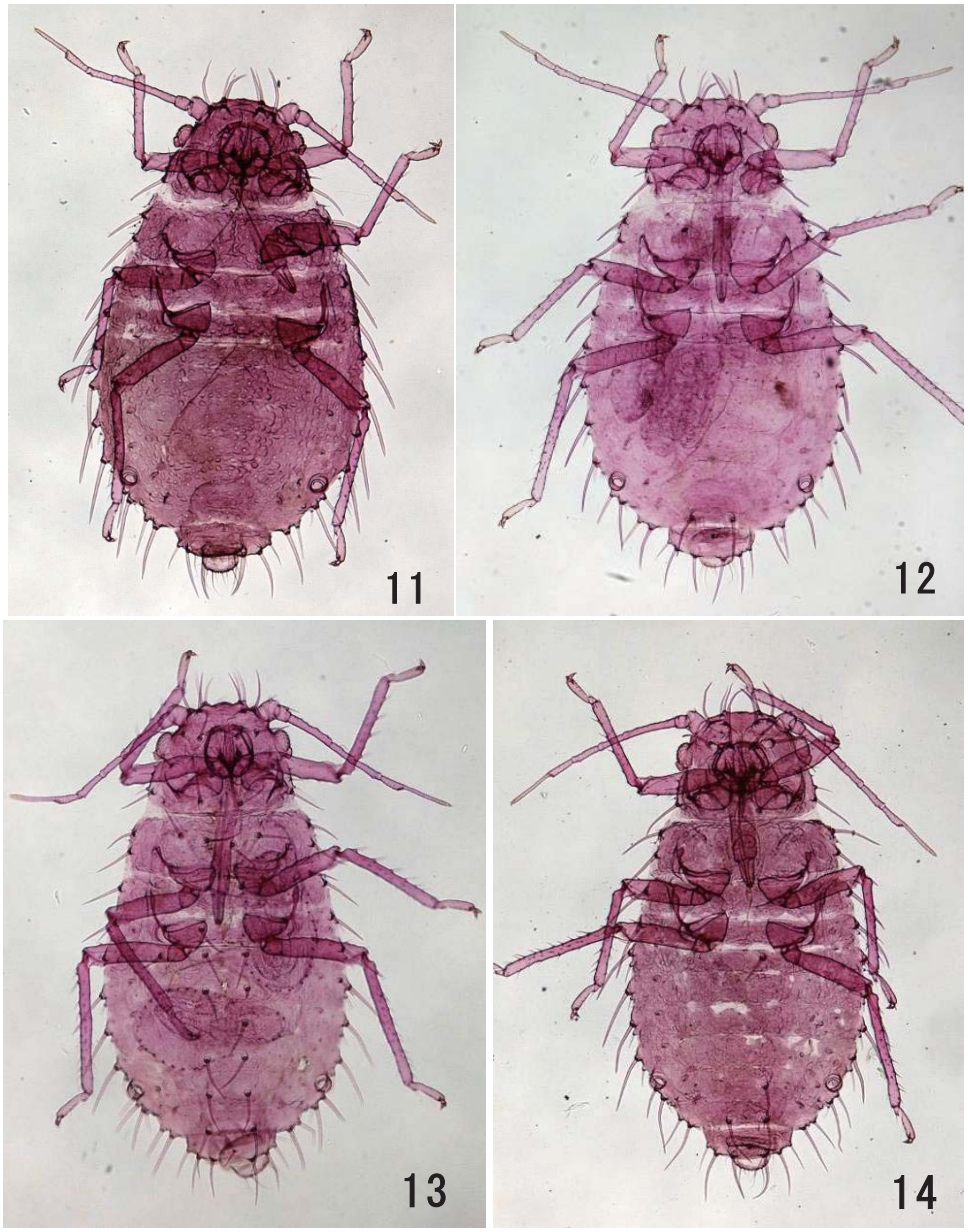
Oviparous female (Figs 4–6). Apterous. Color in life specimen: body dark brown to brown. In mounted specimen: sclerotization and pigmentation as in the fundatrix.

