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THE HORII-GROUP OF FIORINIA ASSOCIATED WITH
RHODODENDRONS IN EAST ASIA
(HOMOPTERA: COCCOIDEA: DIASPIDIDAE)

By SADAO TAKAGI

Abstract

TAKAGI, S. 1975. The *horii*-group of *Fiorinia* associated with rhododendrons in East Asia (Homoptera: Coccoidea: Diaspididae). *Ins. matsum. n. s.* 6: 35-61, 4 tabs., 16 figs.

Seven species of *Fiorinia*, associated with true rhododendrons in Japan, Taiwan and Nepal and having enlarged median lobes in both adult and 2nd instar females, are lumped together to form the *horii*-group. Five of them, occurring in Japan, are described; among them *F. hymenanthis*, *F. odaiensis* and *F. sikokiana* are new species. The 2nd instar males are described for two Japanese species. An attempt to evaluate taxonomic characters and to establish the relationships of the known species of the group is made from morphological data.

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INTRODUCTION

Some scale insects belonging to the genus *Fiorinia*, of the family Diaspididae, are known to occur on true rhododendrons in East Asia. They may be lumped together to form a rather tentative species-group, the *horii*-group. In this paper seven species are recognized from Japan, Taiwan and Nepal. They are all found on the undersurface of the leaves of the hosts. Usually their host plants are those sorts which have indumentum on the undersurface of the leaves, and the female scales are found mining the indumentum. The male scales, when present, are exposed on the indumentum. Infested leaves show yellow spots on the upper surface, so that the occurrence of these scales may easily come to our notice. Morphologically these species agree in the median lobes of the pygidium unusually enlarged for *Fiorinia* in both the adult female and the 2nd instar female. In other characters, however, not all of them show close relationships.

In Japan five species of this group are known. It seems that these species are native to the southwestern half of Japan. They are associated with several sorts of *Rhododendron metternichii* and, in the case of *Fiorinia horii*, also with *Rhododendron makinoi*. They have received little attention from horticulturists, but possibly will become a nuisance to culturists of rhododendrons in near future. Recent commercial success in producing seedlings and cuttings of various rhododendrons, both native and introduced, will make them popular garden plants in Japan. Under this circumstance the propagation and dispersal of their *Fiorinia*-pests will be quite ease through human agencies. This has already come true for *Fiorinia hymenanthis* and *Fiorinia horii*; both these species have been collected only from rhododendrons under cultivation. In Hokkaidô, northern Japan, they may be of recent introduction by man. The life history is largely unknown for the Japanese species. Judging from the material at hand they have two generations a year, wintering over as fertilized adult female.

For the convenience of Japanese horticulturists and applied entomologists the following trivial names are suggested for the Japanese species.

<i>Fiorinia hymenanthis</i>	Syakunage-konoha-kaigara
<i>F. odaiensis</i>	Ôdai-konoha-kaigara
<i>F. nachiensis</i>	Nati-konoha-kaigara
<i>F. sikokiana</i>	Sikoku-konoha-kaigara
<i>F. horii</i>	Horii-konoha-kaigara

The main part of the specimens examined, including the holotypes of the new species, will be deposited in the collection of the Entomological Institute, Hokkaidô University, Sapporo.

DESCRIPTIONS OF THE JAPANESE SPECIES

Fiorinia hymenanthis n. sp.

Once described by me (1961) under the name *Fiorinia horii*, Ins. matsum. 24: 39.

Collected at the following localities, all on *Rhododendron metternichii* under cultivation: Sapporo, Hokkaidô (8-xii-1955, 11-x-1963, 20-v-1970, and 25-vii-1974, S. Takagi; holotype 20-v-1970); Koganei, Tôkyô (21-v-1964 and 7-ix-1964, S. Kawai); Hiko-san, Kyûsyû (8-v-1957, S. Takagi). Specimens mounted of the adult female count over 120 in total. Specimens of the 2nd instar male

were mounted from the material collected at Sapporo on 11-x-1963 and 20-v-1970. Adult males emerged at Sapporo on 22-v-1970 from the material collected two days before; this stage is out of the scope of the present paper.

Female specimens collected at Rokkô-san, near Kôbe, Honsyû, on "Syakunagi" (probably *Rhododendron metternichii*) (27-x-1956, R. Takahashi) are also available, but excluded from the following description on account of their poor condition.

The adult female is oblong, with the head margin broadly rounded; abd. i-iii a little lobed out laterally; pygidium triangular or only slightly roundish, weakly sclerotized dorsally in a broad median region and ventrally in apical region. Antennal tubercles small, somewhat variable in size and shape, each with a strong curved seta. Interantennal process often present, if present variable in size and shape from a quite small, conical prominence to an elongate, irregularly incised tubercle, at most much shorter than antennal seta. Anterior spiracles each with a cluster of 2-6 disc pores; posterior spiracles usually lacking disc pores, sometimes with one. Microducts strewn in a band between anterior spiracles around labium, and also between posterior spiracles.

The median lobes of the pygidium are somewhat divergent and largely produced

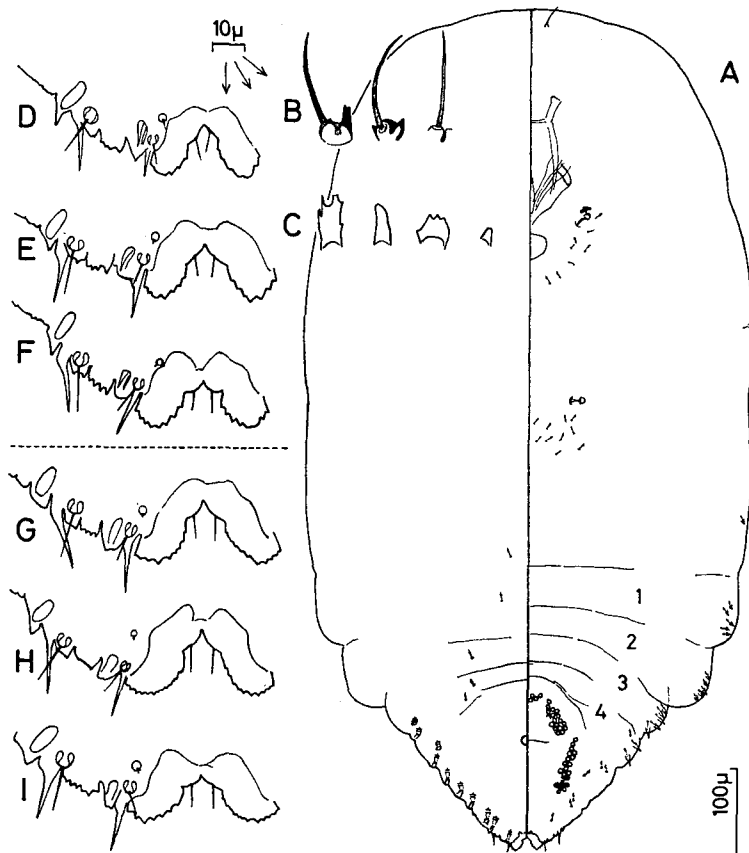


Fig. 1. *Fiorinia hymenanthis*, adult female: A, body; B, antenna; C, interantennal process; D-I, median and 2nd lobes of pygidium. A-F, Sapporo; G-I, Hiko-san.

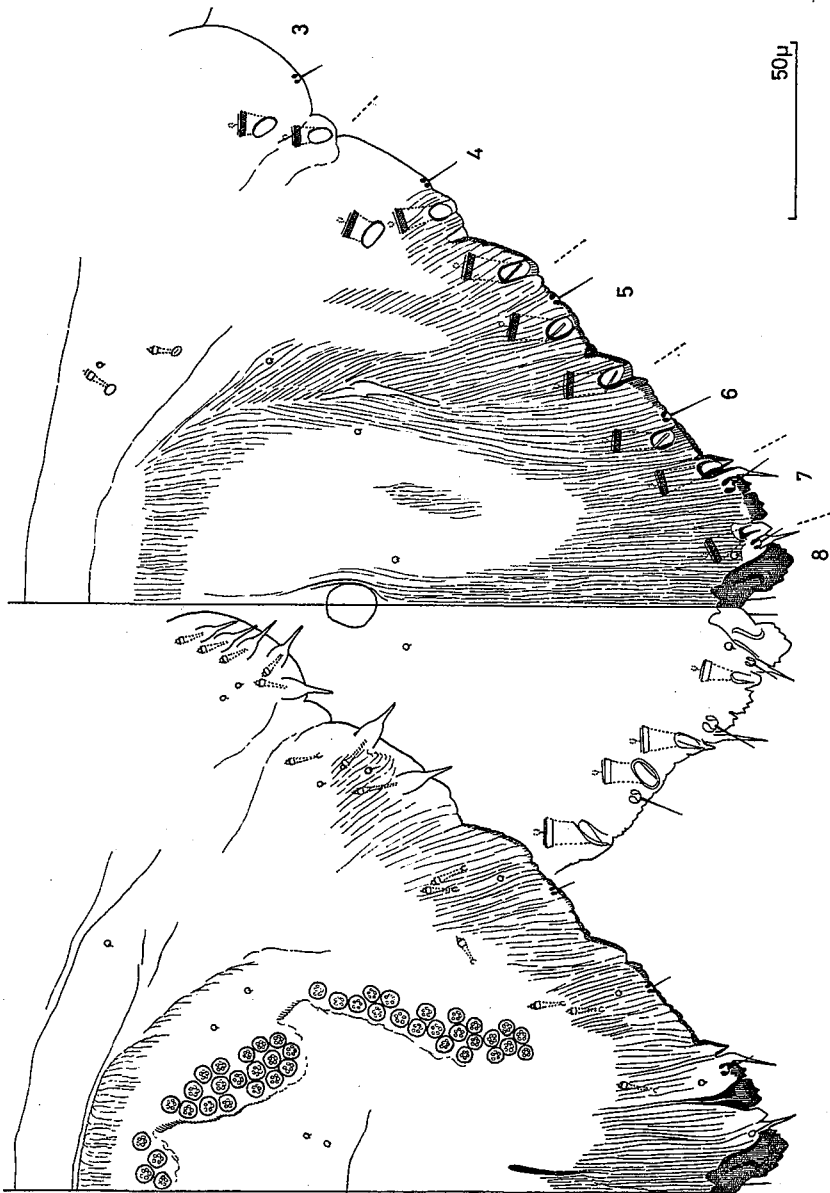


Fig. 2. *Fiorinia hymenanthis*, adult female: pygidium. Sapporo.

beyond the apical margin of the pygidium, forming a distinct notch at the apex of the latter; each lobe more or less rounded, or apically rather angular, and roughly serrate (quite robust and well rounded in the specimens from Hiko-san). Second lobes with inner lobule in a low, broad, serrate or smooth process; outer lobule similar in shape to the inner, but narrower; a pair of slender ventral scleroses distinct, obscure or obsolete on base of inner lobule.

