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Author(s)	Takagi, Sadao
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A FURTHER STUDY ON THE HORII-GROUP OF FIORINIA
(HOMOPTERA : COCCOIDEA : DIASPIDIDAE)

By SADAŌ TAKAGI

Abstract

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Six species of the *horii*-group of *Fiorinia*, all feeding on the leaves of rhododendrons, are reviewed: *F. hymenanthis*, *F. odaiensis*, *F. nachiensis*, *F. sikokiana* and *F. horii* from Japan and *F. himalaica* from Himalaya. The distribution of the Japanese species is shown on maps. Local variation is given for each species mainly concerning the numbers of secretory organs and the shape of the median lobes in the adult female. Second instar males are figured for *F. nachiensis* from Oki Island, *F. sikokiana*, *F. horii* and *F. himalaica*. They are compared with those of other species of *Fiorinia*, and the "glandular" and "non-glandular" types of the 2nd instar males are distinguished. A dual pattern of abrupt and continuous changes of characters in the *nachiensis*-series, which is composed of *F. hymenanthis*, *F. odaiensis* and *F. nachiensis*, is recognized. The parallel appearance of the non-glandular 2nd instar males in the *horii*-group is suggested.

Author's address. Entomological Institute, Faculty of Agriculture, Hokkaidō University, Sapporo, 060 Japan.

Contents

Introduction	3
Material and review	
<i>Fiorinia hymenanthis</i>	3
<i>Fiorinia odaiensis</i>	8
<i>Fiorinia nachiensis</i>	10
<i>Fiorinia sikokiana</i>	14
<i>Fiorinia horii</i>	18
<i>Fiorinia himalaica</i> *	20
Distribution of the Japanese species	23
Discussion	
<i>Nachiensis</i> -series	23
<i>Fiorinia sikokiana</i> , <i>F. horii</i> and <i>F. himalaica</i>	27
Second instar males	28
Concluding remarks	29
Acknowledgements	31
References	32

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INTRODUCTION

The *hori*-group of *Fiorinia* is an assemblage of species feeding on rhododendrons of the subgenus *Hymenanthus* in East Asia. The known species are commonly characterized in the adult and 2nd instar females by the median lobes unusually enlarged for members of the genus. In 1975 I dealt with 6 species of the group from Japan and Nepal (Takagi 1975a, 1975b). Three species of them appeared to be closely related, and paradigmatic morphoclines were constructed for most of the female characters observed changing among them. The series composed of the 3 species was accordingly supposed to approach to the ancestral-descendant series which has brought them forth. The other 3 species appeared to be isolated, and the possibility of parallelism or convergence was suggested concerning the appearance of the unusually enlarged median lobes. It seemed to me that the comparisons of all these species required reflection on gradualism and saltationism, phenotypic suppression and manifestation, and adaptive and non-adaptive changes of characters.

A supplementary review of these species is here intended on the basis of further material from Japan, Nepal and India in expectation of proceeding with the problem of the evolutionary pattern of the group.

MATERIAL AND REVIEW

Fiorinia hymenanthus

This species was described from specimens collected on cultivated rhododendrons at Sapporo, Tôkyô and the mountain Hiko-san. However, the 1st 2 localities are not its native habitats. The material from the last locality was obtained in a garden collection of native plants of the mountain (1200 m), at the Hiko-san Biological Laboratory of Kyûsyû University, and probably belongs to the fauna of the mountain; it will be denoted by "Hiko-san (A)".

Further material referable to this species is at hand from the following localities: Higasiyama Onsen (1975, I. Togashi) and Tadami (28 May 1977, T. Sunose), Hukusima-ken, Honsyû. The hosts, probably belonging to *Rhododendron metternichii* var. *pentamerum* (= *R. degronianum*), were in cultivation, but presumed to have been transplanted from nearby habitats.

Torigoe, Isikawa-ken, Honsyû (24. Dec. 1974 and Jan. 1975, I. Togashi). The material was collected on *Rhododendron metternichii* var. *hondoense* at Nonoi, where the hosts had been transplanted from a wild habitat at Torigoe.

Hanase (12 Oct. 1977, S. Takagi) and Hiei-zan (21 Aug. 1977, H. Takada), Kyôto, Honsyû, on *Rhododendron metternichii*. At Hanase the material was obtained from wild plants; at Hiei-zan in the ground of a temple.

Yunoyama Onsen, at the foot of Gozaisyo-dake (1210 m), Mie-ken, Honsyû (29 Sept. 1976, S. Takagi). Collected from a well-grown tree of *Rhododendron metternichii*, which, after the owner, was transplanted years ago from a higher altitude of Gozaisyo-dake.

Omogo-kei, Ehime-ken, Sikoku (2 March 1976, K. Kamemoto, sent to me by M. Matsuda). Collected from commercial saplings of *Rhododendron metternichii* about 10 years old, which were brought there from somewhere in Kôti-ken, Sikoku, in 1975; further information as to the source of the host plants was unavailable.

Hiko-san, Kyûsyû (26 Apr. 1976, Y. Miyatake). Collected from *Rhododendron*

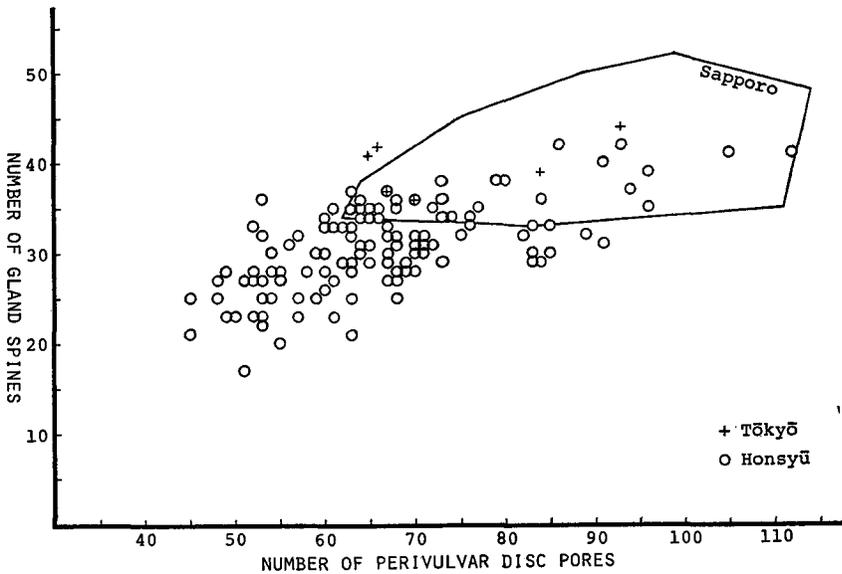


Fig. 1. *Fiorinia hymenanthis*, adult female. Number of gland spines against number of perivulvar disc pores in specimens from Tôkyô and other localities in Honsyû. The polygon is constructed for the specimens collected at Sapporo and studied by Takagi 1975b. Number of individuals (n) and correlation coefficient (r) in larger samples: Sapporo, $n=60$, $r=0.44$; Higasiyama Onsen, $n=24$, $r=0.83$; Tadami, $n=22$, $r=0.52$; Torigoe, $n=29$, $r=0.72$; Hanase, $n=30$, $r=0.53$; Yunoyama Onsen, $n=23$, $r=0.16$.

metternichii in the garden collection of native plants at the Hiko-san Biological Laboratory. The material will be denoted by "Hiko-san (B)".

Tara-dake. (983 m), Saga-ken, Kyûsyû (15 April 1976, S. Kawai). Collected from *Rhododendron metternichii* near the summit of the mountain.

When this species was described in 1975, the concept of it was based on several samples, which obviously represent only part of the species. The further samples at hand show that it is considerably variable. It is known now that this species inhabits a broad region of Central Honsyû and also North Kyûsyû.

The adult females collected from Central Honsyû and here examined show, as a whole, a wide range of variation in the number of the perivulvar disc pores (Fig. 1), but there is no clear geoclimatic tendency (Fig. 3). There seems to be some correlation between the numbers of the gland spines and perivulvar disc pores in most of the local samples (see under Fig. 1). Compared with the specimens from Sapporo those from Central Honsyû have the numbers of these secretory organs extended or shifted to small values.

The adult females from Central Honsyû show a continuous variation in the shape of the median lobes. In Fig. 4 examples from some localities are arranged in local order from north to south. Though these lobes are variable even among specimens from the same locality, they appear to have a tendency to become more produced and more rounded in southern localities. This tendency is also exhibited by the 2nd instar females and more clearly (Fig. 5). In this stage these lobes are less variable within the same localities than in the adult stage.

These adult females are also considerably variable in the development of the

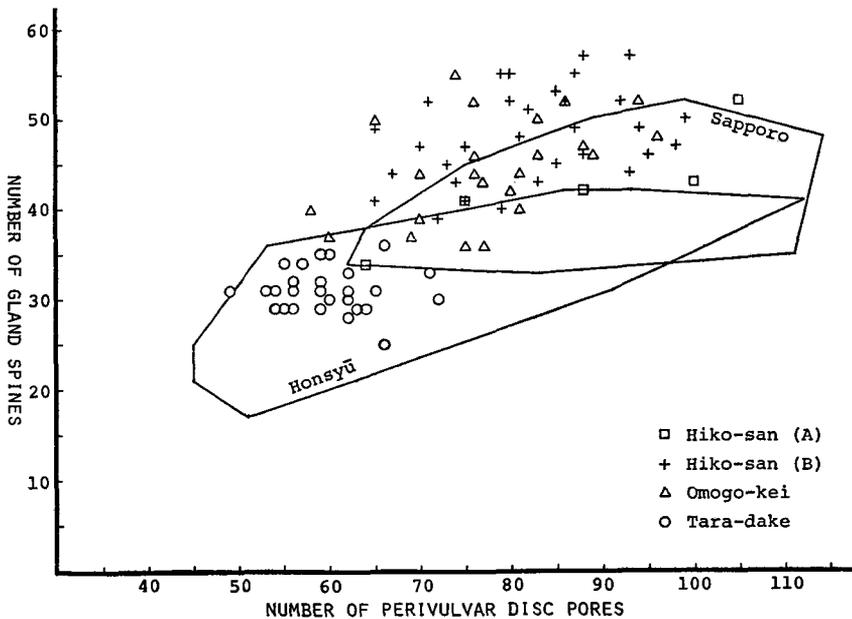


Fig. 2. *Fiorinia hymenanthis*, adult female. Number of gland spines against number of perivulvar disc pores in specimens from Kyūsyū and Omogo-kei. The upper polygon is constructed for the specimens collected at Sapporo and studied by Takagi 1975b; the lower for the specimens collected in Honsyū and mapped in Fig. 1 (except those from Tôkyô). Number of individuals (n) and correlation coefficient (r): Hiko-san (B), $n=32$, $r=0.28$; Omogo-kei, $n=23$, $r=0.29$; Tara-dake, $n=30$, $r=-0.04$.

interantennal process. This process is found in most of the examined specimens from northern localities (Higasiyama Onsen and Tadami); in those from other localities it is often (Hanase) or mostly (Torigoe and Yunoyama Onsen) lacking and, if present, usually poorly developed.

Compared with the adult females from Honsyū those from Hiko-san are characterized as follows: 1) The interantennal process is always found and usually well developed; 2) The dorsal submedian microducts on the prepygidial abdominal segments tend to be numerous; 3) The gland spines tend to be numerous (Fig. 3); 4) The median lobes tend to be expanded laterally out of the apical notch of the pygidium (this is also the case in the 2nd instar female) (Fig. 6); 5) The paraphyses arising from the base of the 2nd lobe are obsolete or, if present, ill developed (this is also the case in the 2nd instar female). The specimens collected at Omogo-kei on commercial rhododendrons belong to this form.