Body 1.96–2.50 mm long. Head almost fused with pronotum, with 8 dorsal setae, of which the longest one is 8.2–11.5 times as long as the basal width of antennal segment III. Antennae 6-segmented, about 0.44–0.48 times as long as body; segment III with 2–5 setae, of which the longest one is 1.2–3.0 times as long as the basal width of the segment; primary rhinaria with minute cilia; processus terminalis 2.0–2.6 times as long as basal part of terminal segment. Ultimate rostral segment 0.88–0.96 times as long as segment II of hind tarsus, with 2 secondary setae. Thorax with dorsal setae arranged in double transverse rows on pronotum and mesonotum and in a single transverse row on metanotum. Hind tibiae more or less swollen, with 2–32 scent plaques. First tarsal chaetotaxy 5:4–5:3–5. Abdomen with dorsal setae arranged in a single transverse row on each tergite; tergites I to VI with 3 or 4 pairs of setae, tergite VII with 2–5 setae, tergite VIII with 6–8 setae along the hind margin of sclerotic band; marginal sclerites on segments I to VI each with 2 or 3 setae. Siphunculi as in the fundatrix. Cauda with 12–19 setae.

Male (Figs 7–10). Apterous. Color in life specimen: body mottled green. In mounted specimen, the following characters brown in color: head, pronotum, siphunculi, dorsal bands on meta- and mesonota, scleroites at the base of the dorsal setae on pleural and



Figs 7–10. Male. 7: general aspect; 8: antennal segments III and IV; 9: head; 10: posterior part of abdomen.



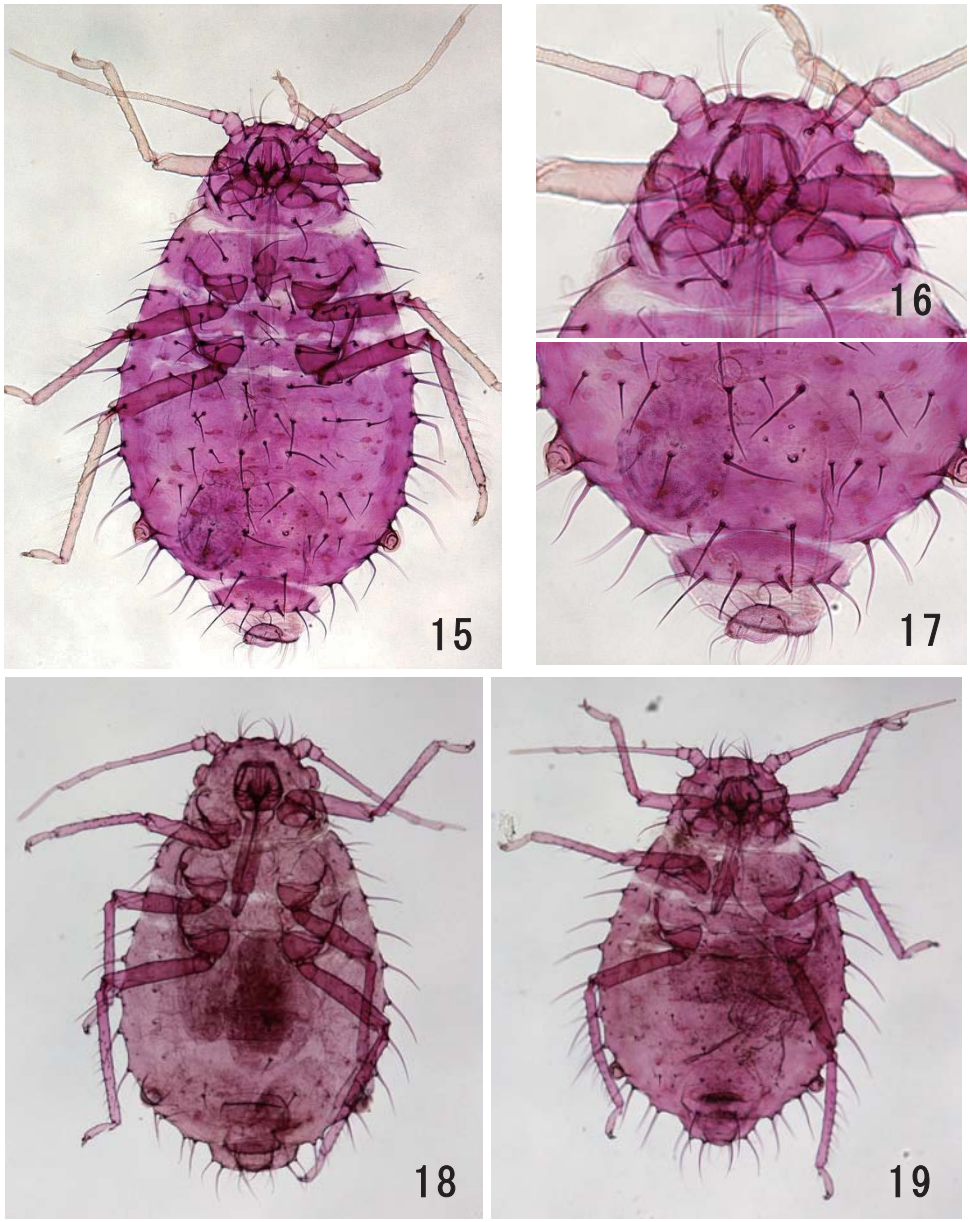
Figs 11–14. Apterous viviparous females (11–12, summer form; 13–14, third generation). 11: typical summer form; 12: individual with 6 dorsal stout setae on head and a pair of mesal stout setae on abdominal tergite VII; 13: individual with a pair of mesal setae on each abdominal tergite; 14: individual with fewer mesal setae.