One slender marginal gland spine between median and 2nd lobes (on abd. viii) and also just laterally to 2nd lobe (on abd. vii); rarely another similar gland spine

on the preceding segment. Marginal gland spines 1-4 (usually 1-3) towards base of pygidium (on abd. iv), broadened basally; 2-9 and 2-6 similar gland spines on lateral lobes of abd. ii and iii, respectively. Much smaller, conical gland spines on or just within body margin as follows: 0-1 (usually 0) on prothorax, 0-3 on mesothorax, 1-5 on metathorax, and 2-8 on abd. i. Marginal dorsal macroducts usually eight in number on each side, their segmental positions are as follows: one on abd. iii, two on iv-vi each, and one on vii; at times the total number on one side is reduced to seven. Submarginal dorsal macroducts usually present: 0-3 (usually one or two) on abd. iii, and 0-1 on iv; at times absent on both segments. Submedian dorsal microducts on supposed abd. i-iv, obviously larger on iv than on the anterior segments, gradually dislocated mesad from on iv towards on i; in the specimens collected at Sapporo and Tôkyô these microducts are few (one or two on one side of each segment) and at times partially absent, whereas in the specimens from Hiko-san they tend to increase (one on abd. i, 1-3 on ii, 2-5 on iii, and 2-7 on iv). Perivulvar disc pores numerous, 0-12 medians, 8-23 anterolaterals, and 11-40 posterolaterals.

The 2nd instar exuvial cast of the female is oblong, with the head margin flatly rounded, and with the pygidium comparatively small and triangular in outline. Pygidial lobes similar to those of adult female; median lobes divergent, forming a distinct notch at apex of pygidium; inner lobule of 2nd lobe with a pair of slender basal scleroses. One slender marginal gland spine between median and 2nd lobes, and also just laterally to 2nd lobe; more or less robust marginal gland spines one on each of abd. ii-iv; a pair of small gland spines situated within body margin on abd. i. Five single marginal macroducts on each side, belonging to abd. iii-vii.

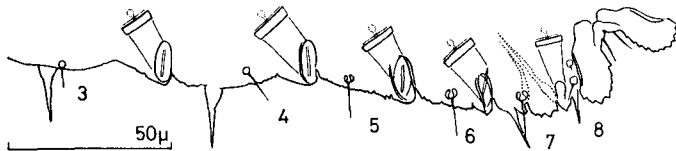


Fig. 3. *Fiorinia hymenanthis*, 2nd instar female: pygidial margin of exuvial cast, dorsal aspect. Sapporo.

The 2nd instar male of this species is very similar to that of *F. odaiensis*. This stage is not described here, for the available specimens of it are not excellent. A general idea of it will be gained from the 2nd instar male of *F. odaiensis*.

This species was previously identified by me with *F. horii*, but a later discovery of another form, which agrees more closely with Kuwana's description of *F. horii*, has revealed that it is in reality an unnamed form. The new species is distinguishable from *F. horii* by the 2nd lobes comparatively well developed, by having two pairs of marginal gland spines around the apex of the pygidium, and by the ventral microducts of the pygidium much fewer. This species is very similar to *F. odaiensis* and *F. nachiensis*, but easily distinguishable from the latter two by the number of the marginal macroducts.

The specimens at hand are somewhat variable in regard to the shape of the

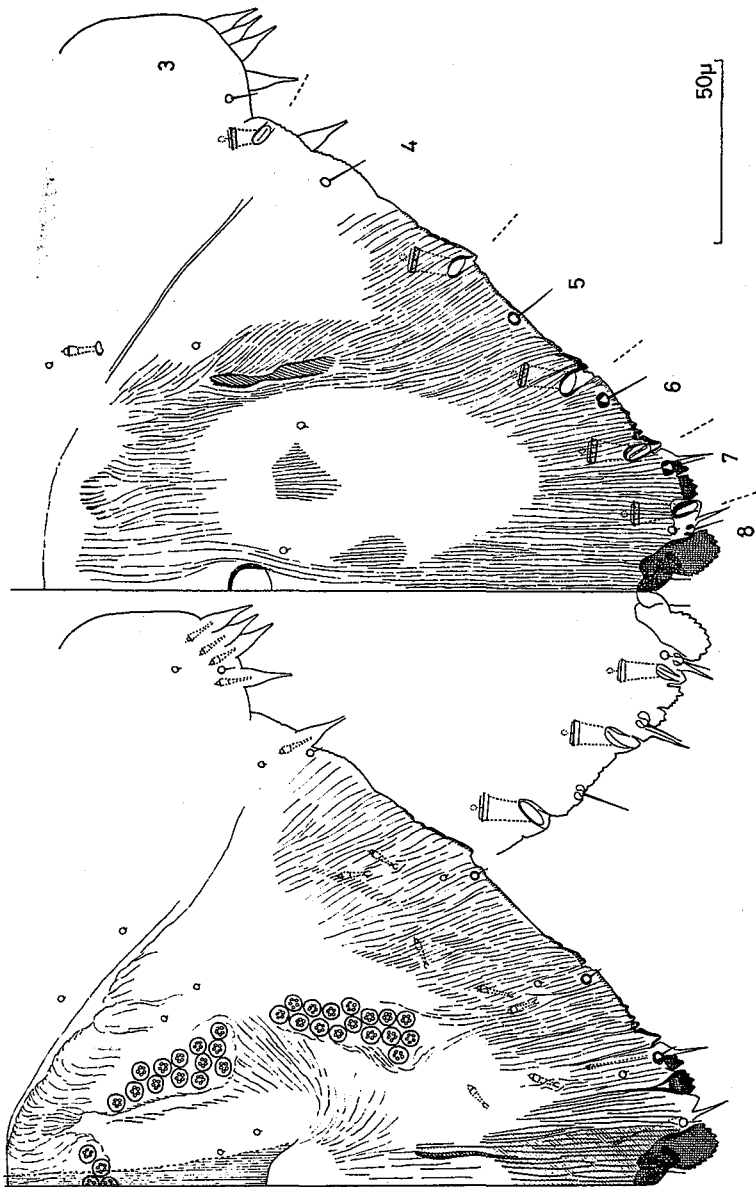


Fig. 4. *Fiorinia odatensis*, adult female: pygidium. Ôdai-ga-hara.

median lobes of the pygidium and the number of the dorsal submedian microducts of the prepygidial abdominal segments. In general, the median lobes are rather angular in the specimens from Sapporo and Tôkyô, whereas they are well rounded in the specimens from Hiko-san. The specimens from Hiko-san are also characterized by the dorsal microducts tending to be more numerous on the 3rd and 4th abdominal segments. The two forms, however, are seemingly not distinct, no obvious gap being found between them in the shape of the median lobes and the number of the dorsal microducts as well as in other characters. The native

localities of this species are not yet known. The specimens collected at Sapporo, Tôkyô and Hiko-san were all found on rhododendrons growing in gardens. It is unknown to me whether the occurrence of this species at Rokkô-san is natural. This species may be native to a broad region in southwestern Japan. Its variations should be revised in the light of native localities.

The aphelinid *Aspidiotiphagus citrinus* Craw, determined by Prof. T. Tachikawa, is a parasite of this scale insect at Sapporo.

Fiorinia odaiensis n. sp.

Erroneously included within *Fiorinia nachiensis* by me (1961), *Ins. matsum.* 24: 40.

Ôdai-ga-hara, Kii Peninsula, Honsyû, on *Rhododendron metternichii* (12-x-1972, S. Takagi); the mounted material includes 80 adult females (one the holotype) and some males of the 2nd instar. Several adult females, the same locality (18-viii-1956, R. Takahashi).

This species is very similar to *F. hymenanthis*, the only remarkable difference in the adult females is found in the number and arrangement of the marginal macroducts. In *F. odaiensis* the number of the marginal macroducts on one side is usually four or five. When the number is five, usually each of the 3rd to 7th abdominal segments is provided with a single macroduct; when four, usually the 3rd abdominal segment is devoid of marginal macroduct. Rarely the number is six, resulting from the occurrence of two macroducts on the 6th abdominal segment; rarely only three macroducts are present on one side.

The median lobes are slightly or little divergent and, in comparison with *F. hymenanthis*, robust and rounded; their bases are more or less sunken into the pygidium.

Other characters mentionable in comparison with *F. hymenanthis* are as follows: Interantennal process usually absent, if present low and irregularly notched or conical. Anterior spiracles each with 1-6 disc pores; posterior spiracles with 0-2. Besides the two pairs of slender gland spines occurring around the apex of the pygidium the following numbers of gland spines should be given: 0-2 on mesothorax, 1-3 on metathorax, 1-6 on abd. i, 2-6 on ii, 1-6 on iii, and 0-2 on iv. Submedian dorsal microducts one or two on one side of abd. i-iv each, at times partially lacking. Perivulvar disc pores 1-11 medians, 11-21 anterolaterals, and 12-28 posterolaterals.

