



| | |
|------------------|--|
| Title | Taxonomic Revision of the Leiobunum curvipalpe-Group (Arachnida, Opiliones, Phalangiidae). : I. hikocola-, hiasai-, kohyai-, and platypenis-Subgroups. (With 21 Text-figures and 2 Tables) |
| Author(s) | TSURUSAKI, Nobuo |
| Citation | 北海道大學理學部紀要, 24(1), 1-42 |
| Issue Date | 1985-03 |
| Doc URL | http://hdl.handle.net/2115/27686 |
| Type | bulletin (article) |
| File Information | 24(1)_P1-42.pdf |



[Instructions for use](#)

**Taxonomic Revision of the *Leiobunum curvipalpe*-Group
(Arachnida, Opiliones, Phalangidae). I. *hikocola*-,
hiasai-, *kohyai*-, and *platypenis*-Subgroups.¹⁾**

By

Nobuo Tsurusaki

Zoological Institute, Hokkaido University

(With 21 Text-figures and 2 Tables)

Contents

| | |
|---|----|
| Introduction | 2 |
| Materials and Methods | 2 |
| 1. The General Features of the <i>Curvipalpe</i> -group..... | 3 |
| 1.1. Morphology | 3 |
| 1.2. Distribution | 5 |
| 1.3. Biology | 5 |
| 1.4. Relationship to Other Members of <i>Leiobunum</i> | 8 |
| 2. Classification Within the <i>Curvipalpe</i> -group | 10 |
| 2.1. Taxonomic Characters | 11 |
| 2.2. Subgrouping of the <i>Curvipalpe</i> -group | 13 |
| 2.3. Key to the Species of the <i>Curvipalpe</i> -group | 17 |
| 3. Descriptions and Records of Species and Races | 18 |
| <i>L. hikocola</i> Suzuki | 20 |
| <i>L. hiasai</i> Suzuki | 23 |
| <i>L. sadoense</i> Tsurusaki | 24 |
| <i>L. simplum</i> Suzuki | 25 |
| <i>L. kohyai</i> Suzuki | 27 |
| <i>L. platypenis</i> Suzuki | 30 |
| <i>L. globosum</i> Suzuki | 34 |
| Summary | 36 |
| Acknowledgements | 37 |
| References | 38 |

1) This paper constitutes a part of the doctoral thesis submitted to the Faculty of Science, Hokkaido University (No.1926).

Jour. Fac. Sci. Hokkaido Univ. VI, Zool. 24(1), 1985

Appendix.....39

Introduction

The *curvipalpe*-group of the genus *Leiobunum* (Phalangiidae, Leiobuninae) is one of the most common groups of phalangiids inhabiting woodlands of montane environments in Japanese Islands. This group, almost wholly endemic to Japan, is distributed from Hokkaido south to Is. Amami-ôshima of the Southwest Islands. Members of the group are commonly found on herbs, shrubs, and on the trunks of trees mainly in beech forests or mesic coniferous forests during the summer. Nineteen species and subspecies of the *curvipalpe*-group have been described by Roewer (1910), Sato and Suzuki (1939), Suzuki (1953, 1957, 1966, 1976b), and Tsurusaki (1982). However, the classification within this group is confused due to the remarkable geographic variations in some important diagnostic characters including male genitalia and karyotypes.

The purpose of this paper is to revise this taxonomically troublesome but biologically fascinating group of opilionids based on a detailed comparative study involving both morphological and karyological analyses. This paper, the first in a series, deals with the definition of the group and revision of four subgroups, *hikocola*, *hiasai*, *kohyai*, and *platypenis*. These subgroups consist of seven species, of which one is treated as comprising two different races.

Materials and Methods

About 9,100 specimens of the *curvipalpe*-group, all preserved in 80% ethanol, were examined during the morphological study. They are listed in "*Specimens examined*" after the description and records of each species. The majority of specimens were collected by myself, and are in my personal collection. Additional specimens deposited in the personal collection of Dr. S. Suzuki (Hiroshima) and in the Zoological laboratory, Faculty of Science, Hiroshima University were also examined.

Chromosome observations: As the materials, gonads removed from living specimens of male adults and juveniles (penultimate and antepenultimate) of both sexes were used. Most preparations were made on the day the opilionids were captured, or a few samples the day after. As the method of chromosome preparation, routine squash-technique using acetic orcein was employed to 1981. From 1982 onwards, a slight modification of the air-drying technique by Takagi and Oshimura (1973) was used in all chromosome preparations.