spinal area of abdominal segments I to VI, dorsal bands on abdominal segments VII and VIII, and marginal sclerites.

Body 1.43–1.66 mm long. Head fused with pronotum. Antennae 6-segmented, about 0.56–0.70 times as long as body; segment III with 0–7 (usually 3–7) secondary rhinaria on apical 1/3, and with 2 or 3 setae, of which the longest one is 1.0–2.0 times as long as the basal width of the segment; segment IV with 5–11 secondary rhinaria on whole length; segment V with 0–2 secondary rhinaria; primary rhinaria with minute cilia; processus terminalis 2.1–2.6 times as long as basal part of terminal segment. Ultimate rostral segment 0.88–0.96 times as long as segment II of hind tarsus, with 2 secondary setae. First tarsal chaetotaxy 5:5:5. Siphunculi as in the fundatrix. Cauda with 7–9 setae. The dorsal chaetotaxy on head, thorax and abdomen is the same as in the oviparous female.

Apterous viviparous female (Figs 11–19). There are apparently two forms in this morph, of which one appears from May to early September (hereinafter "summer form"), and the other one from August to October (hereinafter "autumn form"). The summer form (Figs 11, 12) is characterized by having body corrugated on dorsum and by lacking long dorsal setae, while the autumn one (Figs 15–17) by having smooth body and long dorsal setae, although the intermediate form (Figs 18, 19) between the summer and autumn ones also appears in August and early September.