The 2nd instar female is very similar to that of *F. hymenanthis*, but the median lobes are almost wholly produced, with their interspace tending to be less deeply sunken into the pygidium.

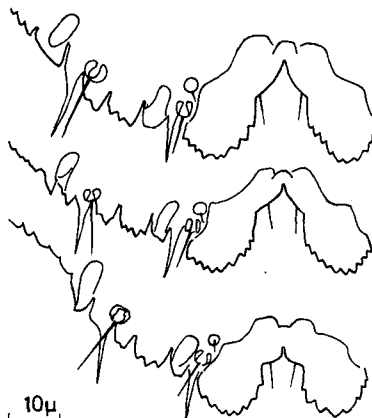


Fig. 5. *Fiorinia odaiensis*, adult female: median and 2nd lobes of pygidium. Ôdai-ga-hara.

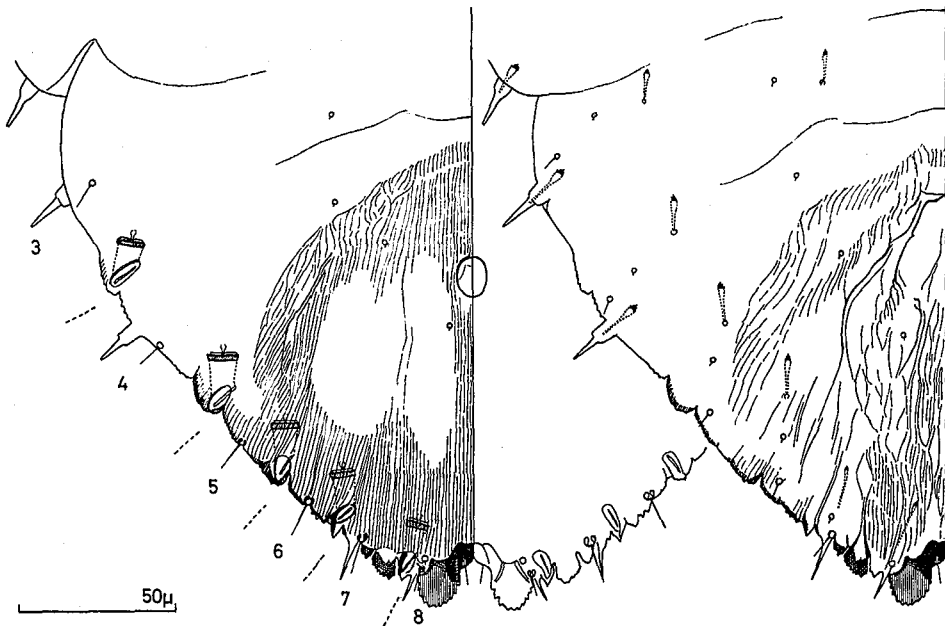
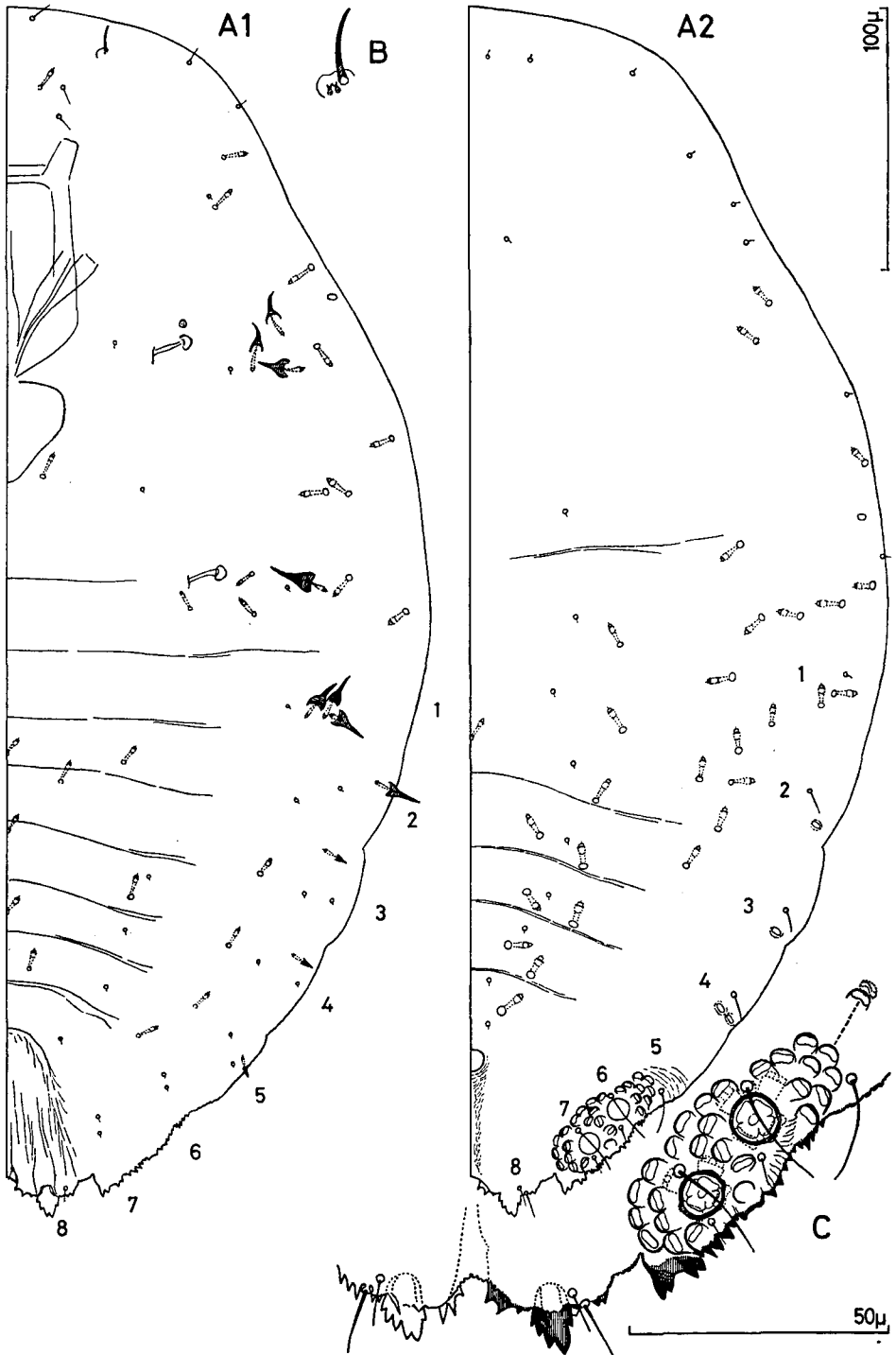


Fig. 6. *Fiorinia odaiensis*, 2nd instar female: pygidium. Ôdai-ga-hara.

The 2nd instar males of *F. hymenanthis* and *F. odaiensis* are very similar to each other. The following description of this stage for *F. odaiensis* practically holds good with *F. hymenanthis*, although the numbers of pores and ducts may be slightly different between the two species.

The 2nd instar male is more or less oval in outline. Derm membranous, with segmentation obscure. Antennae a low, rounded, membranous process, with a rather stiff seta. Anterior spiracles each usually with one trilocular disc pore. The pygidial margin is rugged with sclerotized dentations, among which more prominent ones may correspond to the median and 2nd lobes of the female, though they are little conformed in shape to the latter. The supposed median lobes are not zygotic. Two large and rounded dorsal pores are found submarginally on each side of the pygidium, one on abd. vi and vii each, with four broad ducts (and another slender duct?) opened in it ("communal ducts" of Tippins 1970). These two pores are surrounded by a cluster of much smaller pores, which count 23-31; each of these smaller pores is the orifice of a short duct, of which the inner end shows a sinuate structure. One or two similar pores on abd. iv just within body margin; another one on the preceding two segments each. Other dorsal secretory organs are small ducts scattered in a broad submarginal zone on the thorax and anterior abdominal segments and in a submedian longitudinal band on the abdomen anteriorly to the anal opening. Ventral ducts generally slenderer, scattered submarginally on cephalothorax and arranged medianly and submarginally on abdomen. Well-developed gland spines 2-4 (usually two or three) laterally to anterior spiracle, 0-2 (usually one) laterally to posterior spiracle, 1-3 (usually two) submarginally on abd. i; one (rarely two) similar gland spine on abd. ii on or within body margin; three single, much smaller or almost vestigial gland spines on or within



body margin, belonging to abd. iii-v.

This species was once regarded by me as a variation of *F. nachiensis* mainly owing to the presence of an intermediate individual connecting the two concerning the state of the pygidial gland spines. Discrimination between the two has been possible on the basis of larger numbers of specimens of both, and the intermediate specimen is now referred to *F. nachiensis*. The conclusion that the two are distinct species is supported by the 2nd instar males, which are quite different between the two species (see under *F. nachiensis* for further discussion).

This species was found on wild rhododendrons on the plateau of Ôdai-ga-hara, about 1500 m in altitude.

Fiorinia nachiensis Takahashi

Originally described by Takahashi (1956), Annot. zool. Japon. 29: 60. Later, treated by me (1961), Ins. matsum. 24: 40, on the basis of specimens from the original material, with another form (*F. odaiensis* in the present paper) included as a variation.

Examined specimens were collected at the following localities of Kii Peninsula, Honsyû, on *Rhododendron metternichii* or undetermined rhododendrons, which probably belong to *R. metternichii*: Nati-san, Wakayama-ken (13-vii-1955, R. Takahashi, type-series; 6-xi-1971, S. Takagi); Hokkaidô University Experiment Forest, Kozagawa, Wakayama-ken (7-i-1962, S. Takagi); Iwawaki-yama, near Ôsaka (6-v-1956, R. Takahashi). A total of 96 adult females were mounted; about 20 mounted specimens of the 2nd instar male were taken from the material collected at Nati-san on 6-xi-1971.