The adult females from Tara-dake are not different from those from Honsyū in the numbers of the perivulvar disc pores, gland spines (Fig. 2; Fig. 3) and prepygidial submedian dorsal microducts, and also in the median lobes little expanded laterally (Fig. 6). On the other hand, they are all provided with a more or less developed interantennal process; the paraphyses arising from the base of the 2nd lobe are obsolete or ill developed. Geographically this form must be more related with that from Hiko-san; morphologically it appears to connect the latter with the form from Honsyū.

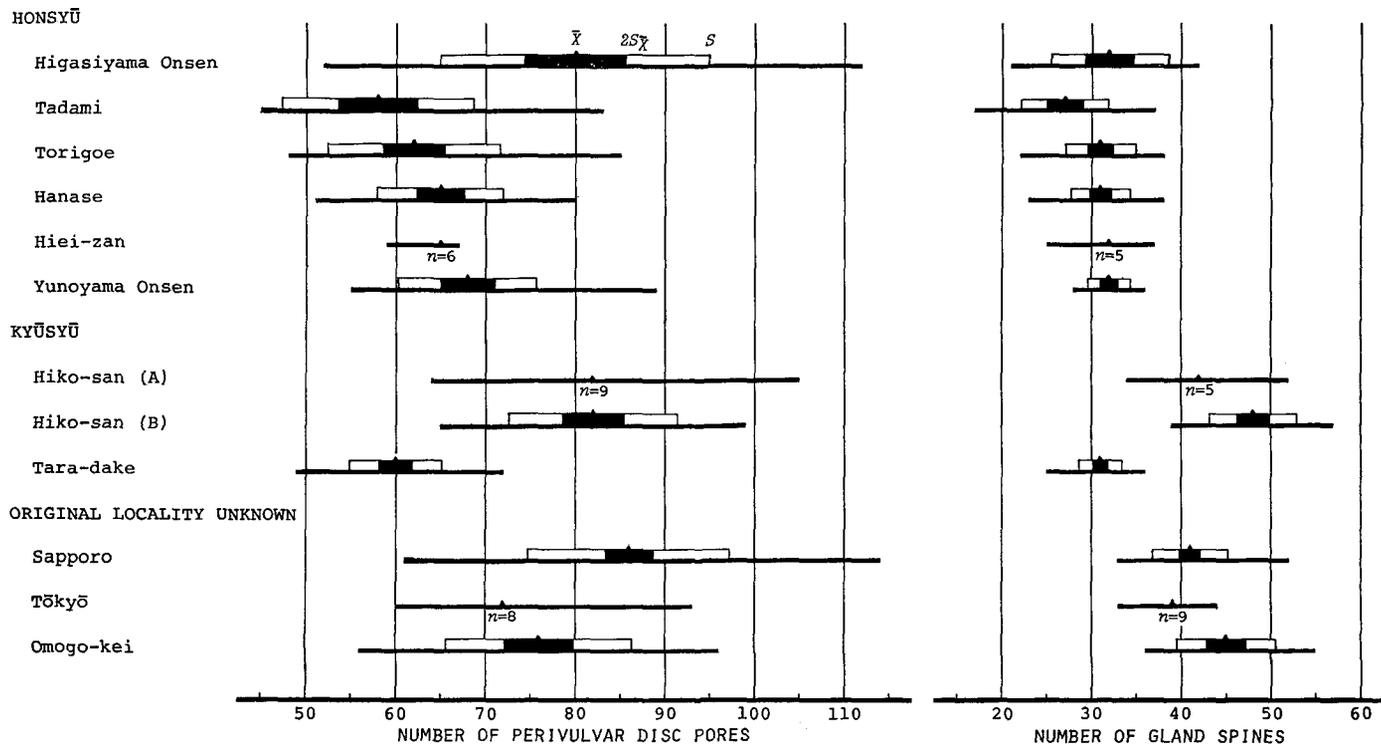


Fig. 3. *Fiorinia hymenanthidis*, adult female. Local variation in numbers of gland spines and perivulvar disc pores. The samples from Honsyū are arranged in local order from north to south.

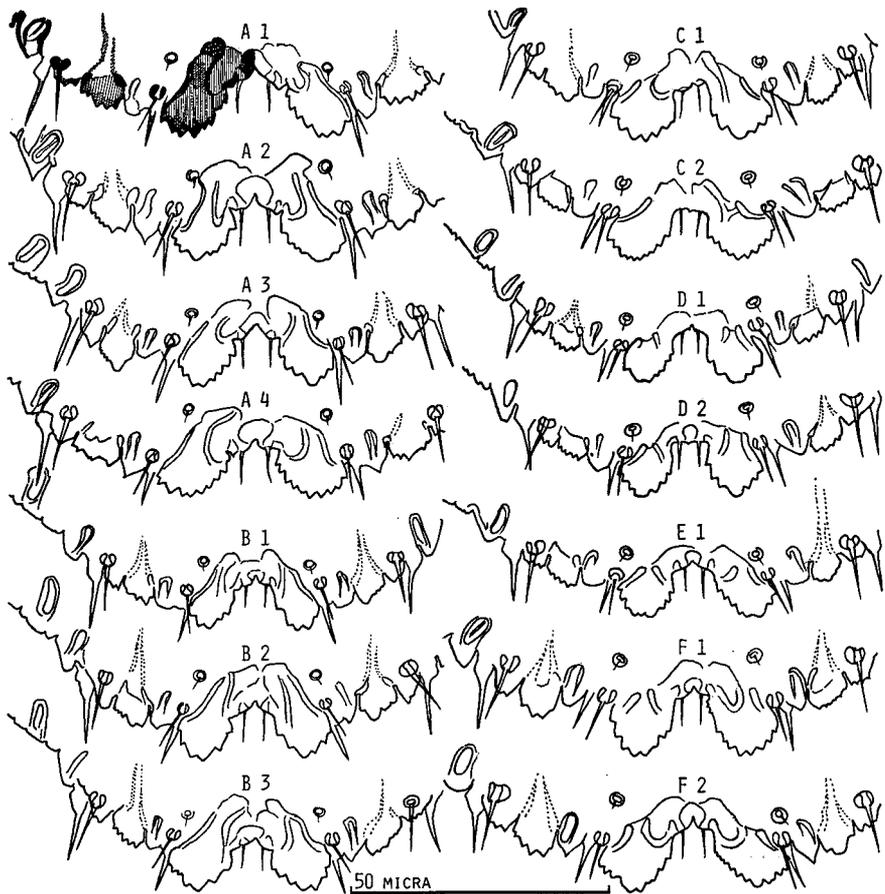


Fig. 4. *Fiorinia hymenanthis*, adult female. Pygidial apex. A1–A4: Higasiyama Onsen; B1–B3: Tadami; C1 and C2: Torigoe; D1 and D2: Hanase; E1: Hiei-zan; F1 and F2: Yunoyama Onsen.

There seems to be no correlation between the numbers of the gland spines and perivulvar disc pores in the samples from Omogo-kei and North Kyûsyû (see under Fig. 2) as well as in the one from Yunoyama Onsen. A significant correlation, however, is found between them when the numbers are averaged for each local sample ($r=0.78$, $n=12$) (Fig. 21).

The number of the disc pores associated with the anterior spiracle was not always determined exactly. Based thus on a limited number of specimens it seems also to show a local variation. The pores are fewer in the local samples from Honsyû (range 1–4 or 2–4, mean 2.2–2.8) than in those from Kyûsyû and Omogo-kei (range 2–4, 2–5, and 3–7, mean 3.2, 3.8 and 4.0, for Tara-dake, Hiko-san (B) and Omogo-kei, respectively). The adult females from Sapporo, studied in the original description, are similar to those from the northernmost locality of Honsyû (Higasiyama Onsen) in some characters, though they approximate the specimens from Hiko-san and Omogo-kei in the number of the gland spines (Fig. 2; Fig. 3) and also in that of the disc pores associated with the anterior spiracle (range 2–6, mean 4.1).

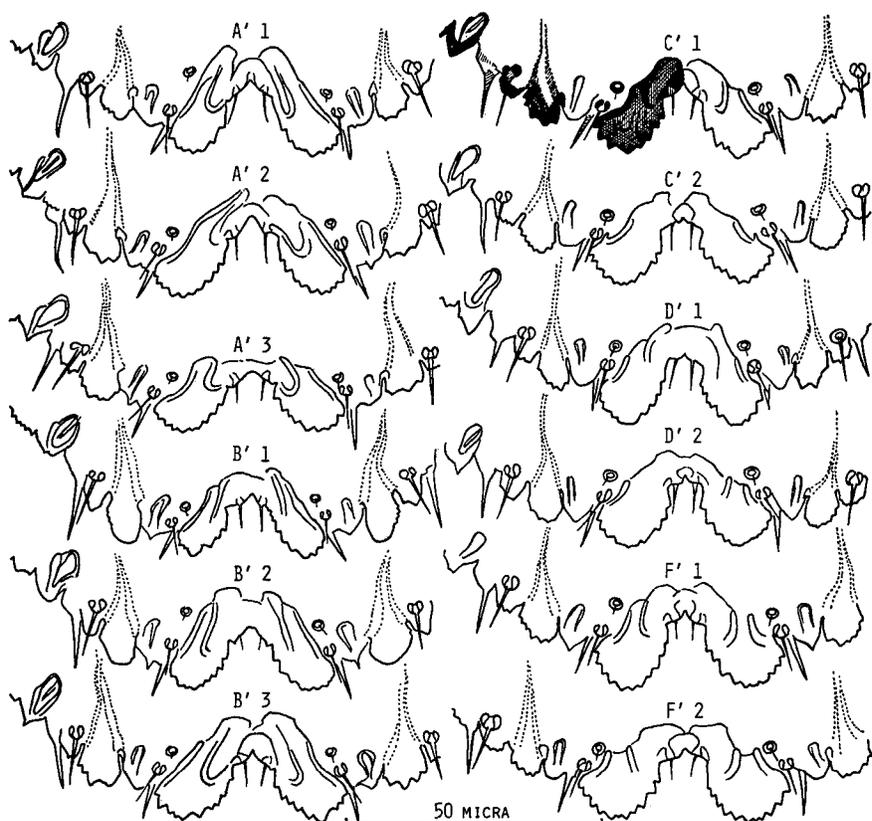


Fig. 5. *Fiorinia hymenanthis*, 2nd instar female exuvial cast. Pygidial apex. A'1-A'3: Higasiyama Onsen; B'1-B'3: Tadami; C'1 and C'2: Torigoe; D'1 and D'2: Hanase; F'1 and F'2: Yunoyama Onsen.

Specimens of the 2nd instar male are at hand from Sapporo, Tadami, Torigoe, Hanase, Hiei-zan, Omogo-kei and Hiko-san (B). As mentioned in my previous paper *F. hymenanthis* agrees exactly with *F. odaiensis* in this stage.

Fiorinia odaiensis

This species was described as occurring on *Rhododendron metternichii* on the plateau of Ôdai-ga-hara (ca. 1500 m), Kii Peninsula, Honsyû. Further material at hand referable to it and from the same plateau (29 July 1976, H. Takada), "Ôdai-ga-hara (B)" as here designated, will be distinguished from the original lot, "Ôdai-ga-hara (A)". Material obtained from saplings about 4 years old of *Rhododendron metternichii* transplanted from Siraya-dake (1177 m), Kii Peninsula (4 May 1976, M. Oda), is also referred to this species.