The procedures of this air-drying technique are as follows: (1) Dissect out testis or ovary in Ringer's solution for *Drosophila* (NaCl 7.5 g + KCl 0.35 g + CaCl₂ 0.21 g/11 distilled water) on a depression slide. (2) Transfer the organs to hypotonic solution (1% sodium citrate) on another depression slide using a dissecting needle and leave for 5~15 min. at room temperature. (3) Transfer the

organs to freshly-prepared fixative (absolute acetic methanol: 3 volumes of absolute methanol and one volume of glacial acetic acid) and leave for more than 5 min. (4) Transfer the fixed material together with fixative onto another depression slide using a pipet. (5) Place the slide under a dissecting microscope and add one or two drops of 3:1 glacial acetic acid/50% lactic acid (i.e. glacial acetic acid: absolute lactic acid: distilled water=6:1:1). This treatment dissociates the tissue into single cells and clumps of cells. (6) When the material becomes transparent and intercellular connection are sufficiently loose, transfer a small drop of the cell suspension onto a freshly wiped pre-cleaned slide (washed in detergent solution, rinsed in distilled water, and stored in absolute ethanol) using a capillary tube with rubber suction tube. (7) Immediately (i.e., before the cell suspension dries) and 5~10 drops of freshly-prepared fixative (absolute acetic methanol) at appropriate intervals. (8) Allow the slide to air-dry completely at room temperature (more than one day).

Chromosome preparations on the slides were stained by Giemsa solution (Merck solution diluted 1:24 in M/15 Sørensen's pH 6.8 buffer: KH_2PO_4 4.54 g + Na_2HPO_4 4.75 g/l) and then rinsed with tap water. No cover slips were mounted. All photographs of chromosomes were taken from these slides without cover slips but with immersion oil.

1. The General Features of the *Curvipalpe*-group

The *Leiobunum curvipalpe*-group was first recognized and named by Suzuki in his extensive revision (1976 b) of the genus in Japan and adjacent countries together with the three other species groups (*maximum*-, *japonicum*-, and *rubrum*-groups). As to the definition of these species groups, Suzuki stated that "(division of) these species groups are based mainly upon the size or shape of body, color pattern, structure of palp, labrum, and male and female genitalic structure", but unfortunately he did not give any details on these diagnostic characters. Therefore, at first I will summarize various features of the *curvipalpe*-group based on the results obtained by the present study and information available from species descriptions by Suzuki (1953, 1957, 1966, 1976 a, 1980 b), Tsurusaki (1982), and Suzuki and Tsurusaki (1983).

The principal features of the group may be summarized as follows: (1) rather uniform external morphology, (2) the great variability in male genitalia, (3) striking chromosomal diversity, (4) wide distribution of the group throughout most of Japan, but the usually small distributional ranges of the species and races, (5) the prevalency of presumable parapatric distribution of closely related species and races, (6) presence of two thelytokous species (Tsurusaki, unpubl.), and (7) ostensible high male-biased sex ratio in adult stage of non-thelytokous forms.

1.1. Morphology

Diagnosis: The *curvipalpe*-group differs from all other described members of

Leiobunum by (1) the presence of enlarged lobe (apophysis) clothed with numerous fine setae on the palpal patella and tibia in all stages of females and in juvenile (up to antepenultimate) males, (2) the enlarged male labrum with several dark colored denticles on its sides (except for *L. kohyai* and *L. simplum*), and (3) distomesal surface of distal segment of male chelicera.

Descriptions: *Male*: Medium to large-sized phalangiids with soft or slightly hardened bodies; dorsum without spines or armaments; coloration of body usually light yellowish orange to reddish orange. Eye tubercle approximately equal in length, width, and height; canaliculate; with small teeth on the carinae. Coxae of legs with anterior and posterior marginal rows of tubercles (Fig. 14G), but rows often reduced or absent. Genital operculum smooth, with only scattered setae, lacking lateral rows of tubercles. Labrum extraordinarily extended, swollen, with several denticles on both lateral sides.

Chelicera medium in size, basal segment dorsally smooth, distal segment usually with some distomesal denticles.