The summer form is described by Takahashi (1961) and Sorin (2002) under the names *T. koyaensis* and *T. takahashii*, respectively. Judging from the original descriptions and figures of these species, *T. koyaensis* is distinguishable from *T. takahashii* by having the pronotum with a pair of minute setae on the dorsolateral area (long stout setae in the latter), the longest seta on hind tibiae that is twice as long as the middle width of the tibia (1.22 times), the first tarsal segments all with 3 setae (3–5 setae), and the abdominal segments I to V each with one long, stout marginal seta (2 or 3 setae, of which one is long and the other ones short or minute). However, these differences were completely included within the variation range of the summer form including the holotype of *T. koyaensis* and the paratypes of *T. takahashii*. Based on present specimens collected on May to early September, the following additional characters were observed: 1) body 0.86–1.55 mm long, 1.5–1.8 times as long as the maximum width; dorsum corrugated, but in some specimens collected on August and early September including the holotype of *T. koyaensis* weakly corrugated or somewhat smooth, 2) head usually with 4 long, stout dorsal setae, but in some specimens collected on May with 6 long stout setae, 3) antennae 5- or 6-segmented, 0.38–0.51 times as long as body; processus terminalis 1.2–1.9 times as long as basal part of terminal segment; primary rhinaria with cilia, 4) pronotum with or without a pair of long stout setae on dorsolateral area, 5) tibial setae variable in length and shape, of which the longest one on hind tibiae is 0.8–2.5 times as long as the middle width of the tibia; outer setae on hind tibiae often short and stout with blunt apices in specimens collected on May to July, but hair-like and longer in those collected on August and early September including the holotype of *T. koyaensis*, 6) first tarsal chaetotaxy 3–5:3–5:3–5, 7) abdominal tergites II to VII fused together, tergites I and VIII defined from the fused tergite, 8) abdominal segments I to V each with 1–3 marginal setae, of which one is long stout and the other 1 or 2 short, but the short ones are sometimes absent especially in the small specimens or partly absent even in the large specimens; segment VI and VII each with 2 long, stout marginal setae, 9) abdominal tergite VII usually with minute setae on spinal area, but in some specimens collected on



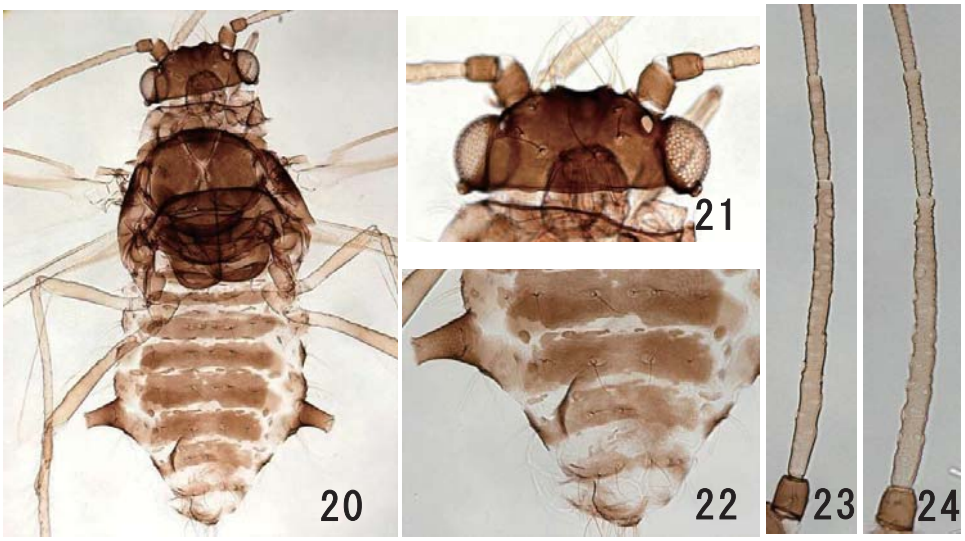
Figs 15–19. Apterous viviparous females (15-17, autumn form; 18-19, intermediate form between summer form and autumn one). 15: general aspect; 16: head; 17: posterior part of abdomen; 18-19: individuals with smoother abdomen than the summer form and fewer setae on the abdominal tergites than the autumn form.

May with a pair of long stout setae.

Among the specimens from the rearing experiment, the third generation (Figs 13,14) (from the first generation, fundatrix) collected on 14 May 2012 is distinguished from the above form in the following characters: 1) head with 8 long, stout dorsal setae (usually with 4 setae in the typical summer form), 2) meta- and mesonotum usually with a pair of long, stout spinal setae (without such spinal setae), 3) abdominal tergites I to VII each with a pair of long, stout spinal setae, but in some specimens partly absent from the anterior tergites (without such spinal setae), 4) body elongated, 1.8–2.0 times as long as the maximum width (1.5–1.8 times), 5) ultimate rostral segment with 2 secondary setae (usually without secondary setae, but in some specimens with 1 or 2 secondary setae), 6) first tarsal chaetotaxy 5:5:5 (3–5:3–5:3–5, but not usually 5:5:5).

