Linzer biol. Beitr.	28/2	899-916	31.12.1996

Lasioglossum (*Evylaeus*) *frigidum* sp. nov., with taxonomic notes on the allied species of *L.* (*E.*) *sexstrigatum* group (Hymenoptera, Apoidea, Halictidae)

S.F. SAKAGAMI (†)* & A.W. EBMER

Abstract: *Lasioglossum* (*Evylaeus*) *frigidum* sp. nov. is described from Japan. This species is distinguished from allied species of the *L.* (*E.*) *sexstrigatum* group most clearly by well developed tergal tomenta of the female. A tentative comparison with some allied species is given for the future clarification of this unusual and difficult group.

Introduction

Firstly *L. frigidum* sp.nov. is described comparing it mainly with two allied species, *L. epicinctum* (STRAND 1914) from Taiwan (♂ unknown) and *L. smilodon* EBMER & SAKAGAMI 1994 (EBMER et al. 1994) from SW. Archipelago, Japan (♀♂ known), followed by some taxonomic comparisons of these and allied species. Some abbreviations: Tn = metasomal tergum *n*, PP = punctures, diameters in µm, IS = interspaces, Fn = flagellomere *n*. Morphometric methods mainly follow SAKAGAMI & TADAUCHI (1965: 143) or SAKAGAMI et al. (1966: 184).

Lasioglossum (*Evylaeus*) *frigidum* sp. nov. ♀♂

Lasioglossum (*Evylaeus*) sp. 22. — FUKUDA et al. 1973: 163.

Lasioglossum (*Evylaeus*) sp. 42. — YAMADA & SAKAGAMI 1988: 13; YAMADA et al. 1990: 38.

Specimens examined (Fig. 7): All from Japan, Hokkaido and Honshu.

Holotype (♀): Aomori Pref., Amagamori (in Misawa), 13.8.1987, leg. M. Yamada.

Paratypes (♀): Hokkaido Pref., HamaKoshimizu (in Abashiri-distr.), all collected by H. Fukuda & K. Yamauchi, 1966: 10.6., 1♀, *Taraxacum officinale*; 8.7., 1♀, *Rosa rugosa*; 27.9., 1♀, *Hieracium umbellatum*. 1967: 19.6., 39♀♀, *Taraxacum officinale*; 9♀♀, *Rosa rugosa*; 1♀, *Colopleum lucidum*; 20.6., 6♀♀, *Taraxacum officinale*; 1♀ *Rosa rugosa*; 1♀, *Colopleum*

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[*] Dr. Sakagami has died unexpectedly on November 4th, when the corrections of this paper have already been finished. He had read and corrected the draft version of this publication.

lucidum; 6:7., 2♀♀, *Taraxacum officinale*; 2♀♀, *Brassica* sp. Aomori Pref., (all by M. Yamada), Amagamori (in Misawa), 9♀♀, same data with holotype; 1♀, 16.8.1986. Hirataki Numa (in Kizukiri), 1♀, 16.6., 1♀, 15.9. 1984. Ibaraki Pref., Muramatsu, 1♀, 13.5.1981, M. Takahashi; 1♀, 19.6.1983, K. Kikuchi. Toyama Pref., HamaKurosaki (in Toyama), 1♀, 10.5.1990, H. Negora. Ishikawa Pref., (all by H. Negoro), Kaneiwa (in Kanazawa), 2♀♀, 12.5.1975 & 15.9.1976; Uchinada Shore, 1♀, 12.5.1975.

Paratypes (♂): 1 nongigantic ♂, same data with holotype; 1 slightly gigantic ♂, Ibaraki Pref., Muramatsu, 4.10.1981, M. Takahashi; 1 primordially gigantic ♂, 31.10.1983, K. Kikuchi; 1 primordially gigantic ♂, Ishikawa Pref., Kanaiwa (in Kanazawa), 15.9.1976, H. Negoro.

Types are provisionally with one of us (SFS) until deposited at the Entomological Institute, Hokkaido University, Sapporo and some other institutions or collections.

Paratypes in the Ebmer collection, Puchenau, Austria: HamaKoshimizu, 19.6.1967, 12♀♀, *Taraxacum officinale*, 1♀, *Rosa rugosa*. Amagomori, 3♀♀, 1 nongigantic ♂, 13.8.1987, 1♀, 16.8.1986 (further dates see above). Hirataki-Numa (Kizukuri), 1 nongigantic ♂, 21.7.1984, leg. M. Yamada.

♀

Body: 4·9-5·6 mm, wing + tegula 4·1-4·6 mm (N=10).

Color: Black, flagella below apically brown. Tegula, wing veins and sometimes tarsi and tergites apically dark brown to brown. Brownish part slightly paler than in *L. smilodon* and *L. epicinctum* (in 1♀ mesoscutum partly slightly metallic green!).

Pilosity: Facial hairs moderately dense and plumose as in *L. epicinctum*, denser and more plumose than in *L. smilodon*. Mesepisternum with dense, plumose underhairs, slightly more hiding surface than in *L. epicinctum*, much denser than in *L. smilodon* and allied species. T1 disc laterally with hairs denser than in *L. epicinctum*, and more denser than in *L. smilodon* and allied species. T2-4 with basilateral tomental patches larger and denser than in *L. epicinctum* >*L. smilodon* >allied species, laterapical fimbriae denser and wider than in *L. epicinctum* >*L. smilodon* >allied species, medially more narrowly interrupted than in *L. epicinctum* >*L. smilodon* >allied species (Fig. 1).

Structure: Head (Fig. 2A, 10) slightly longer than wide, moderately convergent below (as in *L. epicinctum* and *smilodon*). Facial PP distinct, 13-20 µm, distinctly >> IS (as in *L. epicinctum* and *L. smilodon* with pp 10-15µm, much weaker). Mesoscutal (Fig. 3B) and mesepisternal sculpture as in *L. epicinctum*, but the former much coarser than in *L. smilodon*. Propodeal dorsum (Fig. 4) basally longitudinally ridged and apically coriaceous. In *L. frigidum* ridges dense, occupying basal half, on apical half not distinctly superimposed with finer oblique-transverse lineolation as in *L. epicinctum* and *smilodon*. In *L. frigidum* dorsum shorter (Fig. 11), ridges occupying anterior 2/3; in *L. smilodon* ridges very short.

Metasoma: T1 with distinct transverse lineolation in all three species, but in *L. frigidum* partly sparse with shiner interspaces, in *L. smilodon* homogeneously dense with interspaces rather dim, in *L. epicinctum* similar but lineolation weaker and interspaces slightly shiner than in *L. smilodon*, though less than in *L. frigidum*.

♂

Body: 4·6-5·3 mm, wing + tegula 3·5-4·1 mm (N=4).