In the numbers of the perivulvar disc pores and gland spines of the adult females the sample Ôdai-ga-hara (B) is not much different from Ôdai-ga-hara (A), whereas the sample Siraya-dake somewhat differs from them, having the means shifted to smaller values (Fig. 7). Also in the number of the disc pores associated with the anterior spiracle the 1st is not different from the 2nd (range 1-5 and 1-6, mean 3.2

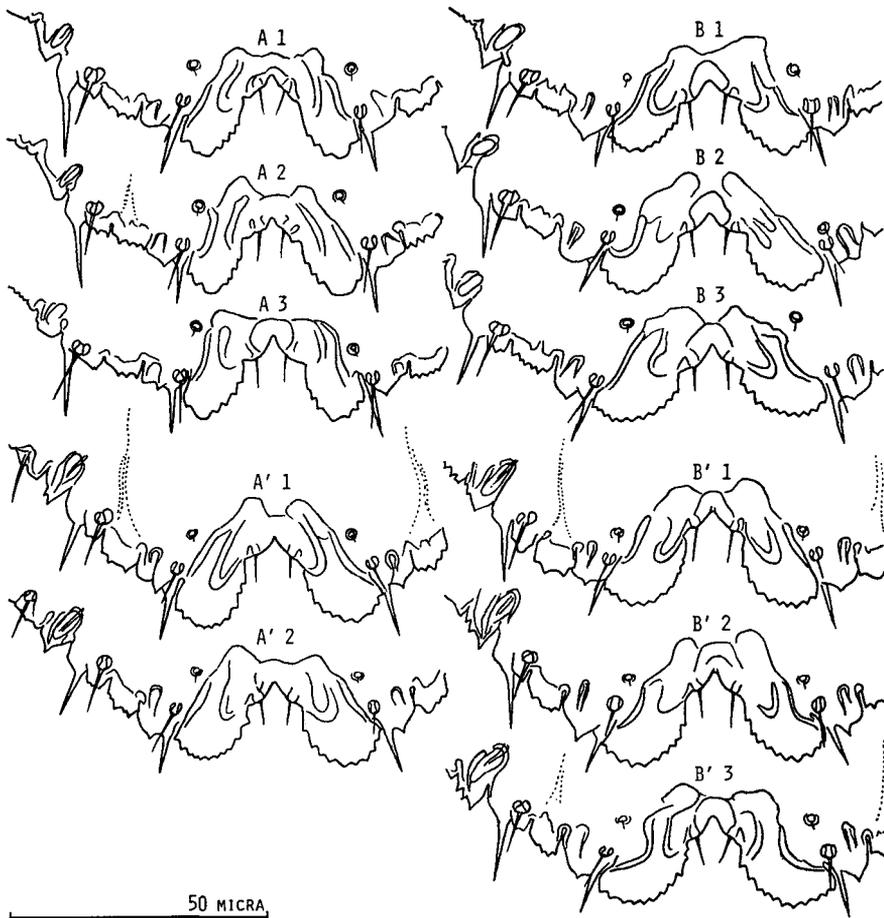


Fig. 6. *Fiorinia hymenanthis*, adult female (A1–B3) and 2nd instar female exuvial cast (A'1–B'3). Pygidial apex. A1–A3 and A'1 and A'2: Tara-dake; B1–B3 and B'1–B'3: Hiko-san.

and 3.3, respectively), whereas the last is somewhat different from them (range 2–4, mean 2.6). One or 2 disc pores are associated with the posterior spiracle in many cases (about 51%) in Ôdai-ga-hara (A) and 1 disc pore is also often associated with in Ôdai-ga-hara (B), but none in Siraya-dake. However, the most noteworthy character found in the new samples is that the gland spines are often lacking on the 7th or 8th abdominal segment or even on both (Fig. 8; Table 1). In all these characters Ôdai-ga-hara (B) appears to connect Siraya-dake with Ôdai-ga-hara (A).

The median lobes are somewhat variable in shape in the adult females of *F. odaiensis* as here understood. They are less variable in the 2nd instar females, in which they are well rounded and produced, with the inner bases usually more or less sunken into the pygidium (Fig. 8).

The 2nd instar male was described in the original description (Takagi 1975b). Further specimens of this stage from Ôdai-ga-hara (B) and Siraya-dake hold to the described pattern of characters.

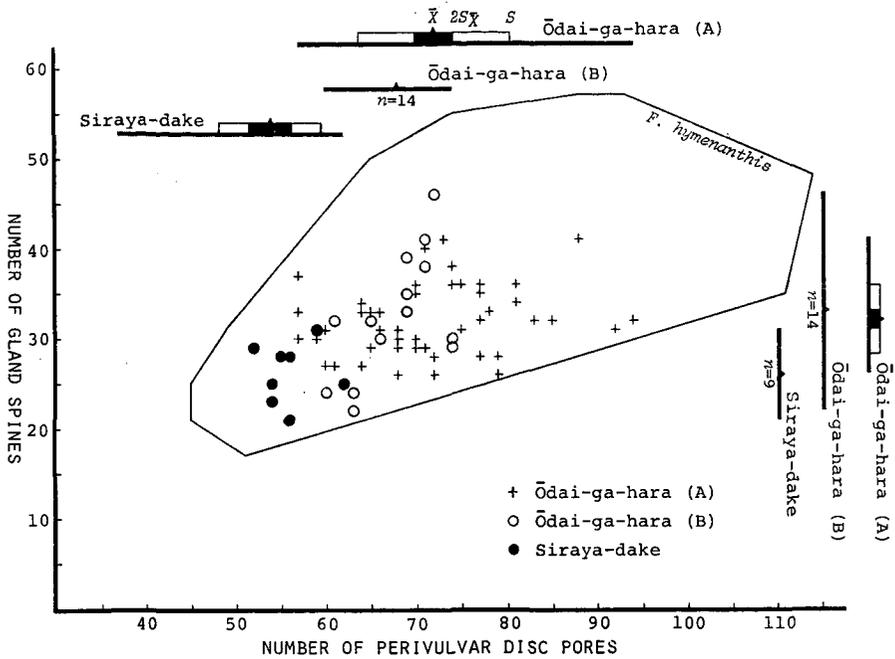


Fig. 7. *Fiorinia odaiensis*, adult female. Number of gland spines against number of perivulvar disc pores. The polygon for *Fiorinia hymenanthis* is constructed from Fig. 2. The Dice-gram shows that the region occupied by the sample from Siraya-dake in the scattergram should be more expanded left, beyond the limit of the polygon, than defined by the dots.

Table 1. Occurrence of gland spines on 7th and 8th abdominal segments in adult females from 2 samples of *F. odaiensis* and 1 sample of *F. nachiensis* (% in parentheses).

Gland spines		<i>F. odaiensis</i>		<i>F. nachiensis</i>
Abd. 7	Abd. 8	Ôdai-ga-hara (B)	Siraya-dake	Oki
1	1	10(35.7)	2(4.3)	20(15.7)
1	0	6(21.4)	14(30.4)	0
0	1	8(28.6)	2(4.3)	76(59.9)
0	0	4(14.3)	28(61.0)	31(24.4)
		28	46	127

Fiorinia nachiensis

This species has been known to inhabit low mountains in the Kii Peninsula, Honsyû. Material referred here to this species was obtained in Oki, an island in the Japan Sea, on the island form (f. *brevifolium*) of *Rhododendron metternichii* in cultivation (May 1977, T. Murai).

The adult females from Oki Island somewhat differ from those from the Kii Peninsula in the numbers of the perivulvar disc pores and gland spines, having larger means (Fig. 9). This difference is never conspicuous, but seems important.

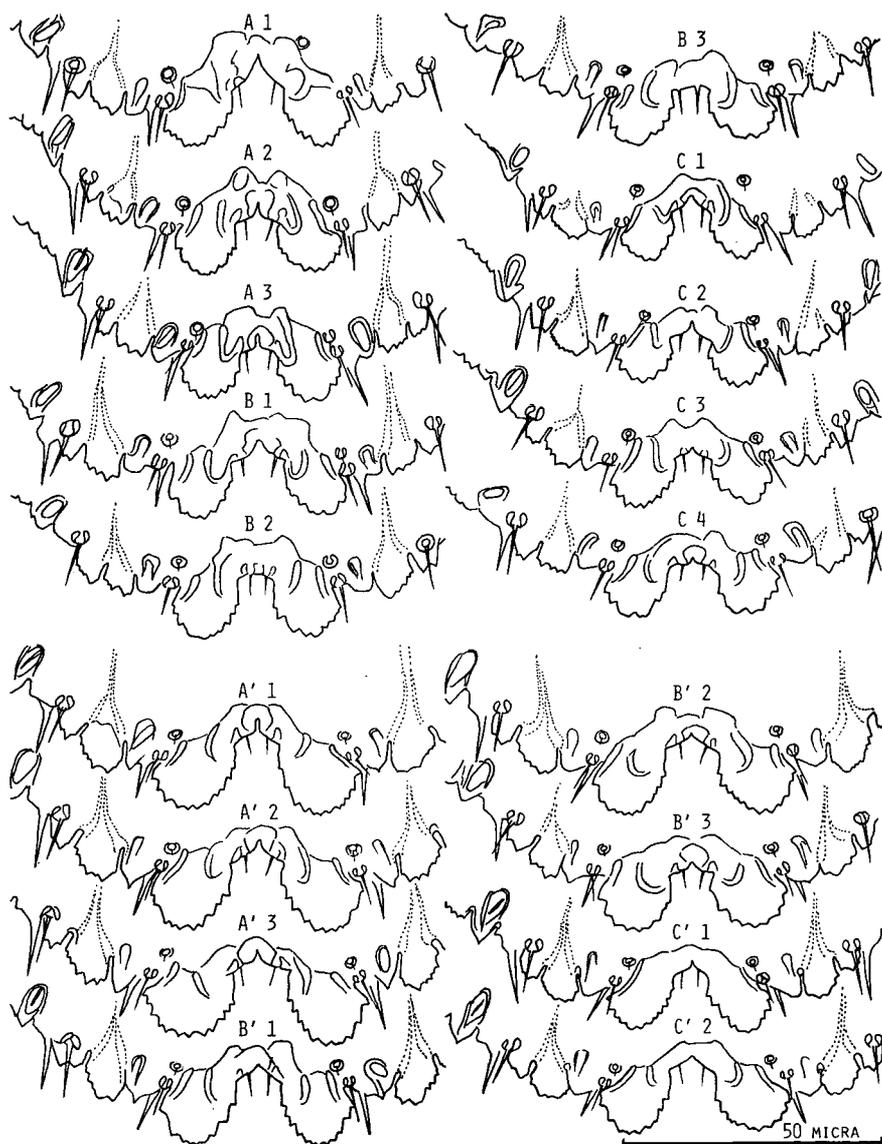


Fig. 8. *Fiorinia odaiensis*, adult female (A1-C4) and 2nd instar female exuvial cast (A'1-C'2). Pygidial apex. A1-A3 and A'1-A'3: Ôdai-ga-hara (A); B1-B3 and B'1-B'3: Ôdai-ga-hara (B); C1-C4 and C'1 and C'2: Siraya-dake.

In the Oki form the larger mean for the number of the gland spines is associated with the frequent occurrence of gland spines on the 7th and 8th abdominal segments, while in the Kii form the gland spines are lacking on these segments with the exception of a single observed case (Fig. 10; Table 1). These forms do not differ in the number of disc pores associated with the anterior spiracle (range 1-4 and 1-5, mean 2.5 and 2.4, in the Kii and Oki forms, respectively).

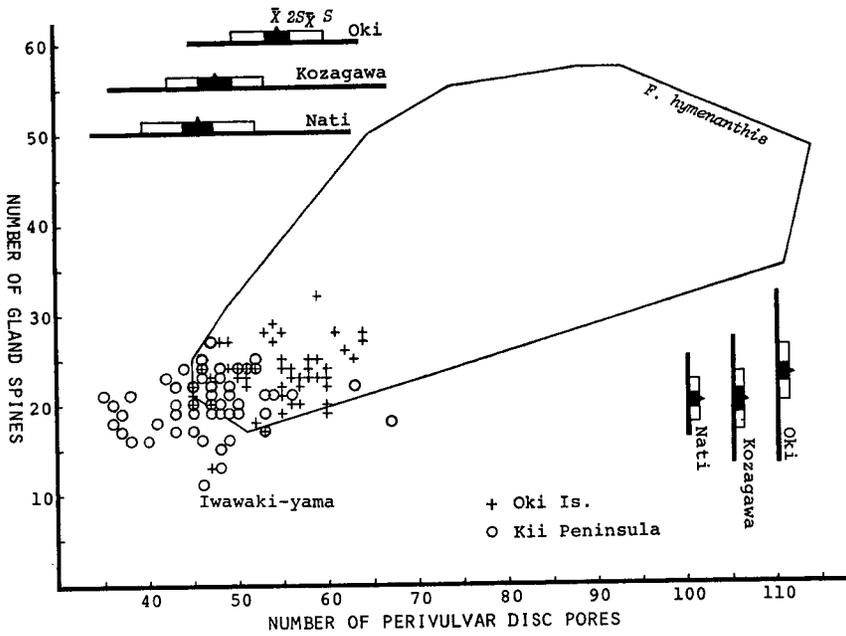


Fig. 9. *Fiorinia nachiensis*, adult female. Number of gland spines against number of perivulvar disc pores. The polygon for *Fiorinia hymenanthis* is constructed from Fig. 2.