Palp: Femur moderately curved below, lacking any prominent tubercles or humps on mesal surface; patella distomesally with a small apophysis; tibia ventrally with at least several teeth mainly on distal part; tarsus ventromesally with a row (or two rows in some species) of well-developed tubercles; Claw pectinate.

Legs long and slender, first femur usually longer than body, with numerous scattered dark colored denticles.

Penis elongated and highly sclerotized, usually flattened dorsoventrally; basal joint of corpus located on ventral side of the shaft; with or without relatively simple alates; glans dorsoventrally movable.

Female: Body usually larger than male but with shorter legs; ground color yellowish to whitish cream, dorsum medially maculated from eye tubercle to tergite VII or VIII with a series of dark brown or bright brown spots whose centers are roundly faded. Labrum, short, slender, and gradually narrowed toward the apex (except for *L. platypenis*).

Chelicera same as males in general structure but lacking distomesal denticles on distal segment.

Palp relatively slender; patella distomesally with a strikingly extended lobe which is clothed with numerous setae; tibia with a similar but less developed lobe distomesally, ventral surfaces smooth; tarsus slender, lacking ventromesal row of denticles.

Juvenile: In general, similar to adult female, but leg segments including denticles, only hairy. Palp as in female, patella and tibia with distinct distomesal lobes. Subadult male is often discernible from female subadult and all other stages of juveniles by a less prominent lobe of palpal patella and tibia, and somewhat enlarged labrum.

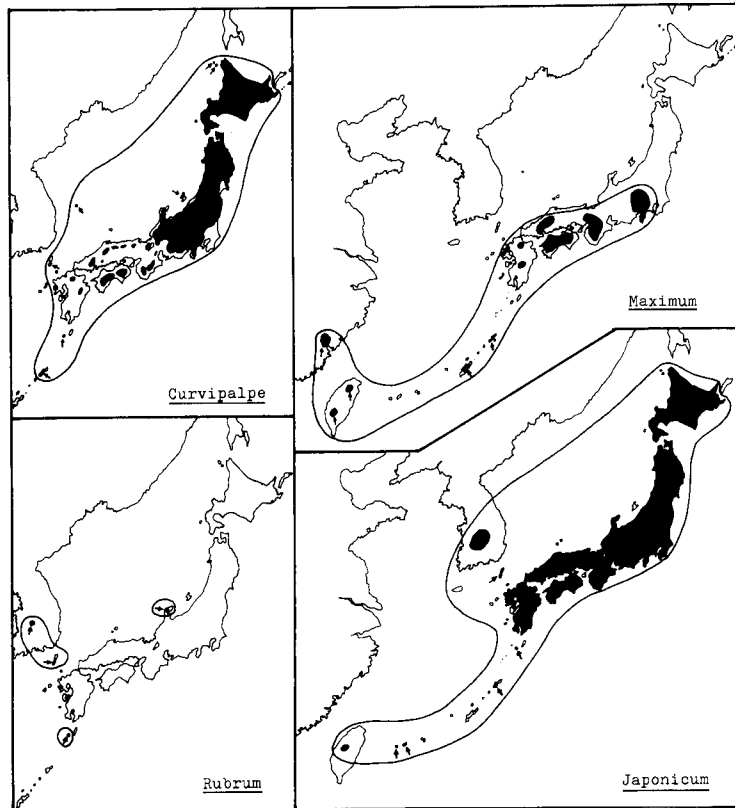


Fig. 1. Distribution of four species groups of the *Leiobunum* in Japan and adjacent areas.

1.2. Distribution

The group is almost confined to the cool temperate zones of Japanese Islands. No record of this group is known from continental Asia.

JAPAN: Hokkaido, Honshu, Shikoku, Kyushu, Is. Rishiri, Is. Rebun, Is. Sado, Is. Tsushima, Is. Yakushima, Is. Amami-ôshima. KOREA: Is. Ullung-do (Fig. 1).

In southwestern Japan, distribution of this group excluding *L. hikocola* seems to be generally confined to mountainous areas above ca. 800 m in altitude. These areas approximately conform to the distribution of beech forests (=Siebold's Beech, *Fagus crenata* Blume).

1.3. Biology

The annual life cycle of this species group is simple. All species are

univoltine and hibernate as eggs. Juveniles, which emerge in spring, become adults during early to mid-July. In species inhabiting subalpine zones of high mountains, e.g. Mt. Tsubakuro race and Mt. Ontake race of *L. montanum* (Tsurusaki, in prep.), emergence of adults is about one month later than in lowland populations. Most individuals die before late September.