Color: Black as in ♀ but some parts pale, more than in *L. smilodon* as follows (Fig. 2B):

Pale parts	*Lasioglossum frigidum*	*Lasioglossum smilodon*
Clypeus below	widely yellow	narrowly yellow brown to dark brown
Labrum	narrowly yellow	brown to dark brown
Mandible	yellow, apically reddish brown	dark brown, apically reddish brown
Flagellum below	yellow brown	brown to dark brown
Tibial apices and tarsi	yellow brown	brown to dark brown

Pilosity: Generally denser than in ♀. Facial and clypeal hairs distinctly denser than in ♀ and also much than in *L. smilodon* ♂ (Fig. 2A, 2B). But all three known *L. smilodon* ♂ are large and more or less gigantic while all *L. frigidum* ♂ being so small that precise comparison is difficult, because in well studied species (particularly in *L. ohei* SAKAGAMI et al. 1966), larger and more gigantic ♂♂ tend to have sparser cephalic hairs than in smaller ♂♂. Similarly mesosomal hairs denser than in *L. smilodon*, and even in metasomal terga, which are less affected by size difference, basilateral and postmarginal tomenta distinctly denser than in *L. smilodon* (Fig. 5).

Structure: Genal gigantism absent (Fig. 2D) to primordial. F1 longer than wide (Fig. 2, B-D) more than in *L. smilodon* and allied species (Fig. 12). In some allied species, of which ♂♂ having been more available, PP sparser in large gigantic ♂♂. In *L. frigidum* this could not be confirmed by the lack of sufficient material. Male genitalia without clear differences from *L. smilodon* (Fig. 6) and many allied species.

Etymology: frigidum – Metasoma seen as if frosted.

Taxonomic and bionomic remarks

In the female this new species is closest to *L. epicinctum* and *L. smilodon* by dense metasomal fimbriae, the development of which is higher than in both species (Fig. 1, A-C). *L. epicinctum* has been known only by the holotype collected at Anping, Formosa (= Taiwan) and reexamined by AWE. Later a second female was collected at Puli, Nantou County, Taiwan (4. V. 1980, Sk. Yamane) which was cited in Figs. 8-11. Additional taxonomic notes on these and other allied species are given later.

Fig. 7 shows the so far known distribution of *L. frigidum*. It is noteworthy that this species has hitherto been collected only at littoral zones. This is particularly clear at Hama Koshimizu, Hokkaido (Fig. 7, No. 1), where a random wild bee sampling was made throughout bee seasons (FUKUDA et al. 1973). *L. frigidum* occupied the second rank in dominance (91♀♀+0♂ out of a total of 1.043 bees collected), only exceeded by *L. albipes* (F.) with 127♀♀+27♂♂, despite *L. frigidum* has not been collected in any other areas in Hokkaido, where similar extensive sampling was made in various localities (Fig. 7). The absence of collecting records in S. Japan may simply indicate the lack of such extensive collecting of halictine bees there, particularly in littoral zones. The phenology of *L. frigidum* in HamaKoshimizu suggests its univoltine life cycle there and also the wide flower preference as in most halictine species.

Additional taxonomic notes on *L. frigidum* and allied species

The *Lasioglossum* (*Evylaeus*) *sexstrigatum* group, to which *L. frigidum* and allied species belong, is mainly characterized by two unusual features; „mainly" because there are some exceptions from the rule as shown below.

(1) Female metasomal terga have conspicuous apical fimbriae as possessed by *Halictus* s. lat. (*Halictus* s.str., *Seladonia, Vestitohalictus* and some other groups) but not by most *Lasioglossum* s.lat., with some rare exceptions, e.g., *Lasioglossum* (*Evylaeus*) *matianense* (BLÜTHGEN 1926) (EBMER & SAKAGAMI 1985) and *Lasioglossum* (*Sudila*) *kandiense* (COCKERELL 1913) (SAKAGAMI et al. 1996). The tergal fimbriae are similar but of different structure in *Lasioglossum* (*Evylaeus*) *marginatum* (BRULLÉ 1832).

On the other hand, such fimbriae are absent in some species, e.g., *Lasioglossum* (*Evylaeus*) *japonicum* (DALLA TORRE 1896), *Lasioglossum* (*Evylaeus*) *zipangu* EBMER & SAKAGAMI 1994 (EBMER et al. 1994), or very poor in *Lasioglossum* (*Evylaeus*) *sphecodicolor* SAKAGAMI & TADAUCHI 1995, all known from Japan. Nevertheless they can be placed within the *L. sexstrigatum* group by sharing the following syndrome:

1 - Head width/length ratio not much deviating from 1·0.

2 - Mesosoma thickset, seen dorsally rather shorter than in other similar groups, e.g. *L. nitidiusculum*-group (EBMER & SAKAGAMI 1985).

3 - Propodeal dorsum generally shorter, often as long as metanotum or rarely as long as mesoscutellum.

4 - Mesepisternum with granulation or not, but never impunctate.

5 - Punctation on face and mesoscutum moderate, neither too coarse nor too fine.

6 - Metasomal terga finely, superficially and rather sparsely punctate.

However, by the presence of such exceptional species, we cannot always distinguish the group categorically from allied ones. Such cases occasionally appear also in other Halictinae (e.g., the coexistence of both black and metallic species in seemingly natural groups, at least in the Palaearctis), and complicate the classification.

(2) In all species of the *L. sexstrigatum* group of which males are known, they tend to exhibit a size-linked cephalic gigantism. Smallest males are normal but larger

ones are becoming gradually more gigantic, up to a grotesque appearance in the largest specimens, often accompanied by the degeneration of sculpture and pilosity (cf. SAKAGAMI et el. 1966). However, males are always rarer than females and their whole variation ranges are usually unknown, nevertheless we would like to compare the males of similar size status, within the species. For instance, all males of *L. frigidum* were normal (Fig. 2D) to primordially gigantic whereas four compared males of an allied species, *L. smilodon*, were all weakly to distinctly gigantic (EBMER et al. 1994), making the exact comparison difficult. Reliable comparison is only possible when the males of a wide variation range, particularly involving the largest specimens, are available, e.g., as in *L. ohei* (SAKAGAMI et al. 1966) and *L. pallilomum* (STRAND 1914) (Sakagami, unpubl.). Except for the mentioned polymorphism the males have little reliable diagnostic features. Pilosity and sculpture are generally as in females though the latter are often less developed with smoother surface. Male genitalia are similar among most examined species (Fig. 6), sharply contrasting to many other halictine groups, in which genitalia are one of the most useful diagnostic characters. One character of possible diagnostic value is the ratio length/width of basal flagellomeres, particularly of F2 as referred to later (Fig. 12, Table 1). Besides the two peculiarities mentioned above the geographical distribution of the *L. sexstrigatum* group is also noteworthy as follows.

(3) The third taxonomic difficulty of this group in partly depends on its unusual geographical distribution. It is transpalaearctic but in an atypical sense. Only one species *L. sexstrigatum* (SCHENCK 1868) occurs in Europe, although it is distributed to the east as far as Japan across Eurasia. Otherwise the group is rich only in East- and Southeast Asia. For example, the species number in Japan may be equal or possibly a little larger than the sum of other carinaless (=propodeum apically not carinate) *Evylaeus* species there. Due to this limitation, many known species have so far been described based on one specimen or a few by earlier western specialists, and their descriptions, particularly of Strand and Cockerell, are poor. It is often being difficult to know each species and their relationships clearly. To improve this situation we must patiently reexamine the type specimens and redescribe each species through comparison with allied species.