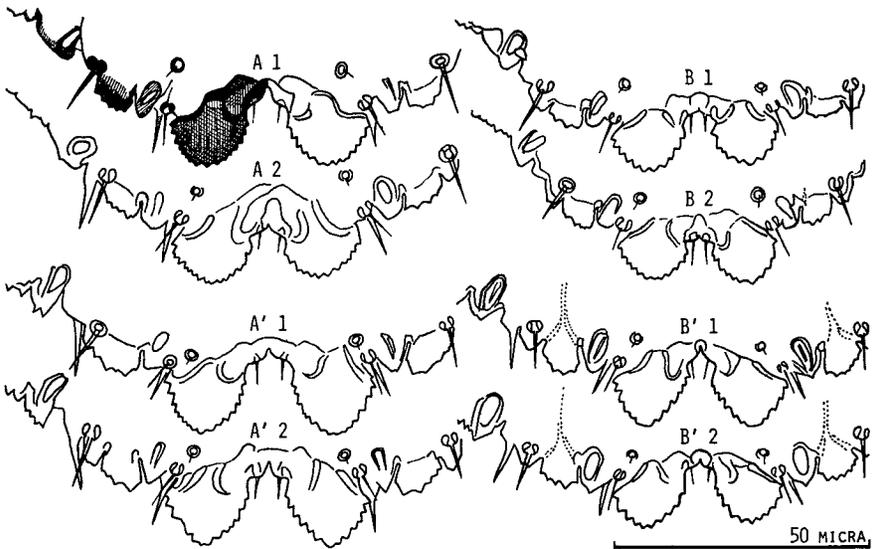


Fig. 10. *Fiorinia nachiensis*, adult female (A1-B2) and 2nd instar female exuvial cast (A'1-B'2). Pygidial apex. A1, A2, A'1 and A'2: Oki Is.; B1, B2, B'1 and B'2: Nati.

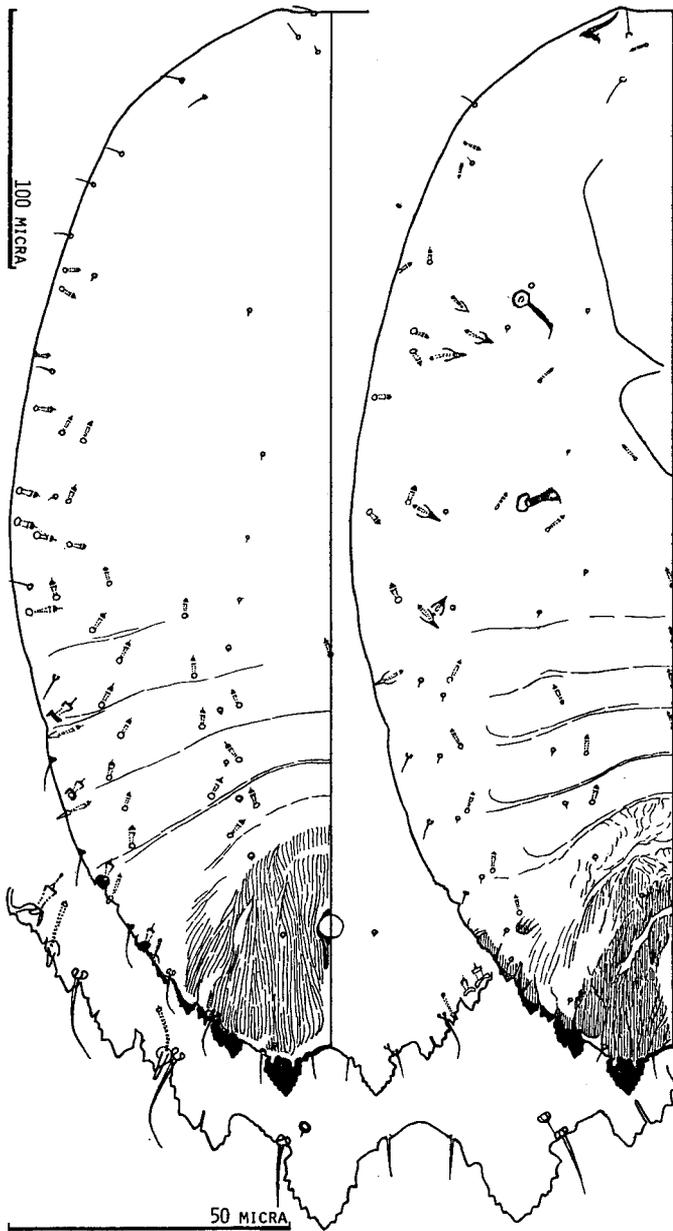


Fig. 11. *Fiorinia nachiensis*, 2nd instar male from Oki Is.

Both adult and 2nd instar females of the Oki form are similar to those of the Kii form in the median lobes, which are wholly produced or nearly so and well rounded and serrate, but differ from the latter by the paraphyses obsolete on the base of the 2nd lobe. In the Kii form the paraphyses are, though much reduced, still visible in the 2nd instar female (Fig. 10).

The 2nd instar male of the Kii form was described in my previous paper (1975b). It is quite different from the corresponding stage of *F. hymenanthis* and *F. odaiensis*. Some specimens of this stage mounted from the Oki material are mummified owing to parasitism except only one, which is figured here (Fig. 11). They agree with the 2nd instar male of the Kii form in general structure. Yet differences are notable. In the Oki form the median lobes are usually pointed apically (more or less rounded in the Kii form) and separated from each other by a space much wider than one of them (usually separated by the width of one of them), small gland spines are found on the body margin as posteriorly as the 6th abdominal segment (not found), and macroducts appearing peculiar in shape occur on the abdominal margin (macroducts occurring on the abdominal margin appear not different from the others). In these characters the 2nd instar male of the Oki form is rather similar to that of *F. hymenanthis* or *F. odaiensis*.

Fiorinia sikokiana

This species was originally described on the basis of a small number of specimens collected in Sikoku. New material was obtained on wild or cultivated *Rhododendron metternichii* in the following localities, which are in or near the Tyûgoku District, Honsyû: Mikawa-yama, Hyôgo-ken, on wild plants (4 Oct. 1977, S. Takagi); Osika-kei, Tottori-ken, on wild plants (7 Oct. 1977, S. Takagi); Okutu, Kagamino and Yubara, Okayama-ken, on plants transplanted from nearby mountains (May 1976, E. Inoue); Takeni, Hiroshima-ken, on wild plants (11 Oct. 1977, S. Takagi); Hikimi, Simane-ken, on 2 potted plants (9 Oct. 1977, S. Takagi), the samples from the different pots will be distinguished as "Hikimi (A)" and "Hikimi (B)".

The adult females mounted from the new material are a little variable locally in the numbers of the perivulvar disc pores and gland spines (Fig. 12). The median lobes are also only a little variable in shape; these lobes in the 2nd instar females appear less variable as in the other species here treated (Fig. 13).

Rather remarkable changes occur in the number of the macroducts between the samples from eastern localities (Mikawa-yama; Osika-kei; Okayama-ken) and those from western localities (Takeni; Hikimi) and also between Hikimi (A) and (B) (Table 2). The macroducts are basically 8 in number on each side of the body and arranged marginally as follows: 1 on the 3rd abdominal segment, 2 on each of the 4th to 6th, and 1 on the 7th. The number is variable owing to the occasional occurrence of 1 submarginal macroduct on the 3rd or 4th abdominal segment or

Table 2. Frequency of number of macroducts on one side of body in adult females of *Fiorinia sikokiana* (% in parentheses).

Sample	Number of macroducts*							
	4	5	6	7	8	9	10	11
Mikawa-yama			1 (0.9)	14 (12.3)	73 (64.0)	25 (21.9)	1 (0.9)	
Osika-kei			1 (0.8)	20 (16.8)	78 (65.6)	20 (16.8)		
Okayama-ken			6 (6.0)	22 (22.0)	46 (46.0)	23 (23.0)	2 (2.0)	1 (1.0)
Takeni	1 (0.8)	6 (5.0)	27 (22.8)	56 (47.1)	22 (18.5)	6 (5.0)	1 (0.8)	
Hikimi (A)		4 (8.7)	10 (21.7)	20 (43.5)	10 (21.7)	1 (2.2)	1 (2.2)	
Hikimi (B)		9 (20.4)	19 (43.2)	12 (27.3)	4 (9.1)			

* Marginal and, when present, submarginal macroducts.

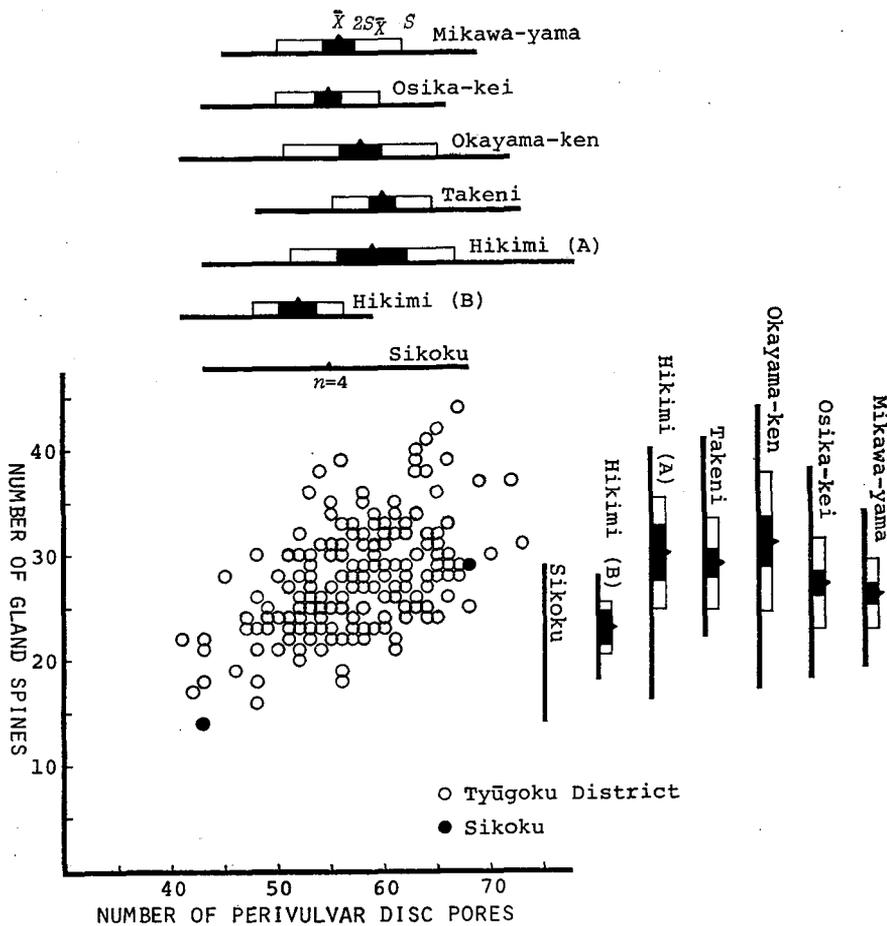


Fig. 12. *Fiorinia sikokiana*, adult female. Number of gland spines against number of perivulvar disc pores.

rarely on either and the loss of 1 or more marginal macroducts.