Adults are very commonly found on trunks of trees or on shrubs or herbs. Samples collected by normal hand sorting often show extraordinarily male-biased sex ratios. For example, I have collected 351 individuals of *L. montanum* (Ishizuchi race: Tsurusaki, in prep.) in the coniferous forest near Tsuchigoya, Mt. Ishizuchi of Shikoku on 5 August 1982. Of these 308 were males and the remaining 43 were females. The sex ratio (percentage of male) is 87.7% in this case. Another example concerns *L. curvipalpe* (Nagano race: Tsurusaki, in prep.) collected from Higashi-Shirakabako located between Mt. Kirigamine and Mt. Tadeshina, central Honshu, on 1 August 1981. Sex ratio of 90 individuals collected at that time was 98.9% (89 ♂ 1 ♀). However, this extraordinary sex ratio is perhaps not of genetic ground, but due to the sampling error, because collection data of individuals at their subadult or antepenultimate stages seems to show rather normal sex ratio. This extraordinary sex ratio in adults might reflect differences in habitat preference or behavior between both sexes in adult stage, although evidence for such segregation between males and females has not yet been obtained.

Most remarkable biological feature of this group is the presence of thelytokous mode of reproduction in two closely allied species, *L. platypenis* and *L. globosum* (Tsurusaki, unpubl.). Many topics encompassing thelytoky of these two species will be reported elsewhere.

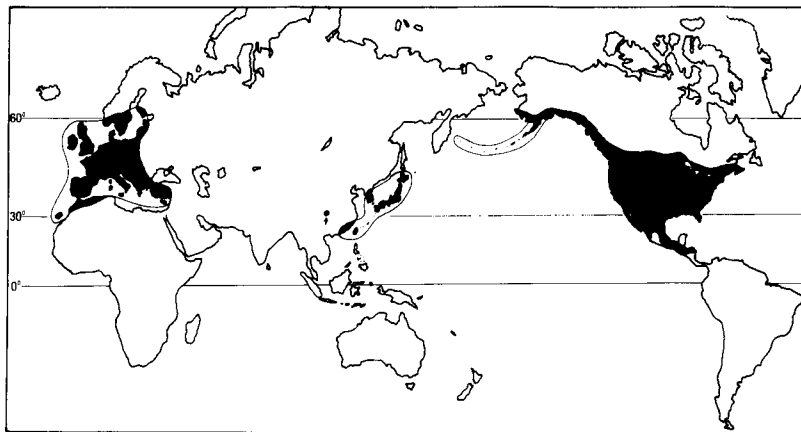


Fig. 2. World distribution of the genus *Leiobunum*. Compiled from Roewer (1923, 1957), Davis (1934), Martens (1978), Suzuki (1976 b), Kauri (1966), and Cokendolpher (pers. comm.).

Table 1. Diagnostic characters among four species groups of Japanese *Leiobunum*

| Characters | <i>Curvipalpe</i> | <i>Maximum</i> | <i>Japonicum</i> | <i>Rubrum</i> |
|---|--|---|--|---|
| I. Size | Medium to large body with legs of normal length | Large body with relatively short legs | Small body with long legs | Medium-sized body with relatively long legs |
| 1. Body length (mm) | ♂ 2.9~5.8 ♀ 4.0~6.4 | 4.4~9.8 9.2~13.7 | 2.5~3.4 4.3~5.7 | 3.2 4.1~5.3 |
| 2. Length of femur I (mm) | ♂ 4.9~7.7 ♀ 3.9~6.1 | 5.0~9.7 5.0~9.8 | 6.7~12.7 3.4~10.7 | 7.9 7.1~9.4 |
| II. Structure | | | | |
| 1. Palp: | | | | |
| • Mesal denticles on femur (♂, ♀) | Absent | Present | Absent | Present |
| • Distomesal lobe or apophysis on patella (♀) | Present, well developed | Slightly developed | Absent | Absent |
| 2. Male chelicera: | | | | |
| • Distomesal denticles on distal segment | Usually present | Present or absent | Absent | Absent |
| • Dorsal denticles on proximal segment | Absent | Present or absent | Absent | Present |
| 3. Male labrum | Usually well developed | Slender | Slender | Slender |
| 4. Eye tubercle | Normal | Low | Normal | Normal |
| 5. Dorsal spine on scutum | Absent | Absent | Absent, but rarely with 1 medial spine on tergite II | Absent |
| 6. Lateral denticles on genital operculum | Absent | Present or absent | Present | Absent |
| III. Hibernating stage | Eggs | Juveniles (in <i>L. japonense</i>) | Eggs | Eggs (?) |
| IV. Distribution (cf. Fig. 1) | Japan, Is. Amami-ōshima, Is. Tsushima, Is. Ullung-do | Southern Japan, The Southwest Islands, Taiwan, Southern China | Japan, Southwest Islands, Taiwan, Korea | Is. Yakushima, Honshu (Wajima), Korea |