Actually we are still not in the state to make a rigorous cladistic analysis of such an enormous and difficult group as the carinaless *Evylaeus*, and particularly of the *L. sexstrigatum* group. For the time being, we must subdivide the group into some subgroups, based on certain characters, even if the phylogenetic significance is still not always clear. Even if these subgroups might be conventional (artificial), such distinction of phenetic groups is inevitable and indispensable as the first step. The artificality does not disturb our work when we recognize it clearly.

As for *L. sexstrigatum* group, we can recognize 2 (possibly artificial) subgroups: T1 with or without transverse lineolation, respectively *L. pallilomum* subgroup (see below) and *L. sexstrigatum* subgroup. The *L. pallilomum* subgroup can further be subdivided in various ways according to the characters adopted for distinction, e. g., head width/length, propodeal sculpture, metasomal fimbriae, etc. Until the rigorous phylogenetic approach could become possible, we must select some character(s) for the phenetic classification as the first approach. Here we tentavely subdivide the *L. pallilomum* subgroup in two forms, based on the metasomal pilosity:

A: Metasomal pilosity, especially tergal fimbriae well developed — *L. smilodon, L. epicinctum, L. frigidum* nov.

B: Metasomal pilosity less developed — all other species of *L. pallilomum* subgroup and many species of *L. sexstrigatum* subgroup.

The difference between A and B is qualitatively given in Fig. 1. It is difficult to quantify the difference of hair density in fimbriae. Fig. 8 presents the difference in the size of lateral fimbriae on T3 expressed by its longitudinal width and inter-fimbria distance in some species of *L. sexstrigatum* group. Although the precise measurement is difficult, two types A and B, are clearly separated from each other by this procedure.

Table 1 gives further comparison of some morphometric characters and some of them are graphically shown in Figs. 9-12. Table 1 shows marked sexual differences in some characters despite only up to five specimens measured. Although some values in males may not fit to the normal distribution due to its cephalic gigantism, the range of SD (standard deviation) could conventionally be used as a measure of such skewed distribution.

Fig. 9 gives approximate body size in some species with body length and wing (+ tegula) length. In all three species in which both sexes are shown, males are distinctly smaller than females despite some gigantic males being larger than females. Among measured species, *L. pallilomum* is smallest and *L. sexstrigatum* largest. These species may give the limits of size range in the *L. sexstrigatum* group.

Fig. 10 shows the ratio head length/width, one of the most important metric values in the halictine bees. In all species cited the ratio does not much deviate from 1·0 as in many allied species, although *L. smilodon* and *L. frigidum* are relatively long-headed whereas *L. sexstrigatum* is opposite.

In Fig. 9, FR, SM, PA, and Fig. 10, PA, the SD is distinctly lager in males than in females, suggesting a marked deviation from the normal distribution, when males of various sizes were involved in the sample.

Fig. 11 gives the relative length of metanotum (MTL) and propodeal dorsum [PDL] in females, another important morphometric character. Here three species (*L. frigidum, epicinctum, smilodon*), being similar in metasomal pilosity, fairly deviate from each other, suggesting the difficulty of placing them in a phylogenetic cohort only based upon the pilosity.

Fig. 12 deals with the ratio F2W/F2L in males, suggested previously as one of the rare characters of possible diagnostic value in males. *L. frigidum* and *L. smilodon* are similar by long F2 as in *L. sexstrigatum*, sharply contrasting to *L. ohei*. It is also noteworthy that *L. sexstrigatum* behaves similarly in the ratio in Sappoŕo, Japan, and Austria, despite the difference in the absolute size in the species examined and the long distance between the two localities. However, the diagnostic value of this ratio may be reliable only when it is independent from the size-linked cephalic polymorphism known in all male-known species.

Table 2 gives the deviation of mean F2L/F2W relative to head width in two species. *L. ohei* and *L. pallilomum* in which many males were available. The ratio fluctuates among head width classes but rather randomly. This ratio is independent of head width changes, and the difference between two species, less than 1·0 in *L. ohei* and over 1·0 in *L. pallilomum*, is kept through the head width range observed, suggesting ist useful diagnostic value also in other species.

Finally, the relationship among three similar species, *L. frigidum, L. smilodon* and *L. epicinctum* is reconsidered. It was confirmed that these species form a phenetic group by the pilosity. Then, there remain two other problems: 1. Whether they form a same group also in other characters? 2. How are their phylogenetic relations? It was shown above that they behaved differently in pilosity and MTL/PDL ratio (Fig. 11). 3. Further, we are still not in the position to deal with the phylogenetic consideration on a so difficult group such as the *L. sexstrigatum* group. Here we merely present the relative similarity among the females of three species, *L. frigidum, L. smilodon,* and *L. epicinctum*. We can recognize the following similarity series among three species *L. frigidum - L. epicinctum - L. smilodon* in facial hairs, mesepisternal hairs, hairs on Tn disc, facial sculpture, whereas *L. frigidum - smilodon - epicinctum* only in propodeal dorsum length and geographic distribution. Or, *L. frigidum* is more similar to *L. epicinctum* than to *L. smilodon* despite geographical ranges of the first two species being more distant from each other than to that of *L. smilodon*. Although further comparative studies are necessary, this discrepancy might relate to the high zoogeographical endemicity of S.W. Archipelago, the homelands of *L. smilodon*, as suggested by the presence of many endemic animals there.

Acknowledgments

We express sincere thanks to all our friends who kindly offered us valuable material for our use. Their names are given in „specimens examined text“.

Zusammenfassung

Lasioglossum (*Evylaeus*) *frigidum* sp. nov. wird von Japan beschrieben. Diese Art unterscheidet sich von den anderen Arten der *L.* (*E.*) *sexstrigatum*-Gruppe meist sehr deutlich durch die gut entwickelten, breiten Wimperbinden der Tergite der Weibchen. Versuchsweise Diagnosen mit einigen anderen nahestehenden Arten werden gegeben, um diese ungewöhnliche und taxonomisch schwierige Gruppe bei zukünftigen Forschungen besser zu kennen.

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The authors' addresses:
Shôichi F. SAKAGAMI,
Ainosato, 1-6, 2-2-610, Kitaku, Sapporo, 002 Japan.

P. Andreas W. EBMER,
Kirchenstraße 9, A-4048 Puchenau, Austria.

Table 1: Values (x̄ ± SD/N) of important morphometric characters in both sexes of some species of the *Lasioglossum* (*Evylaeus*) *sexstrigatum* group, where X = the mean value and SD (standard deviation).