The following observation should also be given: The interantennal process is usually lacking (when present, quite rudimentary); 1-4 (usually 2 or 3) disc pores are associated with the anterior spiracle; 0-2 (usually 1) gland spines occur on the 4th abdominal segment, but none on the succeeding segments.

A total of 27 2nd instar males were mounted from the material collected in 1977. None of them are in excellent condition. They are similar to the corresponding stage of *F. nachiensis* in the general structure of body, but are quite peculiar in having the median lobes usually bilobate (Fig. 14; Table 3). At times the median lobe on one or either side is unilobed and more or less rounded as in the adult and 2nd instar females. These lobes are separated from each other by a space variable in width: at times the interspace is as wide as or only a little wider than one of them, but more often it is much wider than the latter. The gland spines are confined to the thorax and basal abdominal segments as in the Kii form of *F. nachiensis*. Ducts scattered along the pygidial margin are variable in occurrence;

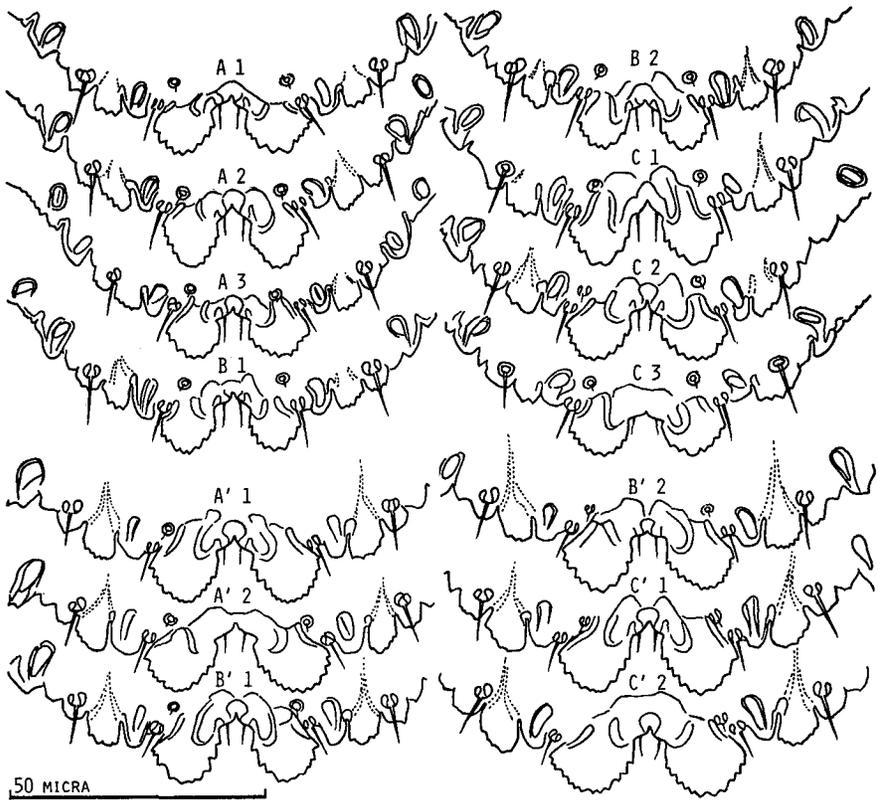
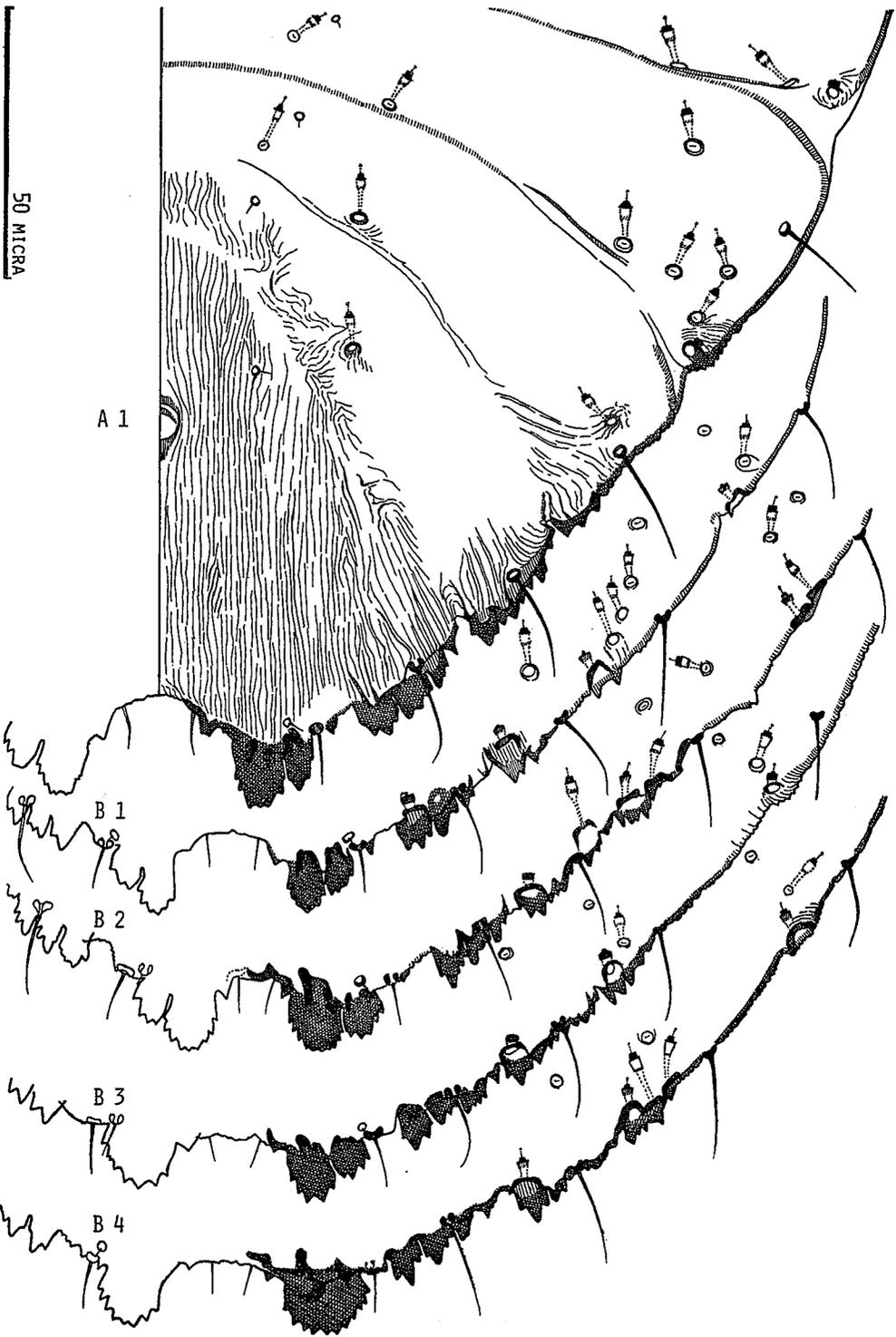


Fig. 13. *Fiorinia sikokiana*, adult female (A1-C3) and 2nd instar female exuvial cast (A'1-C'2). Pygidial apex. A1-A3 and A'1 and A'2: Mikawa-yama; B1, B2, B'1 and B'2: Osika-kei; C1-C3 and C'1 and C'2: Hikimi (B).

Table 3. Occurrence of bilobate and unilobed median lobes in 2nd instar males of *Fiorinia sikokiana*.

Sample	Median lobes both bilobate	Median lobes one bilobate, the other unilobed	Median lobes both unilobed
Mikawa-yama	8	1	2
Osika-kei	1	1	0
Takeni	8	0	0
Hikimi (A)	5	0	0
Hikimi (B)	0	1	0
	22	3	2

Fig. 14. *Fiorinia sikokiana*, 2nd instar male. A1: pygidium in dorsal aspect, Takeni; B1-B4: pygidial margin in dorsal aspect, Mikawa-yama.



some of them on the margin appear different from the others, being quite shortened.

Fiorinia horii

This species has been known from specimens collected on cultivated rhododendrons at Sapporo and Tôkyô. New material was collected on wild plants of *Rhododendron makinoi* near Makihara and also at Tiiwa-kyô, Hôrai-tyô, Aiti-ken, Honsyû (24-26 Sept. 1976, S. Takagi). The material obtained near Makihara will be treated herein. Further material is at hand from *R. makinoi* cultivated at Hamakita, Sizuoka-ken, Honsyû (June 1978, F. Ikeda). These lots of material were collected just in or after oviposition, so that many of the mounted adult females are not in good condition.

The adult females from Tôkyô are somewhat different from the others in the numbers of the perivulvar disc pores and gland spines (Fig. 15). However, in the occurrence of gland spines around the pygidial apex they agree with those from Hôrai-tyô in contrast with those from Sapporo and Hamakita (Table 4). On the other hand, in the number of the macroducts the sample from Hôrai-tyô is very close to that from Sapporo (Table 5). In a word there is no obvious gap in the correlation among numerical characters of these secretory organs. There seems also to be some variation among the samples in the number of the ventral microducts of the pygidium, though it was often difficult to count them exactly. The median lobes are somewhat variable in shape even in the same localities; they are much less variable in the 2nd instar females (Fig. 16).

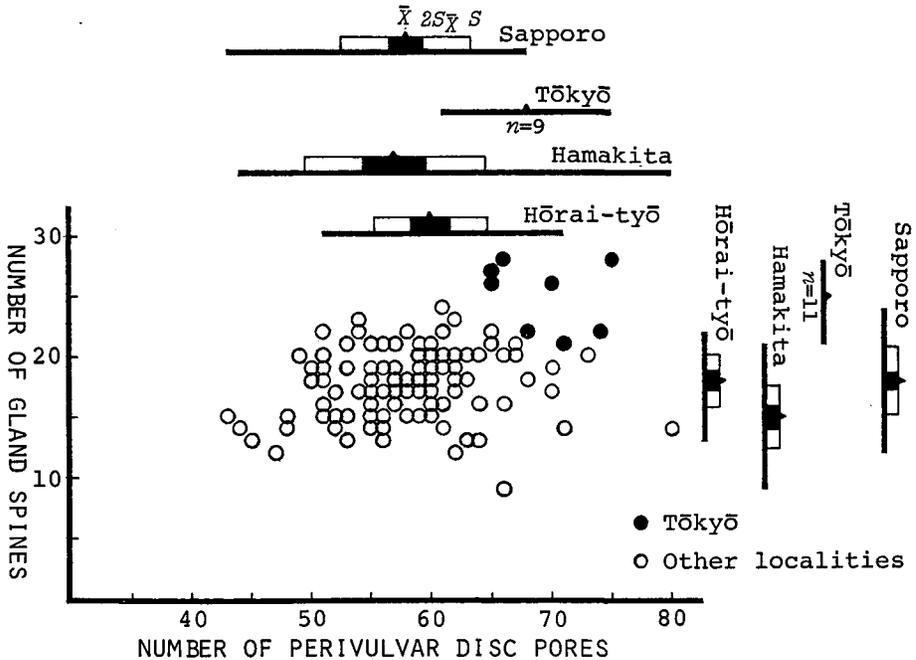


Fig. 15. *Fiorinia horii*, adult female. Number of gland spines against number of perivulvar disc pores.

Table 4. Occurrence of gland spines on 7th and 8th abdominal segments in adult females of *Fiorinia horii* (% in parentheses).

Gland spines		Sapporo	Hamakita	Tôkyô	Hôrai-tyô
Abd. 7	Abd. 8				
1	1	27 (21.4)	13 (21.0)	0	1 (1.5)
0	1	99 (78.6)	49 (79.0)	23 (95.8)	65 (98.5)
0	0	0	0	1 (4.2)	0
		126	62	24	66

Table 5. Frequency of number of macroducts on one side of body in adult females of *Fiorinia horii* (% in parentheses).