F. odaiensis and *F. nachiensis* were regarded as variations of a single species. But a comparison based on a lot of adult females of either shows that they are different in the means of the total numbers of gland spines and perivulvar disc pores. These numbers, combined together, well discriminate between the two (Fig. 15). Diagnostically the two species are effectively distinguishable from each other by the presence of the gland spines belonging to the 7th and 8th abdominal segments in *F. odaiensis* and their absence in *F. nachiensis*. The only exception hitherto found (see under *F. odaiensis*) belongs to *F. nachiensis* and has a gland spine on the 7th abdominal segment on either side. The 2nd instar males are quite different between the two. I have now little doubt that they are distinct species.

In comparison with the preceding two species the adult female of the present species is characterized as follows: The median lobes are wholly produced or nearly so, rounded and parallel. Gland spines absent on abd. vii and viii (exceptionally present on abd. vii as mentioned above); 0-2 on mesothorax and metathorax each, 1-4 on abd. i and ii each, 1-3 on iii, and 0-2 (usually one) on iv. The marginal macroducts are usually four or five in number on each side, all of them being single and occurring on abd. iii (or iv)-vii; at times double on v or vi, then five or six in total; at times only three macroducts on one side, occurring on

Fig. 7. *Fiorinia odaiensis*, 2nd instar male: A1 and A2, body, ventral and dorsal aspect; B, antenna (equal to C in magnification); C, pygidial margin, dorsal aspect. Ôdai-ga-hara.

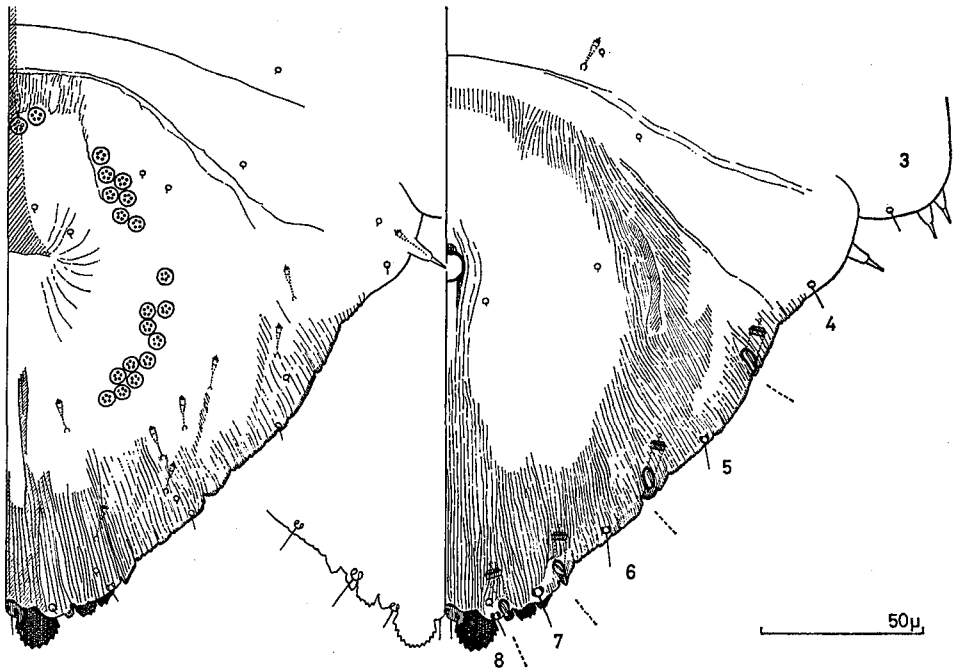


Fig. 8. *Fiovinia nachiensis*, adult female: pygidium. Nati-san.

v-vii. Submarginal macroducts absent. Perivulvar disc pores 1-6 medians, 6-13 anterolaterals, and 9-20 posterolaterals.

Interantennal process present or absent, if present variable in size and shape: in one extreme it is a quite small conical or tubercular process, whereas in the other extreme elongate and variously incised. Anterior spiracles each with 1-4 disc pores; posterior spiracles without disc pores. Submedian dorsal microducts one on i, one or two on ii-iv each, those on i-iii much dislocated mesad; at times partially lacking.

The 2nd instar female is similar to those of the preceding two species, but the median lobes are completely projected, with the median zygotis little sunken into the pygidium. Marginal gland spines single on abd. ii-iv and vii and viii; one small gland spine within margin on i. Marginal macroducts single on abd. iii-vii.

The 2nd instar male is elongate-elliptical in outline. Derm membranous except for weakly sclerotized pygidium. Antennae each represented by a long seta. Anterior spiracles each with one disc pore. The pygidial margin is provided with sclerotized processes, which are similar to and probably homologous with the lobes and pore prominences of the female pygidium. Dorsal marginal setae of pygidium elongate. Gland spines absent on pygidium; 1-3 gland spines laterally to anterior spiracle, one laterally to posterior spiracle, one or two (usually two) on abd. i submarginally, and one on ii near margin (at times lacking); abd. iii usually without gland spine, but at times with one just within margin.

Dorsal macroducts small in size, one opened in pore prominence of abd. iv-vi each (often absent on v), and one between pore prominences of iv and v; other

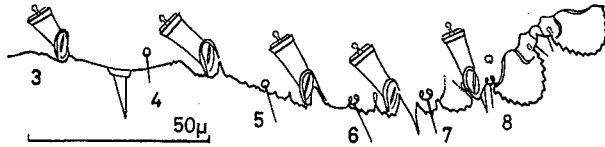


Fig. 9. *Fiorinia nachiensis*, 2nd instar female: pygidial margin of exuvial cast, dorsal aspect. Nati-san.

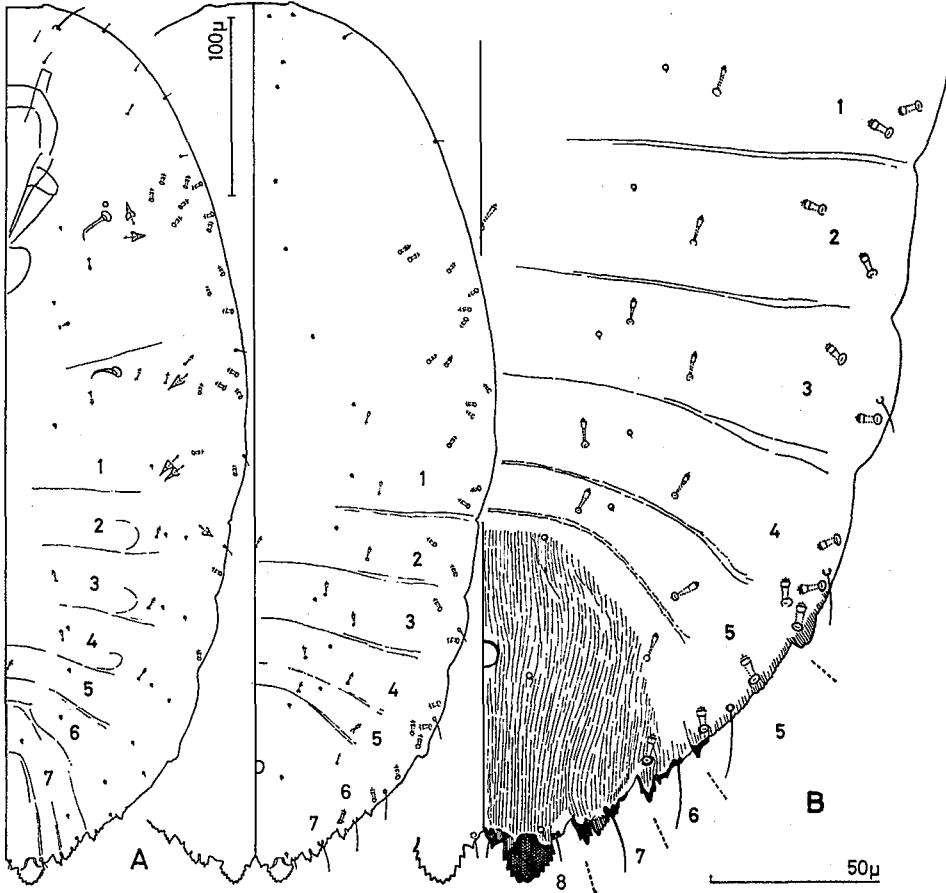


Fig. 10. *Fiorinia nachiensis*, 2nd instar male: A, body; B, abdomen, dorsal aspect. Nati-san.

macroducts scattered mainly along body margin anteriorly as far as mesothorax and submedianly in prepygidial region of abdomen. Similar ventral macroducts scattered along body margin mainly on meso- and metathorax. Smaller ventral ducts few in prepygidial region.

This species is native to Kii Peninsula, since it was collected in a native stand preserved in the Hokkaidô University Experiment Forest, Kozagawa,

Wakayama-ken. At Nati-san, the type-locality, I found several trees of *Rhododendron metternichii* planted by the roadside and harbouring this scale insects. This species seems to inhabit low mountains of the peninsula.

Fiorinia sikokiana n. sp.

Collected at Senbon-yama, Kôti-ken, Sikoku, on a rhododendron probably belonging to *Rhododendron metternichii* but lacking indumentum on the underside of the leaves (14-xi-1964, S. Takagi, one the holotype); at "Awa" (=Tokushima-ken), Sikoku, on "*Rhododendron/Syakunagi*" (general name for true rhododendrons) (1-iv-1948, T. Inobu), labelled "*Fiorinia grandilobis* Takah." Some adult females, mostly in poor condition, and exuvial casts of the female are available.

The adult female is oblong in outline, with the head margin broadly rounded or rather flat, and with the pygidium triangular or slightly roundish marginally. Antennae tubercular, and rounded or pointed, but not elongate, each with a seta. Interantennal process absent. Anterior spiracles each with one or two disc pores; posterior spiracles without disc pore. Microducts few posteriorly to anterior spiracles and between posterior spiracles.