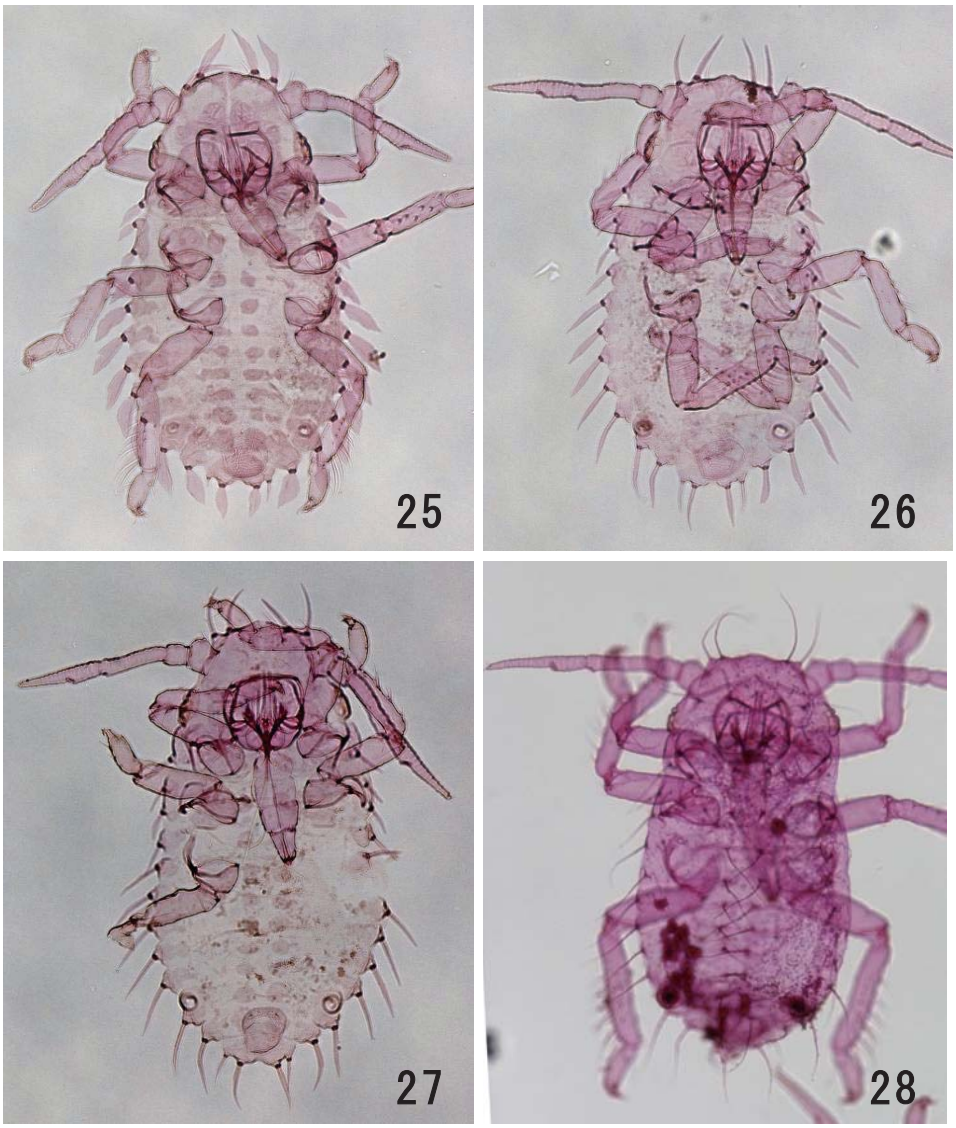
The autumn form is described by Sorin (1979) under the name *P. montanus* based on specimens collected on October, but Sorin did not refer to body color in life and the processus terminalis of antennae. Based on present specimens collected on August and September, the following characters were observed: 1) color in life yellow, 2) body 1.30–1.66 mm long, 1.5–1.7 times as long as the maximum width; dorsum smooth, not pigmented but sclerotized, 3) head with 4 pairs of long dorsal setae, but in some specimens collected on August and early September with minute setae (instead of long ones) on posterior half, 4) antennae 0.46–0.56 times as long as body; primary rhinaria with minute cilia; processus terminalis 1.9–2.2 times as long as basal part of terminal segment, 5) ultimate rostral segment with 0–2 secondary setae, 6) first tarsal chaetotaxy usually 3–5:3–4:3–4, 7) abdominal tergites II to VII fused together, 8) abdominal tergites I to VI each with 6–10 long setae, tergite VII with 2 spinal setae, tergite VIII with 6 setae along the hind margin of sclerotic band, but in some specimens collected on August and early September with fewer long setae (0–4) on each tergite, 9) abdominal segments I to VI each with 2–3 long marginal setae.