Sample	Number of macroducts*					
	4	5	6	7	8	9
Sapporo	1 (0.8)	7 (5.6)	25 (19.8)	41 (32.5)	38 (30.2)	14 (11.1)
Hamakita	2 (3.3)	14 (22.9)	15 (24.6)	22 (36.1)	6 (9.8)	2 (3.3)
Tôkyô		1		2	3	9
Hôrai-tyô		10 (15.0)	14 (21.0)	20 (30.0)	17 (26.0)	5 (8.0)

* Marginal and, when present, submarginal macroducts.

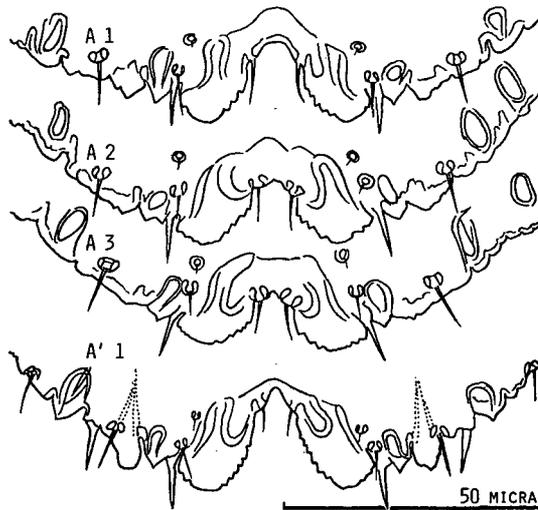


Fig. 16. *Fiorinia horii*, adult female (A1-A3) and 2nd instar female exuvial cast (A'1). Pygidial apex. Hôrai-tyô.

Some specimens of the 2nd instar male were mounted from the material collected near Makihara. They are all in very poor condition owing to the inadequate collection season. They are similar in the general structure of body to the corresponding stage of *F. nachiensis*, *F. sikokiana* and *F. himalaica*, though different in details (Fig. 17). The macroducts occurring along the abdominal margin appear much shortened and are variable in number and occurrence.

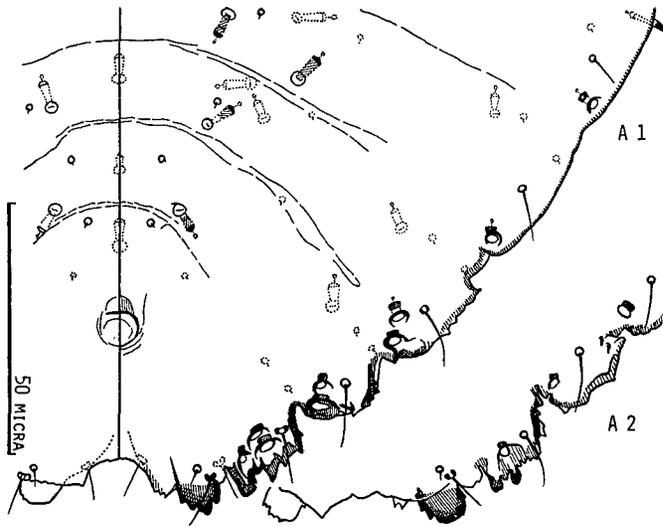


Fig. 17. *Fiorinia horii*, 2nd instar male. A1: pygidium in dorsal aspect; A2: pygidial margin of another specimen, in dorsal aspect.

Fiorinia himalaica

This species was described from specimens taken on *Rhododendron arboreum* in Bagmati, Central Nepal. Further material was collected on *R. arboreum* in some localities of Bagmati at altitudes of 1600 to 2200 m (Aug. – Sept. 1975, S. Takagi). However, many of the adult females mounted from the new material are shrunken in the prepygidial abdomen, having been collected after oviposition, so that the number of the specimens closely examined is rather limited. In spite of the inadequate collection season some 2nd instar males were also collected and several of them were mounted in fairly good condition.

Other lots of material referable to this species were collected in Northwestern Indian Himalaya on *Rhododendron arboreum* in connection with the Research Trips for Agricultural and Forest Insects in the Subcontinent of India: at Chail, near Simla, Himachal Pradesh, 2050 m (27 Oct. 1978) and at Mussoorie, near Dehra Dun, Uttar Pradesh, 1970 m (4 Nov. 1978) and 2230 m (14 Nov. 1978). Some specimens including 2nd instar males were mounted, though not all of them are in good condition. The material collected at Mussoorie, 1970 m, was largely spoiled by severe parasitism, so that it is excluded from the present study.

The adult females examined differ between the Central Nepalese and Northwestern Indian forms in the number of the marginal macroducts (Table 6). They also show somewhat different patterns between these forms in the correlation between the numbers of the perivulvar disc pores and gland spines (Fig. 18). In the adult females from Bagmati plotted in Fig. 18, which come from 5 localities, the number of the gland spines varies in a wide range (6–84) and in no obvious correlation with that of the perivulvar disc pores. However, its frequency distribution is much skewed positively: among 77 adult females determined for the number of the gland spines 65 (ca. 84%) fall in a limited range (6–20), where the correlation is significant ($r=0.38$) as in the adult females from Northwestern

Table 6. Occurrence of marginal macroducts on 5th to 7th abdominal segments in adult females of *Fiorinia himalaica* (% in parentheses).

Marginal macroducts			Bagmati, Central Nepal	Chail and Mussoorie, Northwestern India
Abd. 5	Abd. 6	Abd. 7		
1	1	1	8 (4.0)	0
0	1	1	159 (78.7)	1 (1.3)
0	0	1	35 (17.3)	77 (98.7)
			202	78

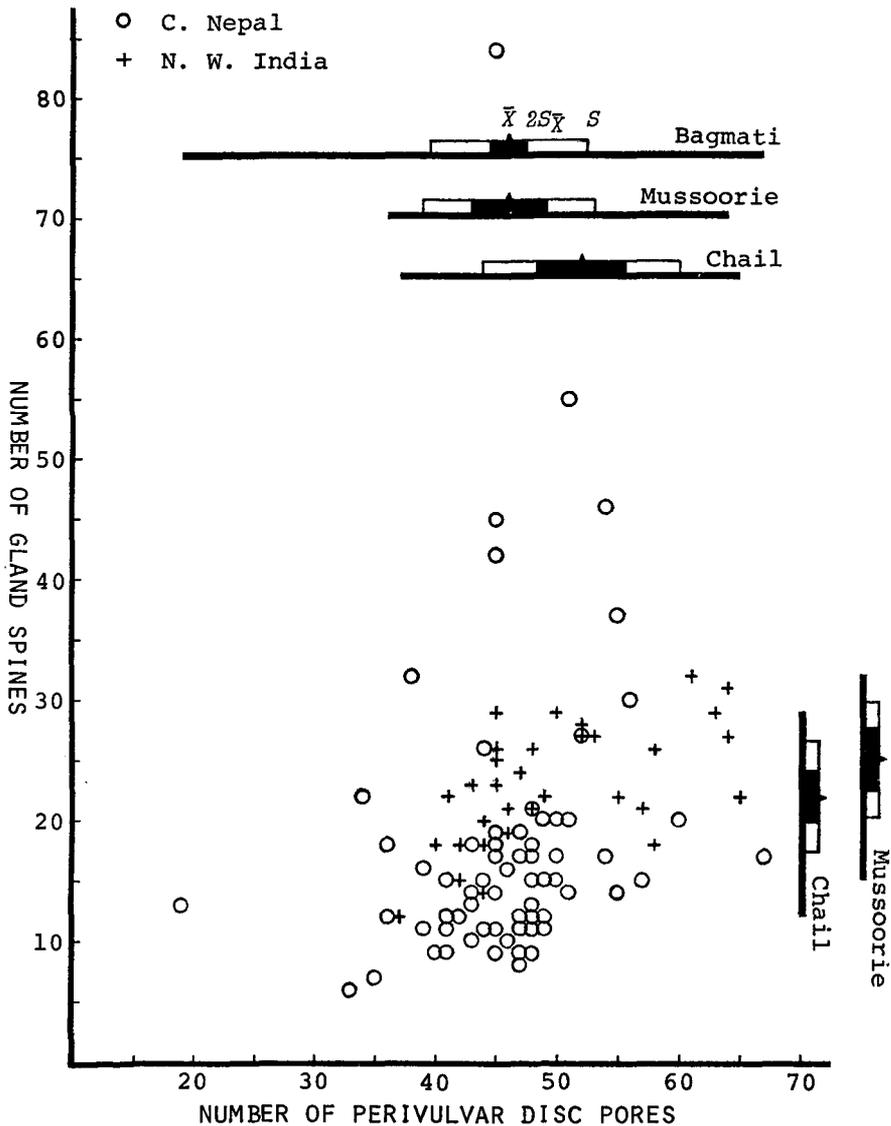


Fig. 18. *Fiorinia himalaica*, adult female. Number of gland spines against number of perivulvar disc pores.



Fig. 19. *Fiorinia himalaica*, 2nd instar male. Nepal: Dunche, 2100 m (75NPL-224).

India ($r=0.58$, $n=32$). In other characters the adult females from Central Nepal and Northwestern India appear very similar in spite of a distance of 750 km between these regions.

The 2nd instar females are variable in the occurrence of the marginal gland spines on the 3rd to 5th abdominal segments. In the Central Nepalese form all or part of these gland spines are often unseen; in the Northwestern Indian form they appear to be always lacking.

The 2nd instar male of this species is very similar to that of the Kii form of *F. nachiensis* not only in the general structure of body but also almost in every detail (Fig. 19). It differs from the latter by the median lobes set a little closer and by the marginal processes other than the median lobes a little less prominent. The ducts show some variation in number and arrangement. A few gland spines occur laterally to both pairs of spiracles and at times also on the 1st abdominal segment.

DISTRIBUTION OF THE JAPANESE SPECIES

Although the collection is far from exhaustive, it may serve for showing the general distribution pattern of the Japanese species (Fig. 20). *F. hymenanthis* is distributed in a broad central region of Honsyû and has a disjunct range in Kyûsyû over 400 km apart from the range in Honsyû. In Honsyû it is replaced by *F. odaiensis* and *F. nachiensis* at the southern border of its range. While both *F. odaiensis* and *F. nachiensis* inhabit the Kii Peninsula, the former seems to be restricted to higher, and the latter to lower, altitudes. *F. nachiensis* also occurs in Oki Island about 300 km distant from the Kii Peninsula. The mainland opposite Oki Island is inhabited by *F. sikokiana*, which is distributed in the Tyûgoku District of Honsyû and Sikoku. These 4 species are associated with *Rhododendron metternichii* (including *R. degronianum*) in their natural habitats. *F. horii* is, in wild, associated with *Rhododendron makinoi*, which is limited in distribution to a narrow range in the provinces of Mikawa and Tôtômi, Central Honsyû.

None of the 5 species have been found to occur together in the same locality. The distribution of the host plants is patchy especially in southwestern Japan, so that the local populations of these *Fiorinia* species must be more or less isolated.