Median lobes slightly divergent, almost wholly produced, with their interspace forming a shallow notch; each lobe almost rounded and serrate. Second lobes with inner lobule in a low, serrate process, and with the outer lobule less produced yet distinct. Marginal gland spines absent on pygidium except for the occasional presence of one gland spine on base of pygidium (on abd. iv); 1-3 on abd. ii and 2-4 on iii well developed; small conical gland spines just within body margin as

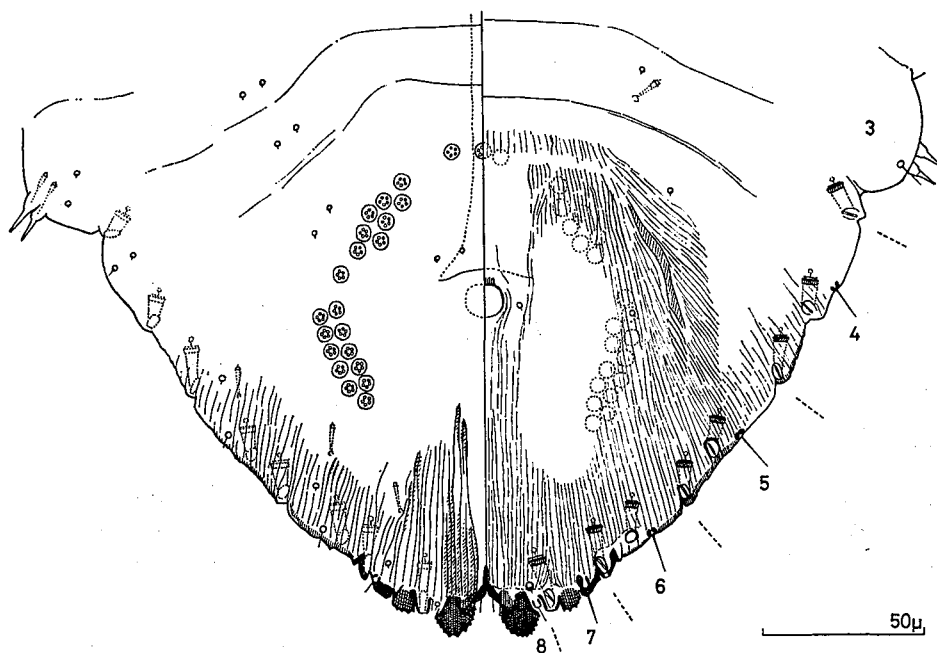


Fig. 11. *Fiorinia sikokiana*, adult female: pygidium. Senbon-yama.

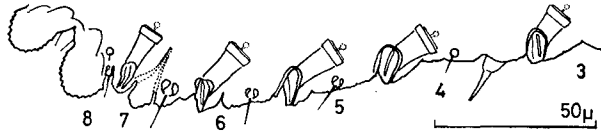


Fig. 12. *Fiorinia sikokiana*, 2nd instar female: pygidial margin of exuvial cast, dorsal aspect. Senbon-yama.

follows: 0-2 on mesothorax, 1-3 on metathorax, and 1-5 on abd. i. Marginal macroducts eight in number on each side, their positions are as follows: one on abd. iii, two on iv-vi each, and one on vii (in one case the marginal macroducts are six in total, being single on abd. iv and v). Submarginal dorsal macroducts absent. Submedian dorsal microducts all same in size and small, single on supposed abd. i-iv, at times partially lacking. Perivulvar disc pores 3-6 medians, 5-13 anterolaterals, and 10-20 posterolaterals.

The exuvial cast of the 2nd instar female is oblong, gradually narrowing posteriorly, with the pygidium triangular in outline. Pygidial lobes are similar to those of the adult female. Marginal gland spines single and well developed on abd. ii-iv, absent on the succeeding segments. Five marginal macroducts on each side, belonging to abd. iii-vii.

This species, collected at the two localities in Sikoku, may be native to the island, though I have little information concerning the status of the host plant in either case. The specimens at hand show some local variations. Especially the median lobes in the adult females from Awa are more robust than in those from Senbon-yama; these lobes in the 2nd instar females are more separated than each other in the Awa specimens. Further comparisons are difficult, since the available specimens are limited in number and mostly poor in condition. These forms are tentatively referred to the same species.

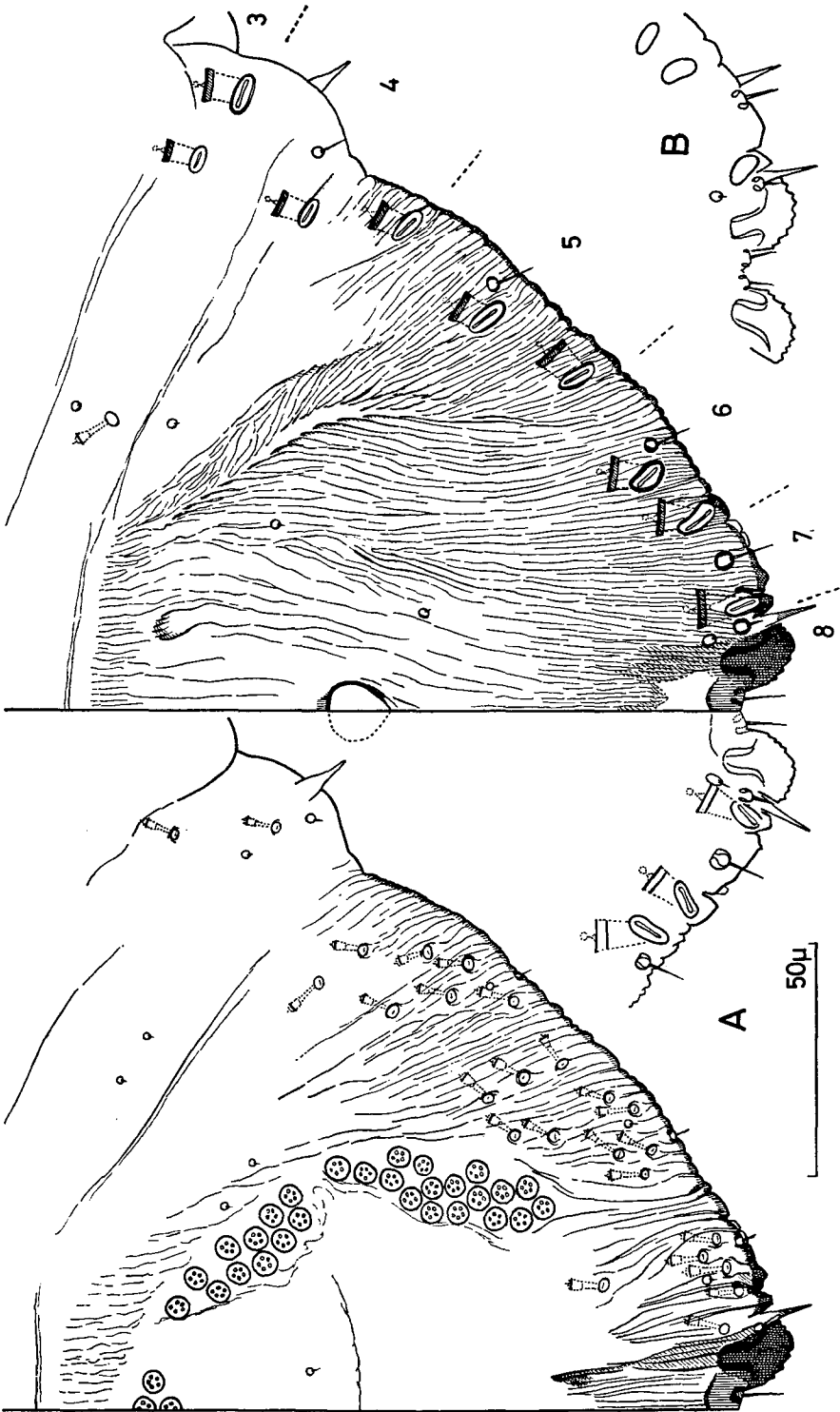
This species is not particularly closely related to any other known species of the *horii*-group, and is easily distinguishable by the combination of the number of the marginal macroducts and the absence of gland spines on both the 7th and 8th abdominal segments. It is also unique in the 2nd instar female by lacking gland spines on the 7th and 8th abdominal segments.

Fiorinia horii Kuwana

Originally described by Kuwana (1927), *Annot. zool. Japon.* 11: 151. The form described by me (1961), *Ins. matsum.* 24: 39, under the name *Fiorinia horii* is not this species, but *F. hymenanthis*.

Specimens were collected at Sapporo, Hokkaidô, on *Rhododendron makinoi* (20-vii-1974, T. Kumata); at Tôkyô, on *Rhododendron makinoi* and *Rhododendron metternichii* (11-xi-1965, S. Kawai). Mounted specimens include 89 adult females in total. The adult females collected at Sapporo were just after oviposition.

The adult female is oblong or rather fusiform, with abd. ii and iii slightly lobed out laterally. Pygidium broad, triangular or more or less rounded. Antennae tubercular, not prolonged, each with a well-developed seta. In-



terantennal process absent, or if present rudimentary, represented by a low tubercular or angular process. Anterior spiracles each with a close cluster of 1-7 disc pores; posterior spiracles without disc pores. Microducts strewn posteriorly to anterior spiracles around labium, and also across median region of metathorax just posteriorly to posterior spiracles.

Median lobes robust, angular or rounded, serrate, situated in a shallow notch at apex of pygidium. Second lobes practically obsolete, represented by a slightly produced, broad, sclerotized margin of pygidium. One slender marginal gland spine present laterally to median lobe; another gland spine at times present laterally to 2nd lobe; 1-4 gland spines on abd. ii and iii each and 1-2 on iv well developed (rarely absent on iv); tubercular or conical gland spines 0-2 on meso- and metathorax each (usually absent on mesothorax), and 1-4 on abd. i.