Alate viviparous female (Figs 20–24). Sorin (1979) gave a detailed description of



Figs 20–24. Alate viviparous female. 20: general aspect; 21: head; 22: posterior part of abdomen; 23, 24: antennal segments II to IV of autumn individual and spring individual, respectively.

this morph under the name *P. montanus*, based on specimens collected on October, but did not refer to body color in life. On the other hand, alatae collected on April and May in the field and those produced by the fundatrix in the rearing experiment had fewer secondary rhinaria than those on October and November. Based on present specimens, the following characters were observed: 1) color in life, head and thorax black, abdomen pale yellow with dorsal black bands, 2) body 1.47–2.75 mm long, 3) antennal segments III–V each with 20–30, 3–8, 0 or 1 secondary rhinaria in the autumn specimens, while in the spring ones, segments III–V each with 11–25, 0–2, 0; primary rhinaria with minute



Figs 25–28. First instar larvae. 25-27: individuals with lamerate marginal setae (25), lanceolate ones (26) and stout ones (27), respectively, produced by the summer form. 28: individual produced by the alate viviparous female appearing in autumn.

cilia; processus terminalis 2.0–3.2 times as long as basal part of terminal segment, 4) tibiae with many long setae, of which the longest one on hind tibiae is 2.4–4.5 times as long as middle width of the tibia.

Larvae (Figs 25–28). Sorin (2002) give a detailed description of the first instar and young larvae. In this study, larvae appearing in middle May to July agreed with his description. Regarding the first instar larvae produced by the summer form, however, some individuals are equipped with lamellate marginal setae (Fig. 25) on thorax and abdomen as in Sorin (2002) but others with lanceolate (Fig. 26) or stout (Fig. 27) marginal setae. Moreover, for the first instar larvae collected in August and September, which were probably produced by the autumn form including the intermediate one, all individuals had stout marginal setae. On the other hand, the first instar larvae produced by fundatrices and by alate viviparous females appearing in autumn had hair-like setae not only on front of head and on the margin of thoracic and abdominal segments, but also on posterior part of head and dorsally on thoracic and abdominal segments. Among these hair-like setae, the longest one on each of head, lateral abdomen and abdominal tergite VII is about 2.5, 3.5–4.5, 4.5–5.5 times as long as the basal width of antennal segment III, respectively. Moreover, the first instar larvae produced by fundatricies and by alate viviparous females appearing in autumn differ from those produced by the summer form by having a long rostrum that is beyond hind coxae.