Character		Species						
		pallilomum	*ohei*	*smilodon*	*epicinctum*	*frigidum*	*sexstrigatum*	
				N = 3 (♀) 4 (♂)	N = 1	N = 4 (♂)	Hokkaido	Austria
♀	BL(10*)	49·0±0·6	53·8±2·5	54·3±0·9	47	54·2±1·5	56·8±1·2	56·2±0·4
	WL(10)	41·6±1·9	46·6±1·0	47·7±1·2	47	45·6±0·5	49·6±0·8	49·8±2·2
	HW(25)	37·4±1·4	40·3±1·0	41·0±0·9	39	39·9±1·1	43·2±0·8	43·0±1·4
	HL(25)	37·6±1·4	40·0±0·9	43·3±1·7	40	40·7±1·2	40·3±1·0	41·4±1·6
	PDL(25)	6·8±0·4	7·3±0·4	8·7±0·5	6	6·8±0·4	7·8±0·4	7·2±0·4
	MTL(25)	5·3±0·7	5·9±0·2	6·5±0·4	6	5·8±0·4	6·3±0·7	6·2±0·7
♂	BL(10)	44·2±2·3	48·0±3·5	50·0±1·0		48·7±3·9	55·4±2·6	55·5±0·9
	WL(10)	39·2±4·2	41·6±3·4	44·2±2·7		37·3±2·5	45·2±2·5	44·1±1·6
	HW(25)	37·5±4·1	39·8±5·3	41·5±1·5		36·0±0·0	38·9±0·1	37·7±0·6
	HL(25)	35·8±0·8	37·2±2·7	40·5±0·5		36·3±0·5	38·4±2·2	37·3±0·4
	PDL(25)	6·8±1·2	7·0±1·4	8·0±0·0		6·7±0·5	6·8±0·7	6·0±0·0
	MTL(25)	4·9±1·4	5·1±1·0	4·9±0·2		4·7±0·5	5·0±0·7	4·5±0·4
	F2L(40)	6·1±0·9	4·7±1·6	6·7±0·3		7·3±0·5	5·9±0·7	7·8±0·6
	F2W(40)	5·7±0·2	5·6±0·5	6·0±0·0		6·0±0·0	4·2±0·6	6·1±0·5
	MDL(25)	22·4±9·6	24·6±7·2	30·0±10·4		20·8±3·9	21·4±8·3	16·8±0·8

* 1 mm = 10, 25 or 40 units. Unless specified *N* = 5.

Abbreviation of characters measured: BL = Body length, WL = Wing (+ Tegula) length, HW = Head width, HL = Head length, PDL and MTL = Length of propodeal dorsum and metanotum, F2L, F2W = Length and width of flagellomere 2, MDL = Mandible length.

Table 2: Fluctuation of mean length to width ratio of male flagellomere 2 (F2L / F2W) relative to head width in *Lasioglossum* (*Evylaeus*) *ohei* (*N* = 32) and *Lasioglossum* (*Evylaeus*) *pallilomum* (*N* = 49).

Range of mean head width (25 = 1 mm).

	- 32	- 34	- 36	- 38	- 40	- 42	- 44	- 46	- 48	- 50
L. ohei										
mean ratio		0·89	0·85	0·88	0·86	0·89	0·89	0·91	0·91	0·82
N		6	8	8	4	5	5	2	1	1
L. pallilomum										
mean ratio			1·07	1·10	1·14	1·16	1·16	1·12	1·13	1·20
N			3	7	9	12	5	7	4	2

In both species males were collected at the same nest sites or reared from nests: *L. ohei* in 1964 at Kitami, Hokkaido, by S. F. Sakagami, *L. pallilomum* in 1980 at Morioka, Iwate Pref., by Y. Maeta and Dr. Y. Sasaki.