Marginal macroducts 5-8 in number on one side, one on abd. iii, one or two (usually one) on iv, one or two on v and vi each, and one on vii. Submarginal dorsal macroducts usually present, one on abd. iii and iv each (at times absent on iii or on both segments). Submedian dorsal microducts all practically the same in size, one rarely present on supposed abd. ii, 0-2 on iii, 0-3 on iv, one or two rarely present on base of pygidium. Many ventral microducts strewn submarginally on abd. iv (or v)-vii, about 18-35 on one side. Perivulvar disc pores 2-8 medians, 7-15 anterolaterals, and 11-25 posterolaterals.

Exuvial cast of 2nd instar female oblong, gradually tapering towards pygidium, which is triangular in outline. Median lobes largely sunken in a deep apical notch of pygidium, divergent. Second lobes with inner lobule well represented, but with outer lobule reduced into a small prominence. Gland spines single on abd. ii-v and vii and viii; one small gland spine on i just within body margin. Five marginal macroducts on each side, belonging to abd. iii-vii.

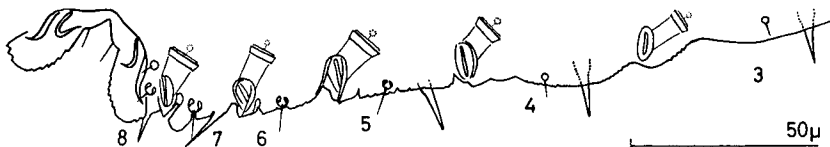


Fig. 14. *Fiorinia horii*, 2nd instar female: pygidial margin of exuvial cast, dorsal aspect. Sapporo.

The specimens from Tôkyô have a tendency to have many perivulvar disc pores and gland spines in comparison with those from Sapporo. All of them, however, form a continuous series of variations (Fig. 16). Both the forms are probably referable to the same species.

This species was originally described from specimens collected at Tôkyô and Yokohama on *Rhododendron makinoi* (=“*angustifolia*”) and two sorts of *Rhododendron metternichii* (“var. *heptamerum*” and “*pentamerum*”). These records may not be concerned with wild rhododendrons. The specimens at hand were also collected on rhododendrons under cultivation, so that the native localities of this species in Japan are not yet known.

Fig. 13. *Fiorinia horii*, adult female: A, pygidium; B, apex of pygidium, with gland spines on both abd. vii and viii. Sapporo.

Takahashi (1934) recorded this species from Taiwan as a feeder of *Rhododendron lasiostylum* (=“*sasakii*”)*; after him it is very common at Pu-li and other localities of the central mountains. Since he did not give any description, it is not certain to me that his specimens really belong to the present species.

The original description is not precise and the accompanying figures may not be exact, but a general agreement of the present specimens with the description and figures may afford a secure basis for the present identification. Especially the agreements in the obliterated 2nd lobes and the numerous pygidial microducts are noticed. In Kuwana's figures these microducts are on the dorsal side, whereas in the present specimens they are on the ventral side; this disagreement is supposed not real. This species is unique in the characters just mentioned, and is not particularly close to *F. hymenanthis*, with which it was once confused.

A REVIEW OF THE HORII-GROUP

The known species of the *horii*-group and their native localities are given below. The 1st three of these species appear to be closely related to each other whereas the other four seem to be isolated. I have not examined *Fiorinia rhododendri*, which is included in the group on the basis of the original description.

Japan

- F. hymenanthis* n. sp. — Southwestern Honsyû and northern Kyûsyû ?
F. odaiensis n. sp. — Kii Peninsula (ca. 1500 m), Honsyû
F. nachiensis Takahashi — Kii Peninsula (low mountains), Honsyû
F. sikokiana n. sp. — Eastern Sikoku
F. horii Kuwana — Central Honsyû ?

Taiwan

- F. rhododendri* Takahashi — Tai-tung Hsien
F. horii Kuwana ? — Central mountains

Nepal

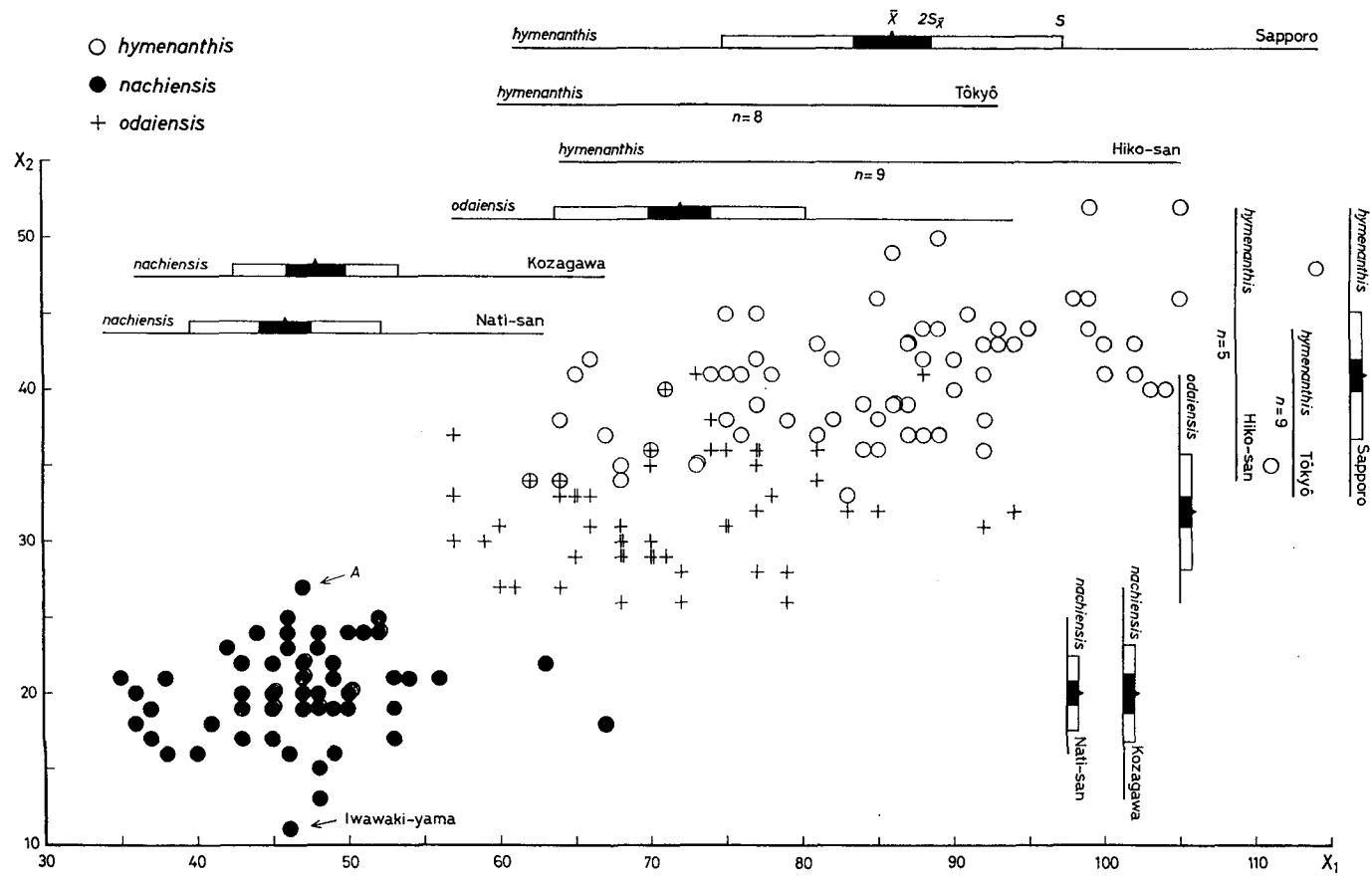
- F. himalaica* Takagi — Central Nepal (1840 m) (see the preceding paper, p. 26)

Nachiensis-series: *F. hymenanthis*, *F. odaiensis* and *F. nachiensis*

In some morphological characters the adult females of these three species present parallel sequences or, in Maslin's (1952) terms, “paradromic morpho-clines”. The 2nd instar females are very similar among these species, but differ in the characters of the median lobes, forming a morpho-cline, which agrees with the corresponding morpho-cline in the adult females. The similarities among the 2nd instar females support the view that these three species are closely related.

* This species is not a true rhododendron, but an azalea. It is, however, evergreen, with persistent leaves.

Fig. 15. Number of perivulvar disc pores (X_1) against number of gland spines (X_2) in *Fiorinia hymenanthis*, *F. odaiensis* and *F. nachiensis*. Dice-grams include some individuals other than shown in the scatter diagram. A: individual with gland spines on abd. vii.



In Fig. 15 is given the association between the total number of perivulvar disc pores and that of gland spines in the adult females of the three species. As a whole this association exhibits a fixed trend throughout formed by two paradromic morpho-clines. The three species occupy successive steps of this 'association morpho-cline'. The "polarity" (Maslin l.c.) of this morpho-cline may be determined within the series. All these species have gland spines on the 7th and 8th abdominal segments in the 2nd instar females, but as adult female *F. nachiensis* alone lacks gland spines on the corresponding segments. On the supposition that the absence of these gland spines is due to a loss *F. nachiensis*, which occupies the reductive extreme in the associated numbers of gland spines and perivulvar disc pores, should represent the derived extreme of this morpho-cline. This interpretation is supported by the fact that less modified (i.e. non-pupillarial) genera related to *Fiorinia* have gland spines on all the abdominal segments as posteriorly as the 8th.

Accordingly, *F. hymenanthis* represents the primitive extreme of the association morpho-cline. Any other morpho-cline paradromic to this morpho-cline should have *F. hymenanthis* as its primitive extreme.