1.4. Relationship to Other Members of *Leiobunum*

Species of the *Leiobunum* are widespread in the temperate regions of the northern hemisphere, and show a typical disjunct distributional pattern. Namely their distribution is limited to the following three major areas: 1) Europe and its adjacent areas (Northern part of North Africa; Asia Minor, 2) Far East Asia, and 3) North America (Fig. 2). In this section, the relations of the *curvipalpe*-group to the other Japanese and exotic groups of *Leiobunum* are briefly discussed. The specimens other than *curvipalpe*-group used for this study are listed in Appendix and those of *curvipalpe*-group are listed after the description and record of each species under "Specimens examined".

As already stated, four major species groups (*curvipalpe*, *maximum*, *japonicum*, *rubrum*) have been, thus far, recognized in the *Leiobunum* of Japan and adjacent areas (Suzuki, 1976 b). Diagnostic adult characters among these four species groups are summarized in Table 1. Except for the *curvipalpe*-group, each group can be regarded as a well-defined superspecies in the sense that it is composed of several closely related allopatric species (semispecies). However, as mentioned later in detail, the *curvipalpe*-group alone is a composite of several superspecies and species complexes. Phylogenetic relationship of these four species groups has been unclear because the gap in external morphology between the groups is profound. However, judging from its morphology the *maximum*-group may represent a rather different lineage from the other *Leiobunum* groups including European and North American species. This group is characterized by: large body and quite short legs, possession of prominently protruded supra-cheliceral lamellae; well-developed patellar and tibial apophyses of the palp in both sexes; smooth leathery surface of body.

The relationship of the *curvipalpe*-group to the other *Leiobunum* species in the other regions has been obscure. Species from Europe distinctly differ from the East Asian and North American species in the structure of male palpi. Namely most European species lack ventromesal row of tubercles on the male palpal tarsus, while in both Asian and North American species development of this male secondary sexual character is very remarkable. Since retrogression of these male palpal tubercles on tarsus is also observed in European species of *Nelima*, a closely allied genus of the *Leiobunum*, European species of *Leiobunum* seem to be closer to the species of *Nelima* of the same region than to their East Asian and North American counterparts. This view may be supported by the resemblance of penis structure and some other external characters in European species of *Leiobunum* and *Nelima*.

The genus *Leiobunum* is the most abundant and characteristic element of the opilionid fauna in North America, especially in its northern and eastern portions. According to McGhee (1975), North American *Leiobunum* consists of several rather distinct species groups. However, as only one of these groups has been studied and published in detail, available data on their phylogenetic interrelation are at