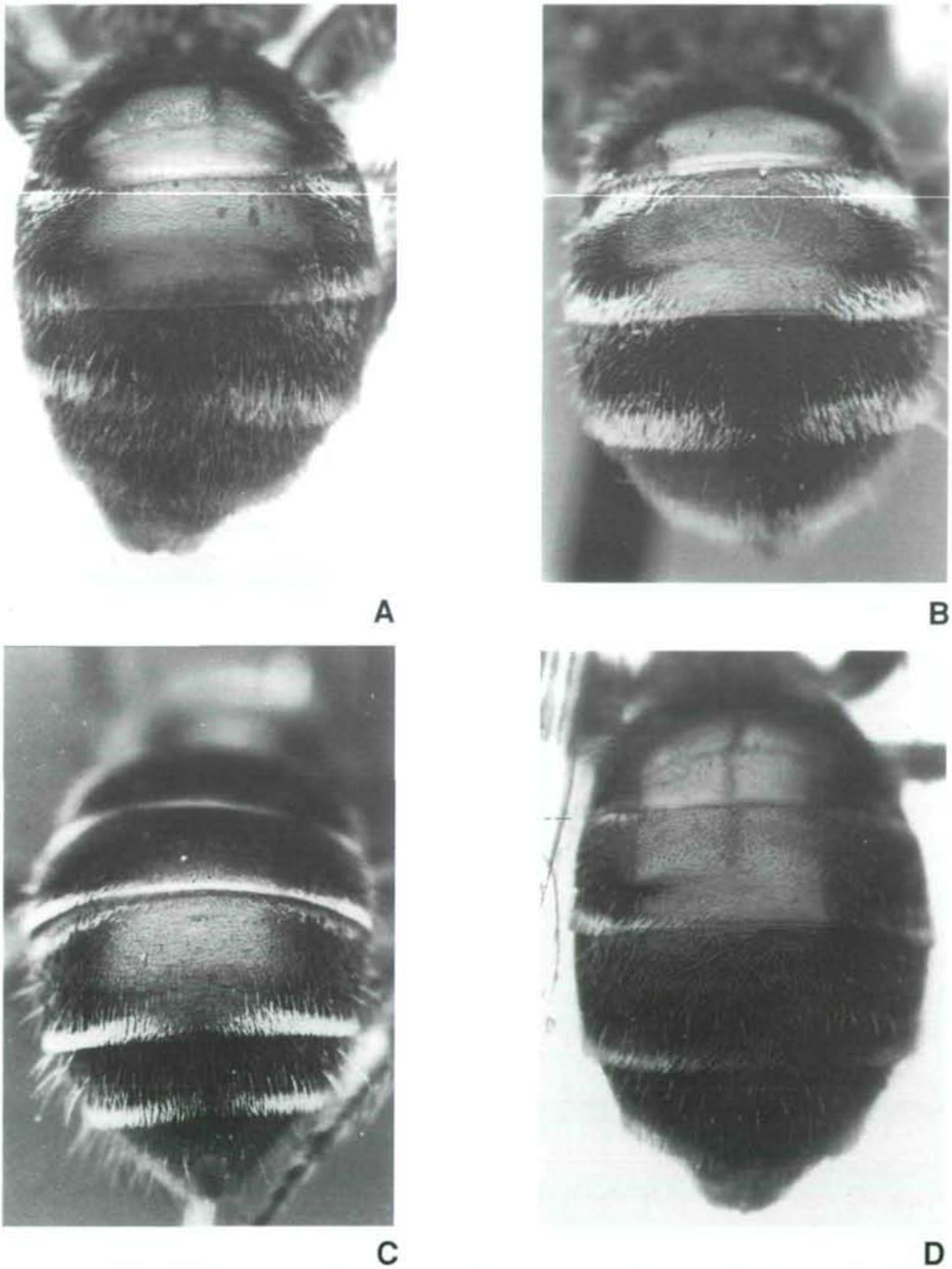


Fig. 1: Tergal pilosity of ♀ metasoma: *L. frigidum* (A) [Paratypus: Japan, HamaKoshimizu, 19. June 1967, on *Taraxacum officinale*, leg. H. Fukuda, coll. Ebmer], *L. epicinctum* (B) [Holotypus: Formosa=Taiwan, Anping, coll. Deutsches Entomologisches Institut, Eberswalde], *L. smilodon* (C) [Paratypus: Japan, Kagoshima Pref., Akuseki-Jima, Tokara, 150-230 m, 2. August 1985, leg. S. Ikudome, coll. Sakagami], *L. sexstrigatum* (D) [Austria, Oberösterreich, St. Georgen an der Gusen, 4. April 1971, leg. and coll. Ebmer].

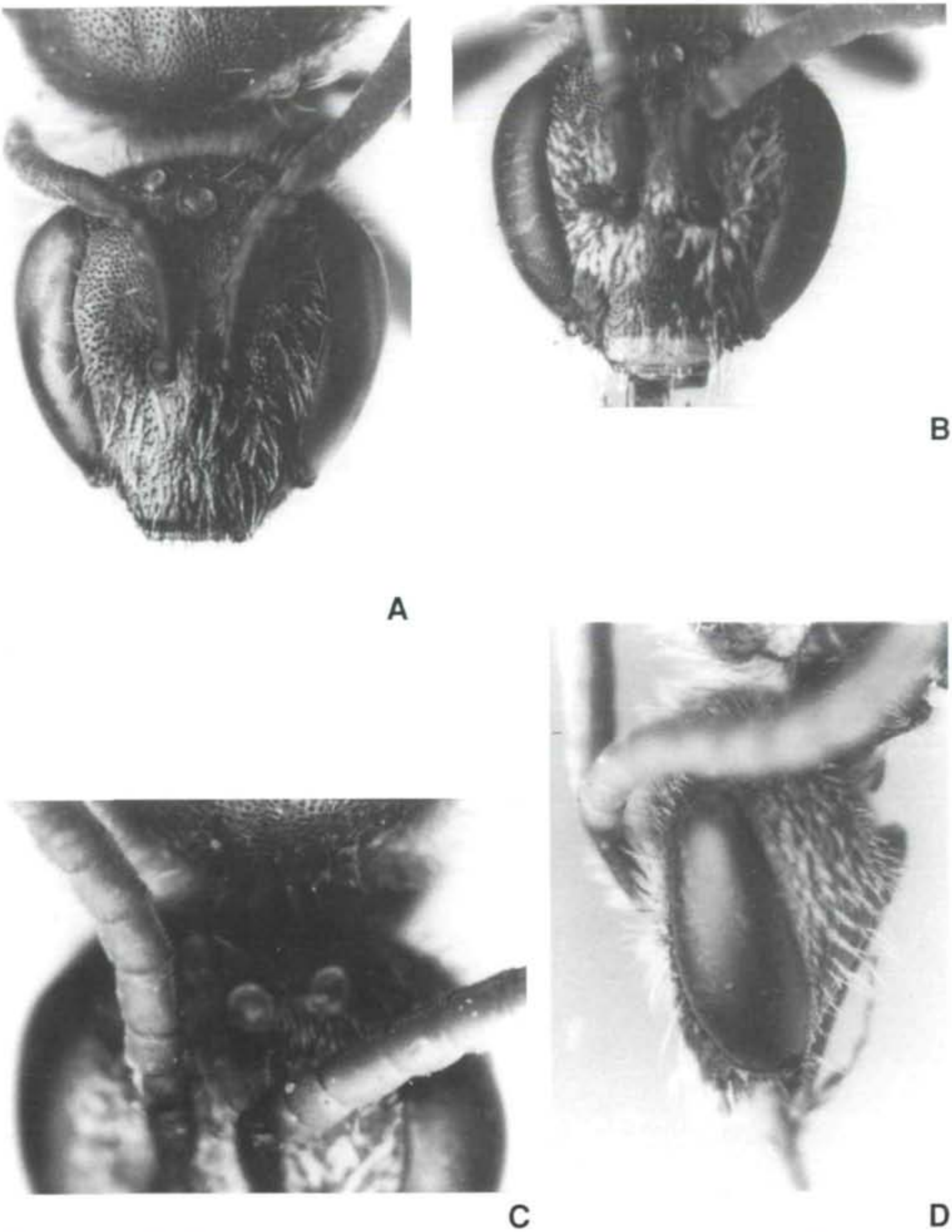


Fig. 2: Head of *L. frigidum* seen frontally (A ♀ [same exemplar as in Fig. 1], B ♂ [Paratypus: Japan, Hirataki-Nama, Kizuruki, 21. July 1984, leg. M. Yamada, coll. Ebmer]), seen dorsally with basal flagellomeres (C ♂), and seen laterally with basal flagellomeres and gena (D ♂).