Patterns change twice in the *nachiensis*-series. One of these changes is concerned with the arrangement of marginal macroducts: the formula of 1-2-2-2-1 (arrangement by order of the 3rd to 7th abdominal segments) as opposed to 1-1-1-1-1 and 0-1-1-1-1, the 1st formula being for *F. hymenanthis* and the other two for both *F. odaiensis* and *F. nachiensis*. Variations from these formulae take place in all the three species. Usual variations occur as follows: in *F. hymenanthis* only two of the 4th to 6th abdominal segments may have double macroducts, and in the other two species one of these segments may have double macroducts. Submarginal macroducts are usually present in *F. hymenanthis*, whereas they are rare in *F. odaiensis* and always absent in *F. nachiensis*. Thus, the total number of macroducts varies from eight to 12 in *F. hymenanthis*, whereas it ranges from three to seven in *F. odaiensis* and from three to six in *F. nachiensis* (Tab. 1). Though *F. odaiensis* and *F. nachiensis* have the common pattern (the occurrence of all single marginal macroducts), they are different in the total number of macroducts mainly owing to a difference in the frequency of the marginal macroduct occurring on the 3rd abdominal segment (Tab. 2).

The other change of pattern is, as already stated, caused by the loss of gland spines on the 7th and 8th abdominal segments in *F. nachiensis*. There has been found one exception (Fig. 15, individual marked with A), in which the gland spine of the 7th abdominal segment is preserved on either side. Among the

Table 1. Frequency of total number of macroducts in *F. hymenanthis*, *F. odaiensis* and *F. nachiensis*.

Total number of macroducts on one side		3	4	5	6	7	8	9	10	11	12
<i>F. hymenanthis</i>	f	0	0	0	0	0	15	37	78	37	5
	%	-	-	-	-	-	8.7	21.5	45.4	21.5	2.9
<i>F. odaiensis</i>	f	3	72	51	7	1	0	0	0	0	0
	%	2.2	53.7	38.1	5.2	0.8	-	-	-	-	-
<i>F. nachiensis</i>	f	6	117	39	4	0	0	0	0	0	0
	%	3.6	70.5	23.5	2.4	-	-	-	-	-	-

Table 2. Frequency of total numbers of macroducts grouped in two classes in *F. odaiensis* and *F. nachiensis* (from data of Table 1).

Total number of macroducts on one side	3—4	5—7	Total
<i>F. odaiensis</i>	75	59	134
<i>F. nachiensis</i>	123	43	166
Total	198	102	300

Chi-square=10.856, $P=0.001$

Table 3. Frequency of number of disc pores associated with posterior spiracle in *F. hymenanthis*, *F. odaiensis* and *F. nachiensis*.

Number of disc pores associated with posterior spiracle		0	1	2
<i>F. hymenanthis</i>	<i>f</i>	119	25	0
	%	82.6	17.4	—
<i>F. odaiensis</i>	<i>f</i>	64	62	4
	%	49.2	47.7	3.1
<i>F. nachiensis</i>	%	100	—	—

examined adult females only two are equivalent to it in the total number of usual gland spines, and, with the two further gland spines added, it has the largest observed number, which approximates the smallest number in *F. odaiensis*.

The mentioned changes in the main external wax-secretory organs are reductive. As to other wax-secretory organs such a trend is not always obvious. The disc pores accompanying the anterior spiracles show a slight tendency to decrease in number from *F. hymenanthis* through *F. odaiensis* to *F. nachiensis*. But the disc pores accompanying the posterior spiracles are more reduced in occurrence in *F. hymenanthis* than in *F. odaiensis*, although these pores are always absent in *F. nachiensis* (Tab. 3).

The reductive trends of the main wax-secretory organs are associated with the reduction of the body size at least between *F. hymenanthis* and *F. odaiensis*. In each species 50 exuvial casts of the 2nd instar female, prepared and mounted by routine method, were measured for the length. The difference between the means is significant between *F. hymenanthis* and *F. odaiensis*, whereas not significant between *F. odaiensis* and *F. nachiensis* (Tab. 4). Some adult females, mounted in good condition, show a similar tendency, though they are few for reliable comparison: the ranges of the measured lengths do not overlap between *F. hymenanthis* and *F. odaiensis*, whereas the range of *F. nachiensis* is only a little deviated towards smaller values than that of *F. odaiensis*.

Another morpho-cline is concerned with the median lobes. It is especially noteworthy because the *horii*-group is formed morphologically by the character of median lobes. At one extreme the median lobes are comparatively narrow, angular apically, and situated in a deep invagination of the pygidial apex. This condition is exhibited by *F. hymenanthis* and, therefore, corresponds to the primitive

Table 4. Length of 2nd instar female exuvial cast in *F. hymenanthis*, *F. odaiensis* and *F. nachiensis*.

Length in mm	Mean	95% confidence interval
<i>F. hymenanthis</i>	1.18	1.16-1.20
<i>F. odaiensis</i>	1.11	1.09-1.13
<i>F. nachiensis</i>	1.10	1.08-1.12

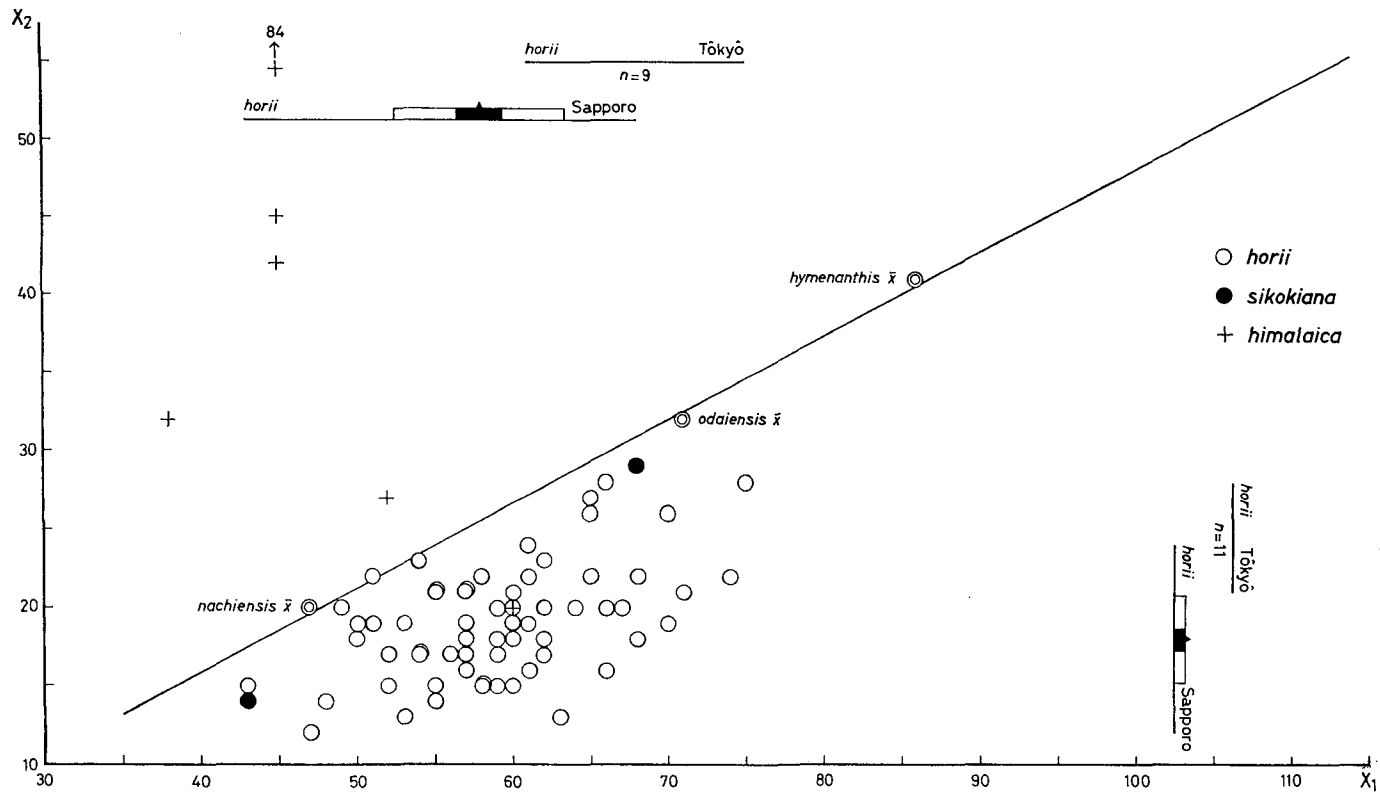
extreme of the morpho-cline. Such median lobes are rather similar to those in many species of *Fiorinia* outside the *horii*-group, although much robust in comparison with the latter. The other extreme is represented by *F. nachiensis*, in which the median lobes are wholly projected and rounded. The three species, especially *F. hymenanthis* and *F. odaiensis*, show some variations within each species concerning the shape and the degree of projection of the median lobes, forming together a fairly continuous series of variations (Fig. 1, D-I; Fig. 2; Fig. 4; Fig. 5; Fig. 8).

Thus, the main female characters of the *nachiensis*-series form paradiromic morpho-clines, which have their primitive extremes at *F. hymenanthis* and derived extremes at *F. nachiensis*. Then, *F. hymenanthis* approaches the ancestral condition of *F. odaiensis*, which in succession approaches the ancestral condition of *F. nachiensis*.