Specimens examined. The following specimens were collected on *Acer rufinerve* (AR) or *Acer crataegifolium* (AC) by me at the Rokkô Mountains in Hyôgo Prefecture, or reared on *A. rufinerve* in the laboratory. Fundatrix: 6exs., Arima-onsen, 14.iv.2012 (AR); 8exs., Mt. Shakunage, 21.iv.2012 (AR). Apterous viviparous female: 4exs., Arima-onsenn, 26.vii.2012 (AC); 6exs., Hôdenbashi, 7.viii.2012 (AR), 1.ix.2012 (AR); 48exs., Mt. Maya, 13.ix.2009 (AR), 21.v.2011 (AR), 20.v.2012 (AR), 1.vii.2012 (AR), 8.vii.2012 (AR), 1.ix.2012 (AR), 9.ix.2012 (AR), 16.ix.2012 (AR); 39exs., Mt. Shakunage, 26.ix.2010 (AR), 14.v.2011 (AR), 22.vi.2011 (AR), 10.ix.2011 (AR), 16.vii.2012 (AR), 19.viii.2012 (AR), 16.ix.2012 (AR); 3exs., Mt. Rokkô, 7.viii.2012 (AR); 12exs., the third generation (reared specimens), 14.v.2012; 14exs., the fourth and following generations (reared specimens), 24.v.2012, 1.vi.2012. Alate viviparous females: 1ex., Arima-onsen, 30.iv.2012 (AR); 9exs., Kita-Rokkô, 4.x.2009 (AR); 11 exs., Mt. Maya, 25.x.2009 (AR); 32exs., Mt. Shakunage, 7.xi.2009 (AR), 3.xi.2011 (AR), 14.v.2012 (AR), 21.v.2012 (AR), 14.x.2012 (AR), 10.xi.2012 (AR); 10exs., the second generation (reared specimens), 23.iv.2012. Oviparous female: 6exs., Mt. Rokkô, 5.xii.2011 (AR); 21exs., Mt. Shakunage, 7.xi.2009 (AR), 10.xi.2012 (AR). Male: 3exs., Mt. Maya, 25.x.2009 (AR); 2exs., Mt. Rokkô, 5.xii.2011 (AR); 8exs., Mt. Shakunage, 7.xi.2009 (AR), 10.xi.2012 (AR). Larvae: many, Arima-onsen, 14.iv.2012 (AR), 26.vii.2012 (AC); Hôdenbashi, 7.viii.2012 (AR), 1.ix.2012 (AR); Mt. Maya, 18.vii.2010 (AR), 21.v.2011 (AR), 20.v.2012 (AR), 1.vii.2012 (AR), 1.ix.2012 (AR), 9.ix.2012 (AR); Mt. Rokkô, 30.ix.2012 (AC); Mt. Shakunage, 14.v.2011 (AR), 21.v.2011 (AR), 22.vi.2011 (AR), 16.vii.2012 (AR), 19.viii.2012 (AR), 14.x.2012 (AR); Reared specimens, 14.v.2012, 24.v.2012, 1.vi.2012, 15.vi.2012.

In addition, the following specimens preserved in SEHU and NIAES were inspected. Apterous viviparous female: holotype of *T. koyaensis*, Mt. Kôya, Wakayama Pref., 23.ix.1960, on *Acer rufinerve*, R. Takahashi leg., SEHU; 6exs., (identified as *T. koyaensis* by R. Takahashi), Mt. Kôya, 27.viii.1961, on *Acer*, R. Takahashi leg., SEHU; 19exs., (identified as *T. koyaensis* by R. Takahashi), Mt. Rokkô, Kôbe, 11.vi.1961, on

Fig. 29. Exuvium of the first instar larva with lamellate setae collected on 1 June 2012.

Acer, R. Takahashi leg., SEHU; 3exs., paratypes of *T. takahashii*, Mt. Hakusan, Ishikawa Pref., 10.vi.2000, on *A. rufinerve*, I. Togashi leg., NIAES. Alate viviparous female: 2exs., (identified as *P. montanus* by M. Sorin), Mt. Rokuman, Ishikawa Pref., 15.v.2001, on *A. rufinerve*, I. Togashi leg., NIAES; 4exs., (identified as *P. montanus* by M. Sorin), Mt. Hakusan, Ishikawa Pref., 5.vi.2001, on *A. rufinerve*, I. Togashi leg., NIAES.

Host plants. *Acer crataegifolium* and *A. rufinerve*. The former is recorded for the first time as a host plant of *Trichaitophorus koyaensis*. So far as I have observed in the field and in the laboratory, the aphid infests the underside of leaves and samaras, without causing any deformations to the plants.