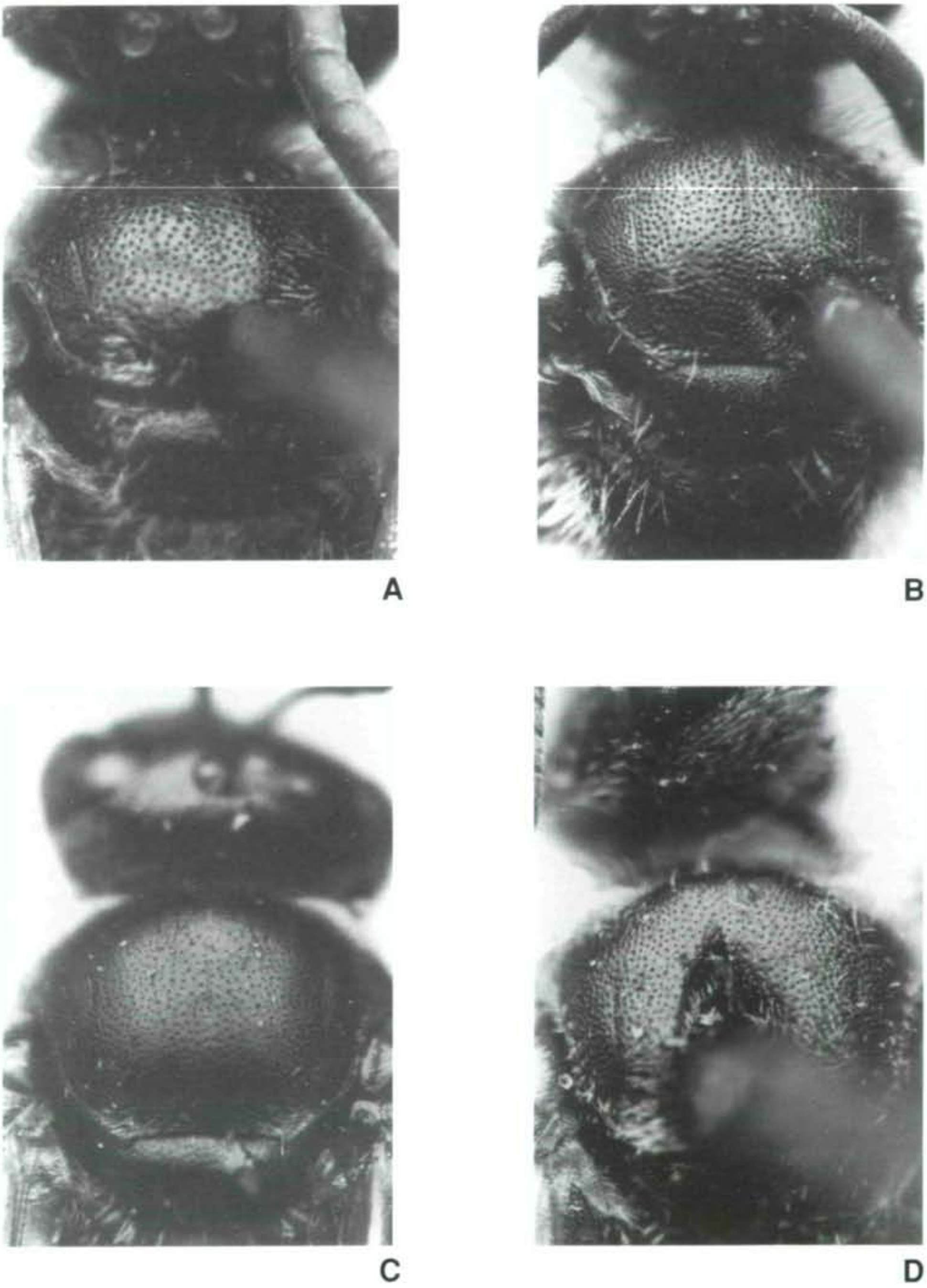


Fig. 3: Mesoscutum of *L. frigidum* (A ♂, B ♀), *L. smilodon* (C ♀) and *L. epicinctum* (D ♀) [same exemplares as in Fig. 1 and 2].

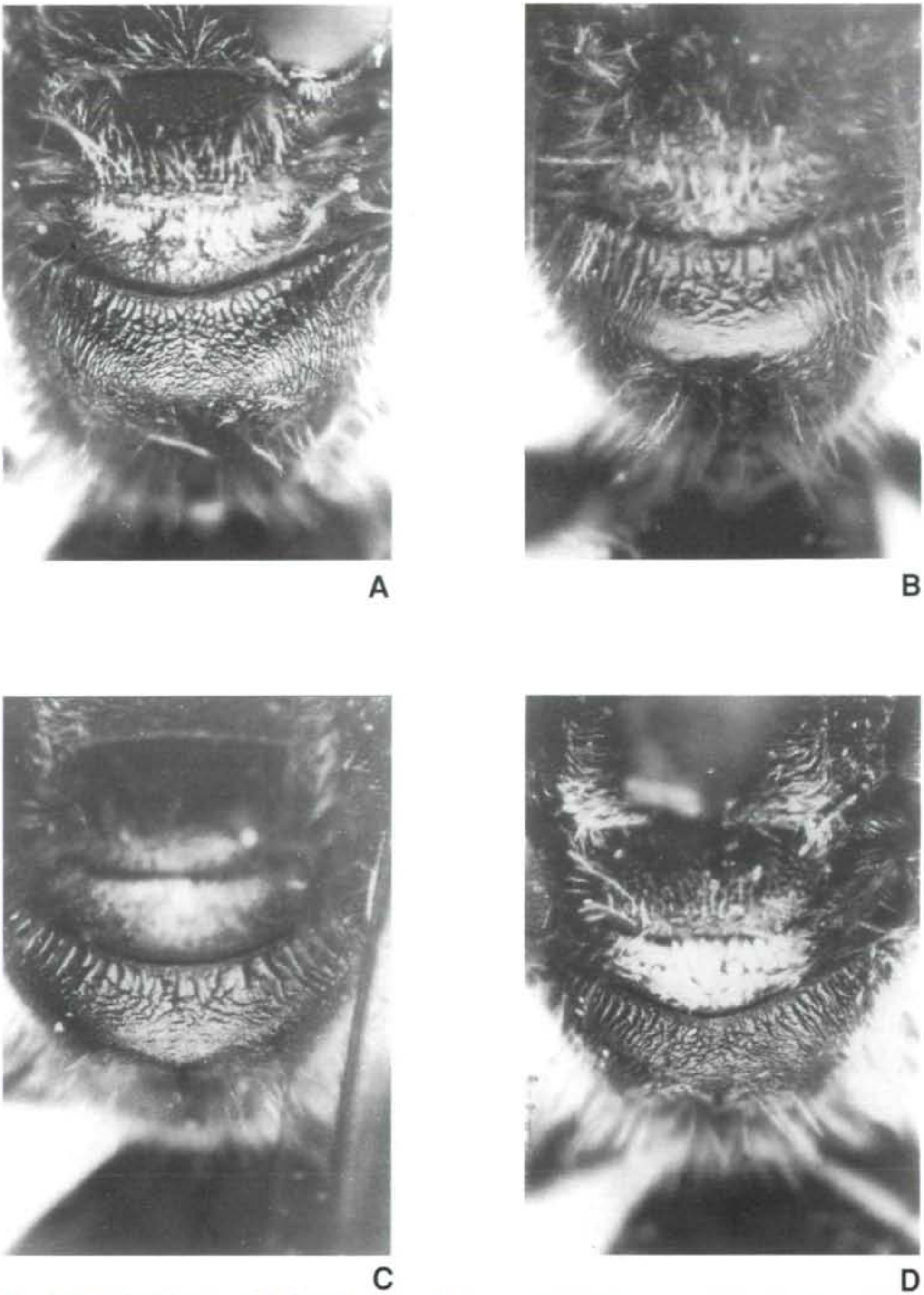
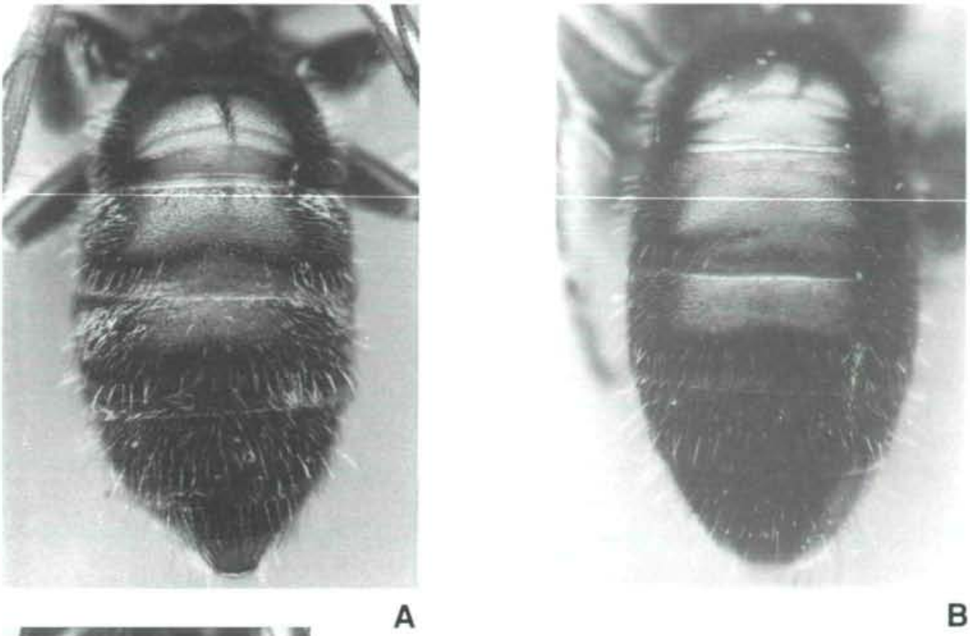