Other species

Upon the principles expressed by Maslin (l.c.) in his "principle of parallelism" and "principle of heterochronic parallelism" the taxonomic evaluation made for the main characters of the *nachiensis*-series may be applied to the other species of the *horii*-group, whether the group is monophyletic or not. These species are so diverse in characters that they seem to be isolated from rather than closely related to each other. It may, therefore, be inappropriate to compare them directly in numerical characters. However, in the association of the total numbers of perivulvar disc pores and gland spines the adult females of *F. sikokiana* and *F. horii* coincide, and approximate the derived extreme of the *nachiensis*-series (Fig. 16). Judging from the description, *F. rhododendri* from Taiwan also has comparatively small numbers of these organs. The adult female of *F. himalaica*, while approximating *F. nachiensis* and others in the total number of perivulvar disc pores, differs from all the other species of the *horii*-group by having a much broader range in the total number of gland spines (Fig. 16). This is due to the occasional emergence of individuals in which the prepygidial gland spines are numerous and tend to arrange in a continuous series along the body margin. Such an arrangement implies the loss of segmental regularity in the occurrence of gland spines and their subsequent (secondary) increase in number. In addition to this, *F. himalaica* exhibits much derived characters: the projected median lobes, the absence of gland spines on the pygidium, and the much reduced marginal macroducts;

Fig. 16. Number of perivulvar disc pores (X_1) against number of gland spines (X_2) in *Fiorinia horii*, *F. sikokiana* and *F. himalaica*. Dice-grams include some individuals other than shown in the scatter diagram. Regression line is fitted to the means for *Fiorinia hymenanthis*, *F. odaiensis* and *F. nachiensis* (from data of the scatter diagram Fig. 15).



the 2nd lobes are much reduced and practically obsolete. It is also peculiar by having strong marginal setae on the pygidium. As a whole the adult female of *F. himalaica* is the most derived form among the known species of the *horii*-group. The 2nd instar female, while having much reduced 2nd lobes, retains gland spines on the pygidial segments except for the 6th abdominal segment; among the Japanese species of the *horii*-group only *F. horii* is equivalent to *F. himalaica* in this regard.

F. sikokiana is characterized by having fairly projected median lobes and by lacking gland spines on the pygidium in both adult and 2nd instar females, but shows no numerical reduction of the marginal macroducts in the adult female. In *F. horii* the median lobes are sunken into the pygidium, whereas the 2nd lobes are practically obsolete, the marginal gland spines are usually lacking on the 7th abdominal segment, and the marginal macroducts have tendency towards numerical reduction; further, this species is peculiar by having numerous ventral microducts on the pygidium. The 2nd instar female of this species has marginal gland spines on the pygidial segments except for the 6th abdominal segment and has rather developed 2nd lobes. Judging from the description, *F. rhododendri* presents another combination of characters.

Thus, *F. sikokiana*, *F. horii* and *F. rhododendri* exhibit different combinations of characters, which should be interpreted as various mosaics of primitive and derived characters. Any obvious phylogenetic connection can not be established among them. *F. sikokiana* may have some relationship with the *nachiensis*-series, but no connecting form between them is known.

Second instar males

In the course of the present study the 2nd instar males of *F. hymenanthis*, *F. odaiensis*, and *F. nachiensis* have been available and examined. On the basis of the female characters these species are supposed to be closely related phylogenetically and to form a series which can be interpreted as an approximation of the ancestral-descendant sequence.

The 2nd instar males of *F. hymenanthis* and *F. odaiensis* are quite similar to each other. They well agree in basic structure with the 2nd instar males of three species of *Fiorinia* described by Tippins (1970) and other species of the genus. All these are similar to the 2nd instar males of some non-pupillarial, related genera. And they are all quite different from the conspecific 2nd instar females.

The 2nd instar male of *F. nachiensis* belongs to a different type. At first sight it appears not to be much different from the 2nd instar female of the same species; this may be due to the elongate body and also to the pygidial lobes, which are similar in shape to those of the female. It lacks the peculiar glandular system composed of "clustered pores" and "communal pores" (as used by Tippins l.c.), and this also contributes to the impression that it is quite different from the 2nd instar males of *F. hymenanthis* and *F. odaiensis*. In a closer comparison, however, it is similar to the latter in the arrangement of prepygidial ducts, in the elongate marginal setae of the pygidium and in the gland spines of the thorax and two basal abdominal segments (Fig. 7 and Fig. 10).

The gap between the 2nd instar males of *F. odaiensis* and *F. nachiensis* is, therefore, unexpectedly large. They belong to different types, yet they retain some characters in common.

CONCLUDING REMARKS

In my previous paper (Takagi 1961) I made two errors in interpreting forms of the *horii*-group. One was an erroneous identification of *F. hymenanthis* with *F. horii*. It is simply due to too hasty a conclusion. Though such an error is incidental to taxonomic practice, it may be avoided by careful reservation. The other error was a specific union of *F. odaiensis* with *F. nachiensis*. At that time only a limited number of adult female specimens were available for these species, and one of them, now referred to *F. nachiensis*, was intermediate between the two species concerning the pygidial gland spines (see Takagi l.c. Fig. 37). If further material were not available for the present study, I would again refer all these forms to a single species. The conclusion that these forms belong to two distinct species has been derived from an approach in terms of populations rather than typified forms. This conclusion has support from another stage, the 2nd instar male.

Now I adopt two established concepts to follow further discussion. One of them is that phylogenetically close organisms are similar in their genetic systems, of which any changes proceed without saltation. The other concept is that all growth stages of an organism are controlled by a single genetic system.

In the foregoing pages it is suggested that *F. hymenanthis* and *F. odaiensis* are "escapes" (as used by Maslin l.c.) from the ancestral lineage of *F. nachiensis*. So far as represented by the association morpho-cline of the total numbers of perivulvar disc pores and gland spines of the existing forms (Fig. 15) the evolving lineage (chrono-cline) seems to have slid upon an unvarying base. In this view the change of the pattern of marginal macroducts between *F. hymenanthis* and *F. odaiensis* seems abrupt, and, on the other hand, the numerical decrease of macroducts between *F. odaiensis* and *F. nachiensis* is quite slow (Table 1). As the simplest explanation for this a threshold may be supposed between *F. hymenanthis* and *F. odaiensis* in the phenotypic change of macroducts.

The loss of gland spines on the 7th and 8th abdominal segments in *F. nachiensis* also induces a new pattern. The fact that in this species one of the three individuals with the largest observed number of usual gland spines holds further gland spines on the 7th abdominal segment (Fig. 15) is assumed not accidental. The loss may have advanced gradually in the immediate ancestor of *F. nachiensis*, individuals without gland spines around the pygidial apex increasing in frequency in the population in association with the advancing numerical reduction of gland spines. However, the loss of those pygidial gland spines has appeared abruptly in this species during the evolutionary course of the *nachiensis*-series. It is suggested that the fixed trend of quantitative changes has eventually induced the new pattern as a result of passing a threshold to lose pygidial gland spines between *F. odaiensis* and *F. nachiensis*.

The 2nd instar males of the *nachiensis*-series also show an abrupt change between *F. odaiensis* and *F. nachiensis*. They may represent different haploid-phase manifestations* of similar genetic systems in response to a threshold supposed to lie between *F. odaiensis* and *F. nachiensis*. This inference may go too far, but various thresholds do exist in nature. Sondhi's (1962) model is a threshold

* The chromosomes of these species are unknown. In the diaspidid chromosome system the male is haploid in the postembryonic stages, with the chromosomes of paternal origin eliminated early in the development (Brown 1965).

hypothesis concerning phenotypic manifestation or suppression and is based on experimental studies.

Ostensibly independent evolutionary changes in different stages of development are known in various groups of organisms, yet their biological significance is not always clear. It is difficult to read the significance of the abrupt appearance of the new type of the 2nd instar male in *F. nachiensis*. In life this species seems not to be materially different from *F. odaiensis* except for the difference in altitude of their habitats. However, the adult female of *F. nachiensis*, having fewer wax-secretory organs, is more advanced than *F. odaiensis* in association with the pupillarial mode of life. The phenotypic suppression of the *odaiensis*-type of the 2nd instar male in *F. nachiensis* may be a direct consequence of the genetic change caused by the evolving adult female. In that case the neutral, or at least not critical, adaptive value of the varying characters of the 2nd instar male is assumed. In the Coccoidea the male stages are more or less transitory in comparison with the adult female, which is enduring in the life cycle.

The finding of these different 2nd instar males among the closely related species means that we must be cautious about the taxonomic statement based on this stage alone. Indeed, reliance on any single stage of development may be misleading. The life cycle is the essential unit in biology (Bonner 1965). The "developmental approach" (Orton 1955), based on the integrated ontogeny, will be fruitful in Coccoidea taxonomy, even if it is possible only for limited species.

Finally, the median pygidial lobes of the adult and 2nd instar females should be commented upon. In the *nachiensis*-series the primitive extreme exhibits invaginated median lobes, and the derived extreme projected ones. The trend towards the disappearance of the apical invagination of the pygidium may be a reductive change, for this seems to be a step towards the reduction of the interlobar space (the supposed 9th abdominal segment). Nevertheless, the median lobes themselves seem not to be affected by any reductive change, but become robust, in the evolutionary sequence of the *nachiensis*-series.

The reductive change of adult female features is a common tendency in pupillarial scale insects, and is well manifested by the *nachiensis*-series in some morpho-clines. In this series the only obvious exception is presented by the median lobes. This exception must be of special significance. It may be related with the mining habit of the females under the leaf-indumentum of the host plants, and in that case the strong median lobes may be functional in the 2nd instar. This is now no more than speculation. Among the *Fiorinia*-species outside the *horii*-group an enlargement of the median lobes is quite unusual. *F. minor* Maskell is such a rare species, but it occurs on plants without indumentum on the leaves.

The only morphological reason to lump all the seven species associated with true rhododendrons is their agreement in the enlarged median lobes. Except for the three species of the *nachiensis*-series there is no evidence to support the view that they are phylogenetically closely related. Convergence, therefore, may be involved provided the trend towards enlarged median lobes is an adaptive change for mining the leaf-indumentum of rhododendrons. There are, however, no definite evidences to support this view, either. To proceed further, we have to wait for the discoveries of other species of *Fiorinia* occurring on rhododendrons in East Asia.

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