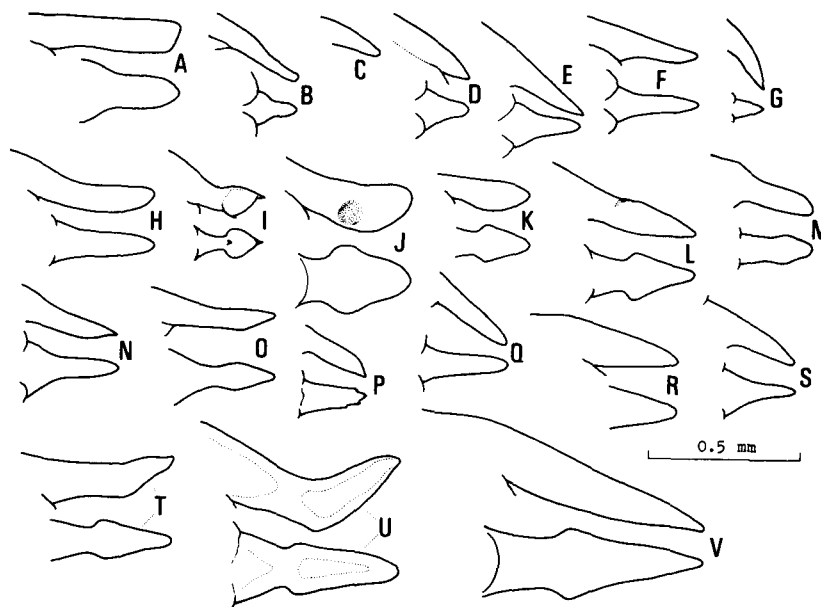


Fig. 3. Male labra of various species of *Leiobunum* (excluding *curvipalpe*-group). (above, lateral view; below, ventral view) A-C: East Asian forms. A, *L. japonense japonicum*; B, *L. rubrum*; C, *L. japonicum japonicum*. D-G: European forms. D, *L. rotundum*; E, *L. limbatum*; F, *L. rupestre*; G, *L. ghigii*. H-V: North American forms. H, *L. ventricosum*; I, *L. aldrichi*; J, *L. politum*; K, *L. brachiolum*; L, *L. nigripes*; M, *L. gordoni*; N, *L. townsendi*; O, *L. flavum*; P, *L. viridosum*; Q, *L. relictum*; R, *L. crassipalpe*; S, *L. vittatum*; T, *L. calcar*; U, *L. leiopenis*; V, *Hadrobunus* sp. Provenance of the material is given in appendix.

present very few. The presumable closest relative of the *curvipalpe*-group seems to occur in the eastern part of North America. Some species from eastern part of North America (e.g. *L. calcar*, *L. leiopenis*, *L. relictum*, *L. crassipalpe*, *L. vittatum*) somewhat resemble *curvipalpe*-group in general structure of male palp, penis, and shape of body. Further, non-alate type of penis, which is a remarkable characteristic in these eastern North American species, is also encountered in some forms of the *curvipalpe*-group (e.g. *L. kohyai*, Mt. Akagi race of *L. curvipalpe*: Tsurusaki, in prep.). *Hadrobunus* spp. (eastern North American genus that is closely allied to *Leiobunum*) also appear similar to the *curvipalpe*-group in these characters. It is well known that eastern North America and eastern Asia share elements in various organisms. In Opiliones, four species, i.e. *Caddo agilis* Banks, *Caddo pepperella* Shear, *Acropsopilio boopis* (Crosby), *Crosbycus dasyncnemus* (Crosby), have been known as species showing such distributional pattern (Suzuki, 1972; Suzuki *et al.*, 1977; Shear and Gruber, 1983). Therefore it is not unlikely that closest sister groups occur in these two widely isolated areas in Leiobuninae

species, too. However, the *curvipalpe*-group seems to be a natural, monophyletic group whose members are united by three synapomorphies: distomesal lobes on palpal patella and tibia in females and juveniles; well-developed male labrum (compare Fig. 3 and 5), and presence of distomesal teeth on distal segment of male chelicera. Further extensive comparisons of characters of all described species of *Leiobunum* and related genera are required in order to estimate reasonable phylogenetic position of the *curvipalpe*-group as well as the interrelation of species groups within the genus *Leiobunum*.

2. Classification Within the *Curvipalpe*-group

Nineteen species and subspecies have so far been described as *curvipalpe*-group members by various authors. All these forms were studied in detail in the present study. As a result, these taxa were arranged into seven subgroups with 11 species, some of which include several geographic races. In the present section, I will describe taxonomic characters used in the classification of this group. A key to the species will also be presented.