Fig. 4: Propodeal dorsum of *L. frigidum* (A ♀, B ♂), *L. smilodon* (C ♀), *L. epicinctum* (D ♀) [same exemplares as in Fig. 1 and 2].



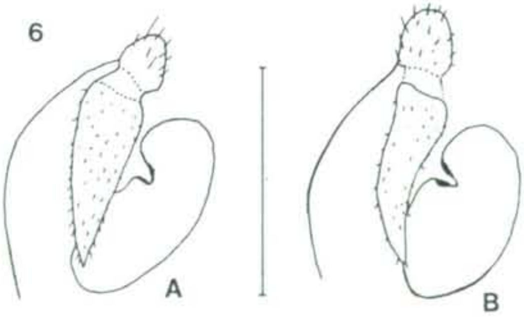


Fig. 5: Tergal pilosity of male metasoma: *L. frigidum* (A) [same exemplar as in Fig. 2B], *L. smilodon* (B) [Paratypus: Japan, Kagoshima Pref., Akuseki-Jima, Tokara, 150-230 m, 2. August 1985, leg. S. Ikudome, coll. Sakagami], *L. sexstrigatum* (C) [Austria, Oberösterreich, St. Georgen an der Gusen, 23. August 1972, leg. and coll. Ebmer].

Fig. 6: Male genitalia seen ventrally (gonostylus: ventral retrose lobe and volsella) of *L. smilodon* (A) and *L. frigidum* (B) (Scale = 0·25 mm).

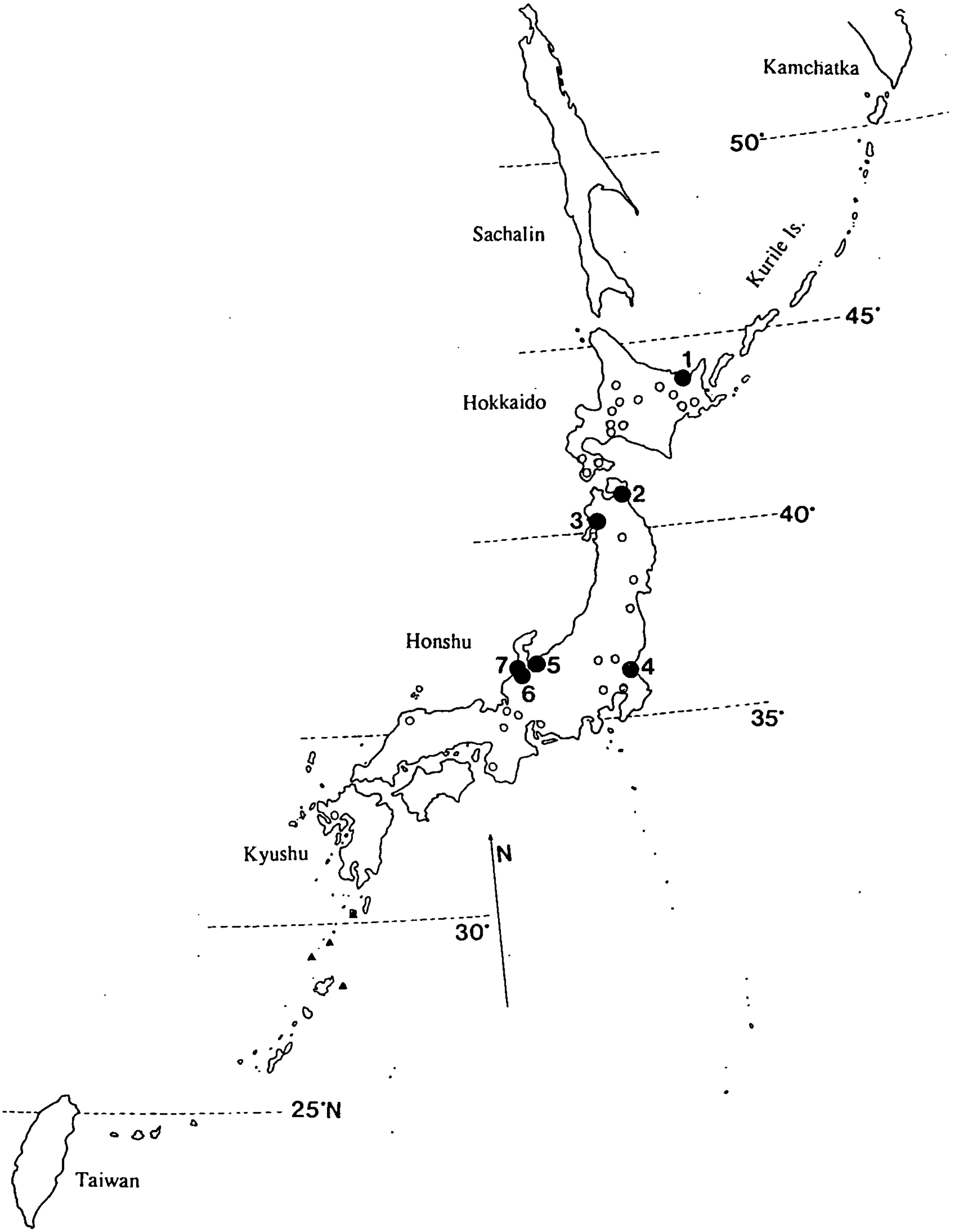


Fig. 7: Distribution of *L. frigidum* in Japan. Black circles = 1. Hama Koshimizu, 2. Amagamori, 3. Kizuruki, 4. Muramatsu, 5. HamaKurosaki, 6. Kaneiwa, 7. Uchinada shore (see specimens examined). Open circles = localities where some specimens of *L. sexstrigatum* group were collected by periodical sampling. Triangles = *L. smilodon*.