DISCUSSION

Nachiensis-series

The local samples here referred to *F. hymenanthis*, *F. odaiensis* and *F. nachiensis* variously overlap in the changing characters of the adult females, forming together a continuous series of changes. Still the 3 species are recognized and distinguished. *F. hymenanthis* as here understood is distinguished from the other 2 species by the arrangement of the macroducts: the marginal macroducts occur on the 3rd to 7th abdominal segments and pair on the 4th to 6th in *F. hymenanthis*, while they are all single and often or usually lacking on the 3rd segment in *F. odaiensis* and *F. nachiensis*. The arrangement of the marginal macroducts is, however, subject to some variation in each of these species. Further, the submarginal macroducts usually occur on the 3rd and 4th abdominal segments in *F. hymenanthis*, while they are often or usually lacking in *F. odaiensis* and *F. nachiensis*. As a consequence the total number of the macroducts is variable

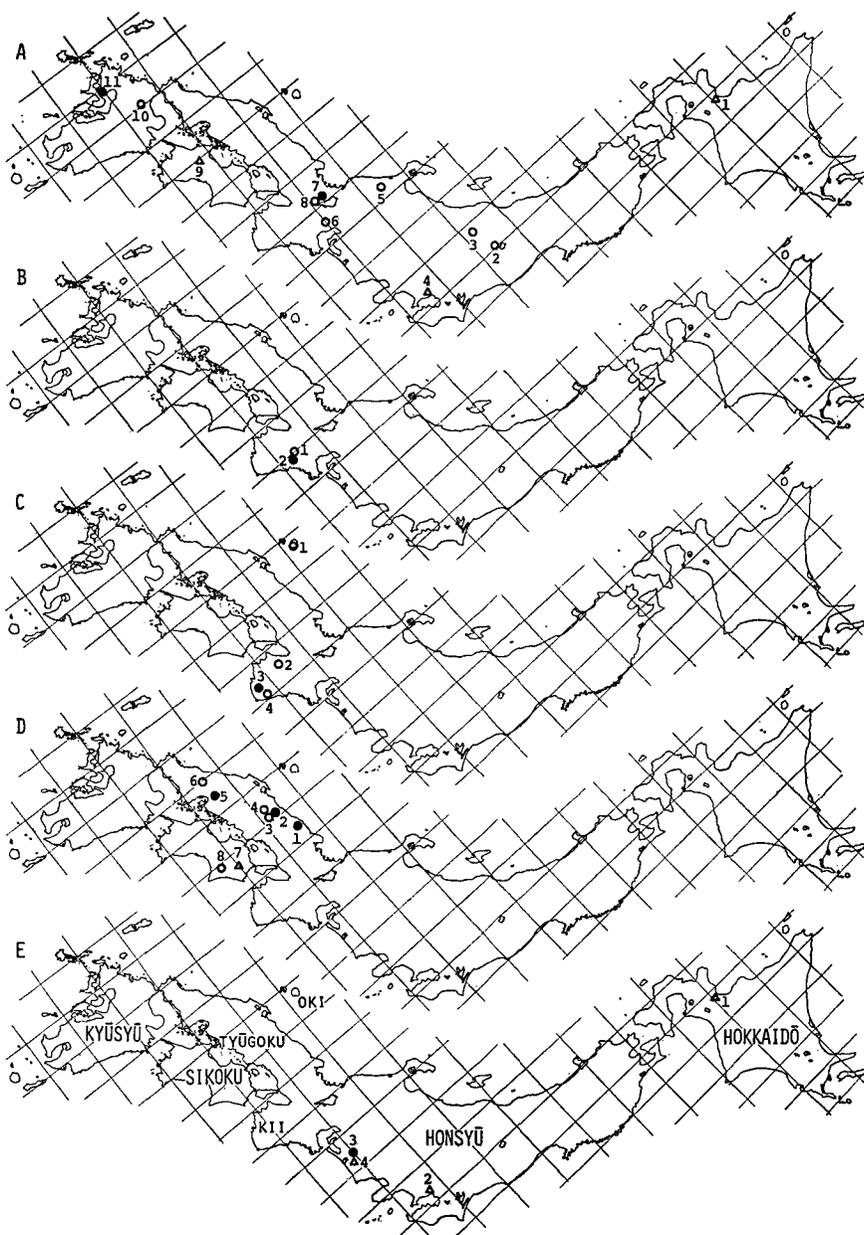


Fig. 20. Collection sites. ●: host growing wild; ○: host cultivated, but presumed to have been transplanted from a nearby habitat; △: host cultivated and of unknown origin. A: *Fiorinia hymenanthis* — 1: Sapporo; 2: Higasiyama Onsen; 3: Tadami; 4: Tôkyô; 5: Torigoe; 6: Yunoyama Onsen; 7: Hanase; 8: Hiei-zan; 9: Omogo-kei; 10: Hiko-san; 11: Tara-dake. B: *Fiorinia odaiensis* — 1: Siraya-dake; 2: Ôdai-ga-hara. C: *Fiorinia nachiensis* — 1: Oki Is.; 2: Iyawaki-yama; 3: Kozagawa; 4: Nati. D: *Fiorinia sikokiana* — 1: Mikawa-yama; 2: Osika-kei; 3: Okutu and Kagamino; 4: Yubara; 5: Takeni; 6: Hikimi; 7: "Awa"; 8: Senbon-yama (on wild host?). E: *Fiorinia horii* — 1: Sapporo; 2: Tôkyô; 3: Hôrai-tyô; 4: Hamakita.

even in the local samples, which overlap in this feature, too. Yet it shows a gap between *F. hymenanthis* and the other species in its frequency. It is not always possible to discriminate between these species in terms of individuals; nevertheless, the gap seems sufficient to distinguish *F. hymenanthis* in terms of populations (Table 7).

Table 7. Frequency of number of macroducts on one side of body in adult females of *Fiorinia hymenanthis*, *F. odaiensis* and *F. nachiensis* (% in parentheses).

Sample	Number of macroducts*											
	2	3	4	5	6	7	8	9	10	11	12	
<i>F. hymenanthis</i>												
Sapporo							9 (6.8)	23 (17.3)	61 (45.8)	35 (26.3)	5 (3.8)	
Higasiyama							2	23	23	4		
Onsen							(4.0)	(44.0)	(44.0)	(8.0)		
Tadami							3 (7.0)	19 (43.0)	18 (41.0)	4 (9.0)		
Torigoe					2 (3.0)	3 (5.0)	32 (55.0)	20 (35.0)	1 (2.0)			
Hanase			1 (2.0)			5 (8.0)	17 (28.0)	30 (50.0)	6 (10.0)	1 (2.0)		
Yunoyama					1 (2.0)	3 (6.0)	34 (71.0)	9 (19.0)	1 (2.0)			
Onsen							1	11	32	11	5	
Omogo-kei							(1.7)	(18.3)	(53.4)	(18.3)	(8.3)	
Hiko-san (B)							1 (2.0)	9 (14.0)	35 (54.0)	12 (19.0)	6 (9.0)	1 (2.0)
Tara-dake							16 (27.0)	43 (72.0)	1 (1.0)			
<i>F. odaiensis</i>												
Ôdai-ga-hara (A)		3 (2.2)	72 (53.7)	51 (38.1)	7 (5.2)	1 (0.8)						
Ôdai-ga-hara (B)		1 (3.6)	11 (39.3)	12 (42.8)	3 (10.7)	1 (3.6)						
Siraya-dake	1 (2.2)	3 (6.5)	9 (19.6)	17 (37.0)	12 (26.0)	3 (6.5)	1 (2.2)					
<i>F. nachiensis</i>												
Oki			4 (3.2)	90 (71.4)	32 (25.4)							
Kii		6 (3.6)	117 (70.5)	39 (23.5)	4 (2.4)							

* Marginal and, when present, submarginal macroducts.

The gap once supposed to exist between *F. odaiensis* and *F. nachiensis* in the numerical characters of the perivulvar disc pores and gland spines of the adult females is now bridged by the Ôdai-ga-hara (B), Siraya-dake and Oki samples (Fig. 7; Fig. 9). These species may still be distinguishable by the shape of the median lobes and also by the presence or absence of the paraphyses arising from the 2nd lobes (Fig. 8; Fig. 10), but these differences alone seem to be rather too subtle to distinguish them. However, the concepts of *F. odaiensis* and *F. nachiensis* should only be modified, because the gap in the 2nd instar males is quite distinct even between the bridging forms. I have little doubt that they are

distinct species in spite of the continuity in the adult female characters. The 2nd instar males also differ in some characters between the Kii and Oki forms of *F. nachiensis*. It may well be doubted if these forms belong to the same species. I think that I have some evidence in favour of the opinion that the Oki form is a primitive survivor of *F. nachiensis*.

Each of the 3 species thus recognized is very much varied in adult female characters, in which the local samples referred to them form as a whole an intergrading series of steps following the sequence *F. hymenanthis*–*F. odaiensis*–*F. nachiensis*. There is even found in this sequence a direct correlation between the numbers of the perivulvar disc pores and gland spines when they are averaged for each species (Fig. 21). This sequence, the *nachiensis*-series as it was called, is, therefore, supposed to approach to the ancestral-descendant lineage which has brought these species into existence.

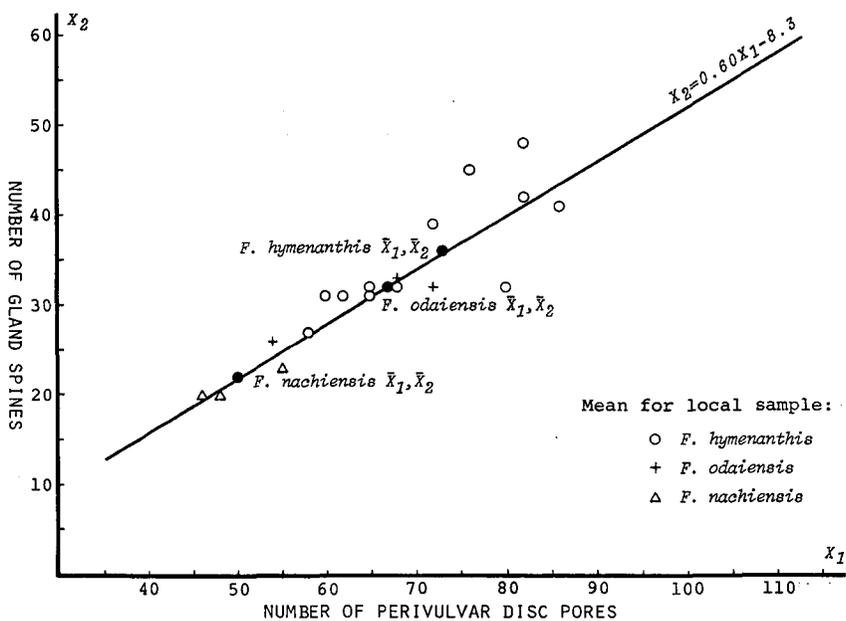


Fig. 21. *Fiorinia hymenanthis*, *F. odaiensis* and *F. nachiensis*, adult females. Mean number of gland spines against mean number of perivulvar disc pores.

The rhododendron-feeding species of *Fiorinia* are all characterized by the median lobes unusually enlarged, though in varying degrees, for members of the genus in both adult and 2nd instar females. In the *nachiensis*-series, in which the median lobes change continuously, part of *F. hymenanthis* such as represented by the samples from Sapporo and Higasiyama Onsen rather approaches in the state of median lobes to diverse species of the genus other than of the *horii*-group, so that it should stand for the primitive extreme of the series. This ex-group comparison gets support from a comparison within the series. In the 2nd instar females all the 3 species of the series have marginal gland spines on the 7th and 8th abdominal segments, whereas in the adult females all the examined samples of *F. hymenanthis* alone have those gland spines. The Kii form of *F. nachiensis* usually lacks them in

the adult female, occupying the opposite extreme of the series in this regard; it seems evident that this state is due to a loss and that it is a derived character in this series. Part of *F. odaiensis* and the Oki form of *F. nachiensis* are intervenient in the state of these gland spines (Table 1).

The changing characters of the *nachiensis*-series, which very probably involve some secondary modifications in each species, appear to represent most, if not all, steps in the evolving lineage from the most primitive form belonging to *F. hymenanthis* to the Kii form of *F. nachiensis*. Such abundant escapes of evolving steps may suggest that these species are young, but are certainly due at least partly to the isolation of local populations. Here we are confronted by sibling species in the sense that the specific divisions seem rather problematic. Yet the extremes of the series are remarkably different, and the gaps by which the 3 species are distinguished are more or less profoundly concerned in the organization of body of the adult female or 2nd instar male.