Life cycle. This study showed that *T. koyaensis* has a holocyclic life cycle on *Acer rufinerve*. The rearing experiment showed that the second generation (the immediate offspring of the fundatrix) developed into alatae only. The third generation (the immediate offspring of the alatae) grew to apterae that were slender than the following generations (Figs 13, 14). The fourth and following generations included apterae that showed the typical characters of the genus *Trichaitophorus* (Figs 11, 12). In the field observation, adult fundatrices were found in middle April on bursting buds of *Acer rufinerve*, and alatae viviparous females (probably the second generation) were commonly found on the underside of leaves from late April to middle May. The summer form apterae appeared from middle May on the underside of leaves or on flowers, and commonly found on samaras rather than leaves from late May through September. The autumn form apterae appeared from August (Figs 15–17), although some apterae appearing in August and early September showed intermediate characters between the summer and the autumn forms in the arrangement of long dorsal setae and in the degree of dorsal corrugation (Figs 18, 19). In the autumn, alate viviparous females, which have hitherto been identified as *P. montanus*, appeared. At the field observation of a single *A. rufinerve* tree on 14 October 2012 at Mt. Shakunage, alatoid larvae including the forth instar were found on withering samaras, and simultaneously many alate viviparous females with their offspring were found on the underside of leaves. This suggests that altae viviparous females emerged on samaras move to leaves, and that the alatae deposited their offspring on the leaves. Subsequent observations on the same tree on 10 November 2012 indicated that these offspring developed into oviparous females and males. These morphs were found from November through to early December, and the eggs were deposited at the base of winter buds.

Discussion

The aperous viviparous female of *T. koyaensis* has a considerable variation in the presence or absence of long stout dorsal setae on head, thorax and abdomen, the presence or absence of short marginal setae on abdomen, the length and shape of tibial setae,

the first tarsal chaetotaxy, and the degree of dorsal corrugation. The alate viviparous female has siphunculi reticulated for the whole length as shown in the same morph of *Periphyllus* species. For this reason, the apterous and alate viviparous females of *T. koyaensis* appearing in autumn were originally described in the genus *Periphyllus* (Sorin, 1979). A similar situation is reported in the Indian population of *Trichaitophorus aceris* Takahashi (Chakrabarti & Mandal, 1986), of which the alate viviparous female has been placed under the name *Periphyllus pusillus* (Quednau & Chakrabarti, 1976). Only apterous viviparous females have been described in other *Trichaitophorus* species (*T. aenigmatosus* Paschencko, *T. ginnalarus* Qiao, Zhang & Zhang, *T. japonicus* Sorin, *T. recurvispinus* Hille Ris Lambers & Basu) (Blackman & Eastop, 2012). This fact may imply that the alate viviparous females of these four *Trichaitophorus* species were described under the genus *Periphyllus* and are still placed in the genus.

Regarding the first instar stadium, first instars with lamellate marginal setae were found in the specimens collected from middle May to July. Among some larval exuvia randomly taken from the rearing colony, three exuvia collected on 1 and 15 June 2012 had lamellate setae (Fig. 29). These instances indicate that first instars with lamellate marginal setae are not an aestivating form known in some *Periphyllus* species. However ecological functions of the first instars with lamellate, lanceolate or stout setae are uncertain. Chakrabarti & Mandal (1986) mentioned that "the embryos from the summer alatae of *T. aceri* have only long marginal hairs, whereas those from pre-winter alatae have spinal, pleural and marginal hairs." In fact, Quednau & Chakrabarti (1976) illustrated long spinal setae on each thoracic and abdominal tergite in the figure of embryo for alate *T. aceri* (described as *P. pusillus*) collected on October. In this study, although the embryos of *T. koyaensis* are not examined, first instars from the apterous viviparous female (both summer and autumn forms) have minute spinal setae (sometimes only setal socket) and long marginal setae (Figs 25–27), and those from the fundatrix and from the alata appearing in autumn had long spinal setae in addition to long marginal ones (Fig. 28). Thus the first instar larvae of *T. koyaensis* also have variation in setal length and shape as well as in the adults.

The lack of long dorsal setae on the body of the apterous viviparous female is one of the genetic characters of *Trichaitophorus* (Takahashi, 1937). So far as I have examined the morphology of *T. koyaensis*, this character is restricted to the summer form apterae, suggesting that the genus *Trichaitophorus* is elected based on a specific morph appearing in summer. Therefore, to clarify the genetic status of the genus *Trichaitophorus*, the further studies are required about life cycle and morphological variation of the remaining species.

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