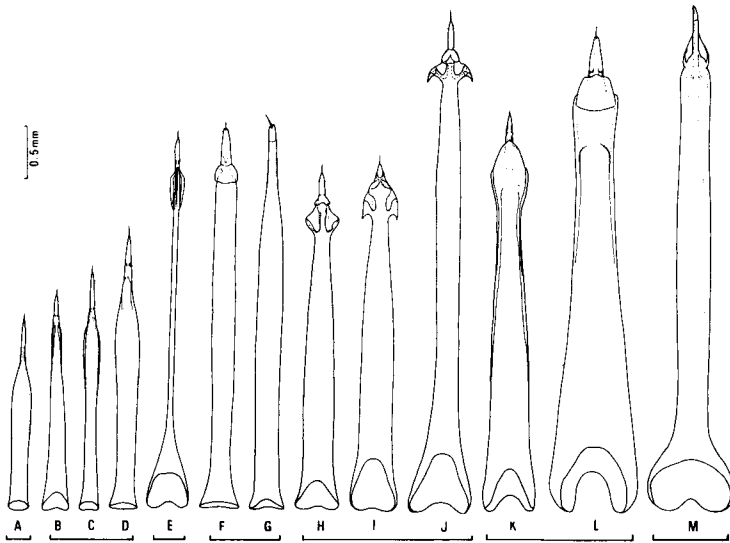


Fig. 4. Penes of various species belonging to the *Leiobunum curvipalpe*-group (ventral view). A, *L. hikocola*. B-D, *hiasai*-subgroup: B, *L. simplum*; C, *L. sadoense*; D, *L. hiasai*. E, *L. montanum*. F-G, *platypenis*-subgroup: F, *L. platypenis*; G, *L. globosum*. H-J, *L. hiraiwai*. K-L, *curvipalpe*-subgroup: K, *L. tohokuense*; L, *L. curvipalpe*. M, *L. kohyai*. Forms belonging to same subgroup are combined by a bracket, respectively.

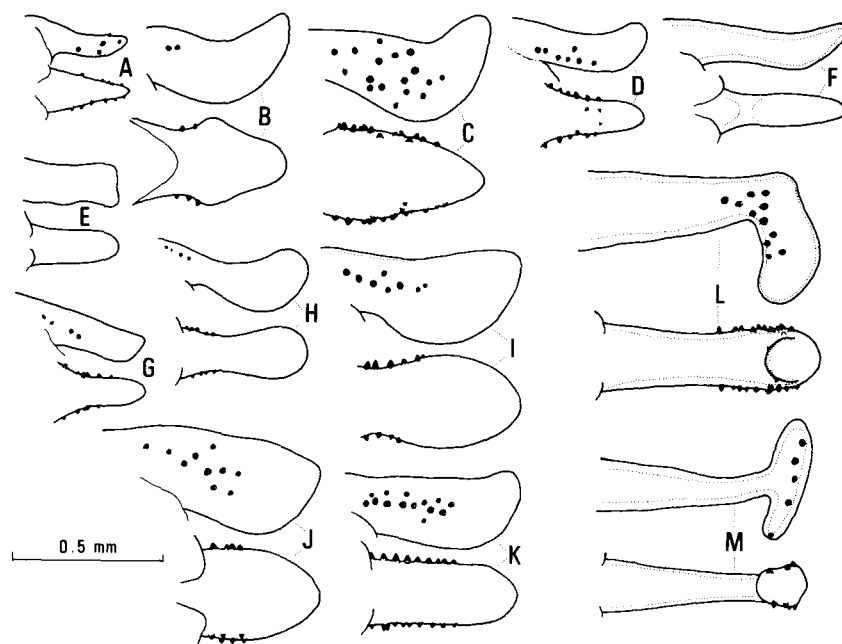


Fig. 5. Male labra of various species of the *Leiobunum curvipalpe*-group (above, lateral view; below, ventral view). A, *L. hikocola*; B, *L. montanum*; C, *L. hiasai*; D, *L. sadoense*; E, *L. simplum*; F, *L. kohyai*; G-I, *L. hiraiwai*; J, *L. curvipalpe*; K, *L. tohokuense*; L, *L. platypenis*; M, *L. globosum*.

2.1. Taxonomic characters

The diagnostic characters of the *curvipalpe*-group have been discussed by Suzuki (1953, 1957, 1976a, 1976b) and Suzuki and Tsurusaki (1983). As the species belonging to this group show fairly stereotyped external morphology, discrimination of individual taxa at the specific and racial levels relies primarily upon features of male genitalia (= penis) and karyotype. Shape of labrum, palp, and genital operculum are also useful to a lesser extent. However, females except for *L. platypenis* and *L. globosum* are difficult to identify unless they are accompanied by males.

(1) Penis

Fig. 4 illustrates structures of penes in 11 species of this group to show their difference in size, shape, and armature. Because of this remarkable diversification, the structure of penis is quite useful for the discrimination of the taxa, but by the same reason, it is difficult to infer the evolutionary relationship of species using this character alone.