Fiorinia sikokiana, *F. horii* and *F. himalaica*

So far as the adult and 2nd instar females are concerned, these species find no close relatives. *F. sikokiana* is another form whose characters are derivable from those of *F. hymenanthis*, but no intervenient form is known between them. If the polarity of the morphoclines in the *nachiensis*-series is applied, *F. sikokiana*, *F. horii* and *F. himalaica* are various mosaics of primitive and derived characters. *F. sikokiana* is more derived than *F. hymenanthis* and part of *F. odaiensis* and *F. nachiensis* by lacking gland spines on the 7th and 8th abdominal segments, but more primitive than the latter 2 species by having paired marginal macroducts on the 4th to 6th abdominal segments. *F. horii* can be regarded as more primitive than the other species by having the marginal gland spine of the 5th abdominal segment in the 2nd instar female, but is more derived than *F. hymenanthis* in some adult female characters. Part of *F. himalaica* also keeps that gland spine in the 2nd instar female, but in the adult female this species appears to be the most derived form of the rhododendron-feeders of *Fiorinia*. Though I have no idea about the ancestral forms of *F. horii* and *F. himalaica*, neither of these species seems to be related phylogenetically to the other ones of the *horii*-group. Parallelism and/or convergence must be involved in the unusually enlarged median lobes, which are quite characteristic of all the species of the group.

It is remarkable that in some of the examined adult females of *F. himalaica* the gland spines, all prepygidial, are extraordinarily numerous in comparison with the perivulvar disc pores (Fig. 18). This occurs in the Central Nepalese form, of which some other examined specimens have the gland spines fewest in the *horii*-group. The trend toward the reduction of secretory organs, as is the case with the *nachiensis*-series, is deemed to have general application to the adult females of pupillarial Diaspididae. All this could suggest an abrupt increase of the prepygidial gland spines in succession to their extreme decrease in *F. himalaica*. In this connection it should be noted that certain diverse species of *Fiorinia* are characterized by having numerous gland spines, or mingled gland spines and microducts, in a marginal series through the prepygidial segments. How can this be explained, if the reduction of the secretory organs is a general evolutionary trend in pupillarial forms of Diaspididae? Is that character primitive in *Fiorinia*? It seems not.

Second instar males

The term "glandular type" is here applied to 2nd instar males with a peculiar glandular system such as those of *F. hymenanthis* and *F. odaiensis*. These species have 2 types of modified macroducts on the abdomen, which are, in Tippin's (1970) terms, "communal ducts" occurring on the 6th and 7th segments and "cluster ducts" crowding around the communal ducts (isolated ducts similar in shape to individual cluster ducts also occur on the 2nd to 4th segments). The 2nd instar males of some other species of *Fiorinia*, which are diverse in female characters, belong to this type, though they show some variation in the occurrence of the modified macroducts (Table 8). This type is also characterized by reduced marginal processes of the pygidium, the supposed median lobes being represented by small ragged processes widely separated from each other.

Table 8. Occurrence of communal ducts and cluster ducts in 2nd instar males of some species of *Fiorinia*.

Species	Communal ducts		Cluster ducts				Material
	Abd. 6	Abd. 7	Abd. 4	Abd. 5	Abd. 6	Abd. 7	
<i>F. externa</i>	+	+	+	+	+	+	Maryland, on <i>Tsuga</i> (Tippins 1970)
<i>F. pinicola</i>	+	+			+	+	Georgia, on <i>Ficus</i> (Tippins 1970); Japan, on <i>Pittosporum</i> ; Taiwan on <i>Podocarpus</i>
<i>F. japonica</i>	+	+			+	+	Taiwan, on <i>Taxus</i>
<i>F. vaccinia</i>	+	+			+	+	Japan, on <i>Eurya</i> and <i>Pieris</i>
<i>F. hymenanthis</i>	+	+			+	+	Japan, on <i>Rhododendron</i>
<i>F. odaiensis</i>	+	+			+	+	Japan, on <i>Rhododendron</i>
<i>F. sp. (nr. theae)</i>	+	+			+	+	Nepal (75NPL-51)
<i>F. theae</i>	+	+		+	+	+	Taiwan, on <i>Eurya</i>
				+			Georgia, on <i>Camellia</i> (Tippins 1970); Taiwan, on <i>Eurya</i>
<i>F. proboscidea</i>		+*		+			Taiwan, on <i>Syzygium</i>
<i>F. formosensis</i>					+	+	Taiwan, on <i>Ficus</i>
<i>F. linderiae</i>					+	+	Taiwan, on <i>Lindera</i>
<i>F. minor</i>					+	+	Taiwan, on <i>Ficus</i>

* Situated halfway between marginal setae of abd. 6 and 7.

The 2nd instar males of *F. nachiensis*, *F. sikokiana*, *F. horii* and *F. himalaica* agree in lacking the peculiar glandular system and having well-developed median lobes. In other characters they are not always similar, though the agreement between *F. nachiensis* and *F. himalaica* is quite close. In the *nachiensis*-series the 2nd instar males sharply contrast between *F. odaiensis* and *F. nachiensis*. Although the Oki form of *F. nachiensis* appears to be intervenient between *F. odaiensis* and the Kii form of *F. nachiensis* in the 2nd instar male as well as in the adult female, it definitely belongs to the "non-glandular type". The polarity of the morphoclines in the *nachiensis*-series determined on the basis of the female characters indicates that the glandular type is primitive (Fig. 22).

The bilobate state of the median lobes is, so far as its frequency is concerned (Table 3), not abnormal nor accidental in the 2nd instar male of *F. sikokiana*, though it is quite unusual in the Diaspididae. This may suggest the potentiality of being bilobate in the median lobes of the Diaspidini. Excessive lobate formation is often observed in the median as well as lateral lobes in *Kuwanaspis*, *Nikkoaspis* and certain Leucaspidini.

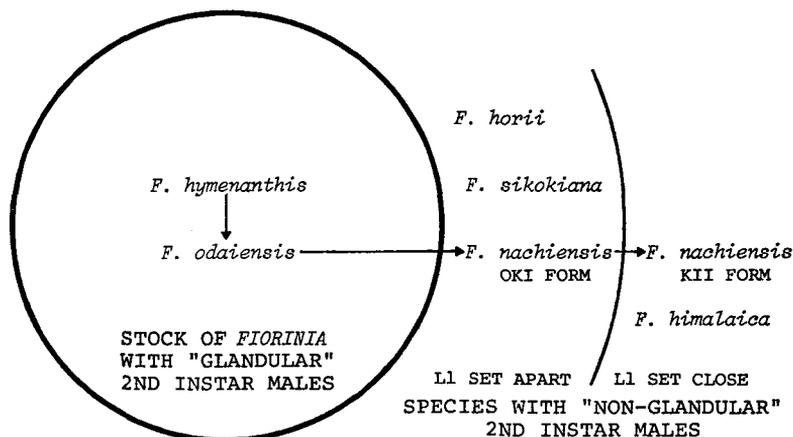


Fig. 22. Occurrence of "glandular" and "non-glandular" 2nd instar males in the *hori*-group of *Fiorinia*. The view here adopted is as follows: part of *F. hymenanthis* approximates the form ancestral to *F. odaiensis*; the Oki form of *F. nachiensis* approximately represents the transition from *F. odaiensis* to the Kii form of *F. nachiensis*; the glandular type as against the non-glandular one is primitive in *Fiorinia*; the 4 species belonging to the non-glandular type could have been derived separately from the stock of *Fiorinia* with glandular 2nd instar males.

Concluding remarks

The morphoclines observed in the *nachiensis*-series show a dual pattern: some characters change gradually and continuously through the series, while others do more or less abruptly somewhere in the series. This distinction may be only comparative: the loss of gland spines on the 7th and 8th abdominal segments in the adult female abruptly begins in part of *F. odaiensis* and ends in part of *F. nachiensis*, but the loss itself seems to be a gradual process (Table 1). The arrangement and total number of the macroducts show a clear gap between the adult females of *F. hymenanthis* and *F. odaiensis* (Table 7). This may simply be due to the extinction of intervenient populations. The possibility of a gradual change in the arrangement of the macroducts is suggested by *F. sikokiana* (Table 2). The 2nd instar male of the Oki form of *F. nachiensis* seems also intervenient in some characters between *F. odaiensis* and the Kii form of *F. nachiensis*.

Nevertheless, the difference between the glandular and non-glandular types of the 2nd instar males is still quite great and profoundly concerned in the organization of body. This stage presents another problem. While the glandular type is supposed to be primitive in the *nachiensis*-series and indeed found in other diverse species of the genus, the non-glandular type also occurs in the 4 rhododendron-feeding species, which, so far as based on the female characters, are diverse and

seem to have no relation with each other. In this regard the close agreement of the 2nd instar males between the Kii form of *F. nachiensis* and *F. himalaica* is quite surprising.

Gradual changes of characters may not necessarily be adaptive in themselves, but when a character changes under the direct action of natural selection it must do gradually. Of the gradual changes in the *nachiensis*-series at least one is supposed to be adaptive in connection with the mining habit of the females under the indumentum of the underside of the host leaves: the morphocline of the median lobes. It ends in wholly produced, semicircular, and elaborately serrate median lobes, which remind me of a circular saw, in *F. nachiensis*. A trend toward this state is even observed within *F. hymenanthis*. The females probably saw the median lobes when they grow under the indumentum*. Because they grow mainly during the 2nd instar, these lobes must have function in the 2nd instar females. In the adult females, which are encased within the sclerotized exuviated skins of the 2nd instar females, these lobes appear to be more subject to individual variation than in the 2nd instar females.

The non-glandular 2nd instar males are provided with enlarged median lobes more or less similar to those of the adult and 2nd instar females. It is doubtful, as is the case with the adult females, that these lobes have any function in the 2nd instar males. For in all the species here treated the males occur on the surface of the indumentum; at most their scales are covered with thin fragments of indumentum. It is also uncertain whether the presence or absence of the peculiar glandular system has any definite significance during the life of the 2nd instar males.

The 2nd instar males of the species here treated pose problems which cannot be settled by mere formal comparisons of characters and which, it seems to me, cannot be approached in terms of directly adaptive changes of characters. We need a theory which can explain all the above coherently. I would like to suggest here Sondhi's (1962, 1963) prepattern-precursor model. It is a threshold hypothesis, which explains an abrupt manifestation of new structures in terms of an unvarying "prepattern" and a varying "precursor". The hypothesis is based on experiments with drosophilae, and has already been adopted by Van Valen (1970) to explain the variation of the cheek tooth structures in a Cretaceous insectivore. Further discussion, however, may be better based on the whole family of Diaspididae, so that it should be beyond the scope of the present paper.

* I have examined a species of *Lepidosaphes* collected from *Rhododendron metternichii* var. *yakushmanum* (= *R. yakushmanum*) in Yaku-sima, an island south of Kyûsyû, at an altitude of between 1600 and 1900 m (11 April 1975, M. Haruki). The female scales were found occurring on the underside of the leaves, on the midrib, under a dense indumentum. This species differs from all the other congeneric ones known to me by having serrate median lobes, which are similar in outline to those of *Fiorinia nachiensis*, in the adult and 2nd instar females; it has a pair of serrate prominent lobes subapically on the abdomen in the 1st instar female. In spite of this it does not belong to *Andaspis*, but undoubtedly to the species-group of *Lepidosaphes tubulorum* and relatives (= Borchenius' *Paralepidosaphes*). (This species seems to be unnamed, yet the specimens available are not good in condition, perhaps owing to the collection season, to describe and name it.) The equipment of the pygidium with serrate prominent lobes is associated with mining habit in some other species, too. *Andaspis crawii* and *Hypaspidiotus jordani*, e.g., occur on the leaves of *Castanopsis cuspidata* and mine the scaly layer of the underside. Other species of *Andaspis* are often concealed under the bark epidermis of host plants.

In conclusion, the view I maintain here may be summarized as follows: 1) Abrupt phenotypic changes could have happened in the evolution of the *nachiensis*-series, which process otherwise seems to have been a summation of gradual and continuous changes; 2) The supposed abrupt changes are concerned in the organization of body more profoundly than the gradual ones are; 3) The manifestation of the non-glandular type of the 2nd instar male, which could have been an abrupt transition from the glandular type, may have occurred at least 4 times in the evolution of rhododendron-feeding species of *Fiorinia* in East Asia.

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