Fig. 8

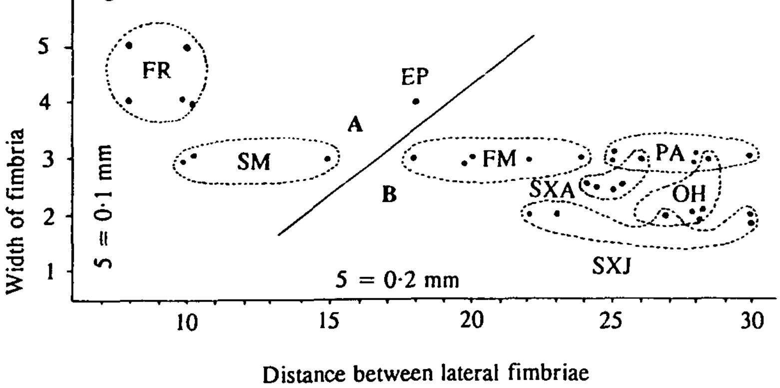


Fig. 9

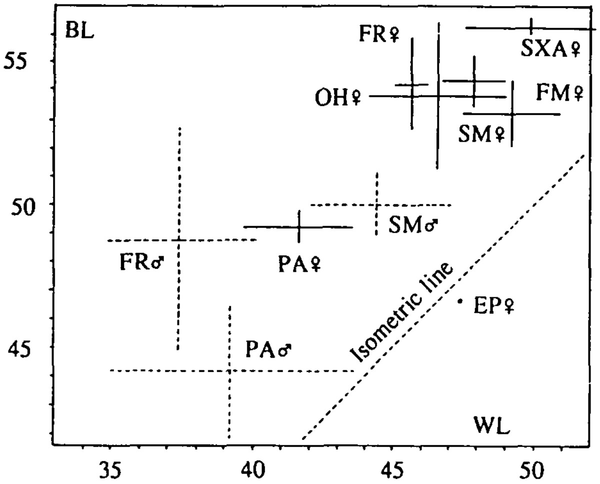


Fig. 8: Relationship between the interfimbrial distance and the longitudinal width of fimbria in ♀♀ of some species of the *L. sexstrigatum* group: Type A: FR = *frigidum*, SM = *smilodon*, EP = *epicinctum*. Type B: FM = *fimbriatellum*, PA = *pallilomum* (Japan), SXA, SXJ = *sexstrigatum* (Austria and Japan), OH = *ohei*.

Fig. 9: Relationship between body length (BL) and wing (+ tegula) length (WL) in some species of *L. sexstrigatum* group (abbreviations in Fig. 8), given by mean ± SD, N = up to 5 specimens (25 = 1 mm), The abbreviations of species as in Fig. 8 (SXJ is excluded as so similiar to SXA).

Fig. 10

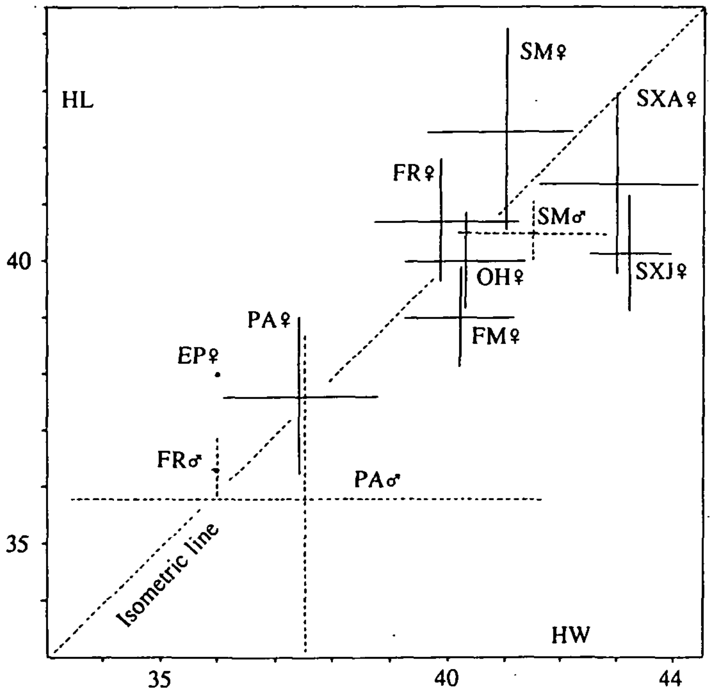


Fig. 10: Relationship between head width (HW) and head length (HL) in some species of the *L. sexstrigatum* group; abbreviations as in Fig. 8. (25 units = 1 mm).

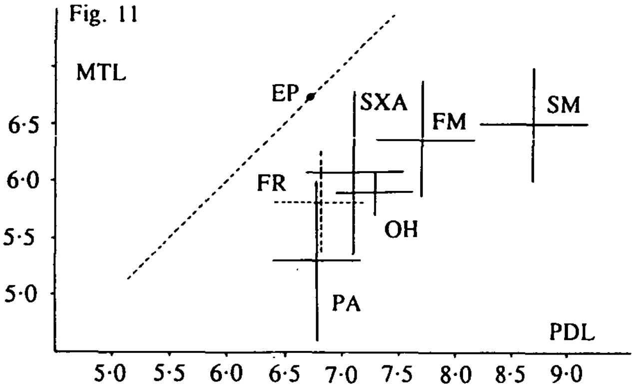


Fig. 12

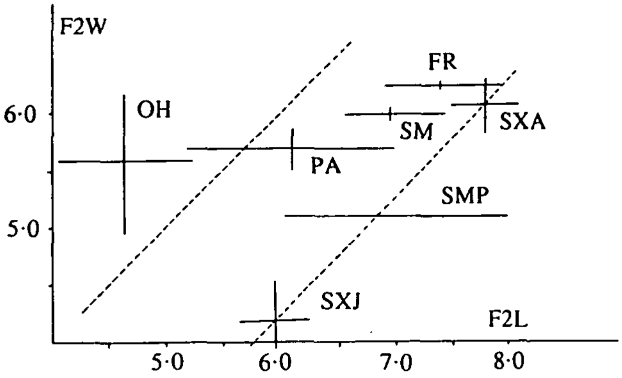


Fig. 11: Relationship between length of propodeal dorsum (PDL) and metanotum (MTL), in ♀♀ of some species of the *L. sexstrigatum* group (abbreviations as in Fig. 8).

Fig. 12: Relationship between length and width of F2 (F2L / F2W) in males of some species of the *L. sexstrigatum* group (SMP = *L. simplicior*, other abbreviations as in Fig. 8).

Zeitschrift/Journal: Linzer biologische Beiträge

Jahr/Year: 1996

Band/Volume: 0028_2

Autor(en)/Author(s): Sakagami Shôichi Francisco, Ebmer Andreas Werner

Artikel/Article: Lasioglossum (Evylaeus) frigidum sp. nov., with taxonomic notes on the allied species of L. (E.) sexstrigatum group (Hymenoptera, Apoidea, Halictidae). 899-916