(2) Labrum

The shape of male labrum is also variable in the 11 species of the *curvipalpe*-group (Fig. 5). Of these, 5 species (*L. platypenis*, *L. globosum*, *L. kohyai*, *L. simplum*, *L. hikocola*) have each a distinct shape of labrum easily distinguishable from all other species. The remaining 6 species have a rather stereotyped club-shaped labrum clothed with several denticles on both lateral sides. The shape and degree of armature of male labrum in these species are still useful diagnostic characters at the racial level.

The labrum is quite uniform in females of most species of the group, but in some species this structure is one of the few reliable diagnostic characters of females. Especially, females of *L. platypenis* which have a unique bifurcate or trifurcate labrum are safely identified by almost this character alone (cf. Suzuki and Tsurusaki, 1983).

(3) Male palp

The following character states of male palpi serve for discrimination of taxa: size and degree of incrassation of each segment; distribution pattern of denticles on tibia (whether confined to distal part or not); number of rows (1 or 2) of ventromesal tubercles on tarsus; and coloration of palp (dark or bright) (Fig. 6).

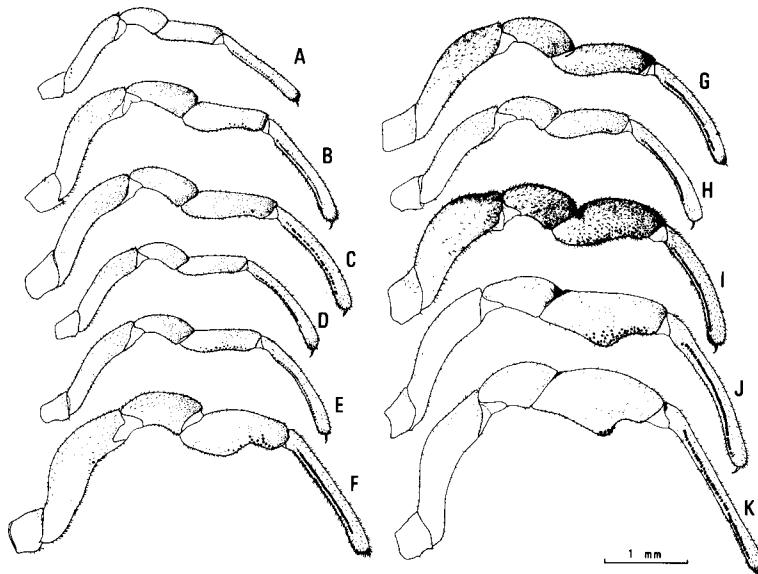


Fig. 6. Male palpi of various species of the *Leibunum curvipalpe*-group (mesal view). A, *L. hikocola*; B, *L. montanum*; C, *L. hiasai*; D, *L. sadoense*; E, *L. simplum*; F, *L. kohyai*; G, *L. hiraiwai*; H, *L. tohokuense*; I, *L. curvipalpe*; J, *L. platypenis*; K, *L. globosum*.

However, of these, size, degree of incrustation, and coloration are somewhat variable from population to population. Occasionally coloration of palp is represented as intrapopulation polymorphism in *L. curvipalpe* and *L. hiraiwai*.

(4) Genital operculum

The shape of genital operculum was first adopted by Suzuki and Tsurusaki (1983) in the discrimination of *L. tohokuense* from *L. globosum* and *L. platypenis*. This character was especially indispensable for the accurate identification of their females. Namely posterior margin of the genital operculum is somewhat obscure and sharply rounded backward in *L. tohokuense*, whereas it is distinct and only slightly rounded in *L. globosum* and *L. platypenis*. However this character seems to be less useful in the discrimination of other species, because most species show various intermediate conditions between both extreme states represented in *L. tohokuense* and *L. globosum*-*L. platypenis*, respectively.

(5) Karyotypes

Chromosomal characters have been used by Suzuki (1957, 1976a, 1976b, 1980b) as one of the most important specific characters in taxonomy of this group. He has suggested that chromosomally different geographic forms should be treated as different species. However, nowadays, species separation on the basis of difference in number of chromosomes alone is not supported (White, 1973; 1978; Key, 1981). I will treat such chromosomally different forms as races within a single species, although number of populations karyotypically analysed are very few as yet.

Some remarkable features of karyotypes of this group may be summarized as follows: (1) Known diploid number ranges from 18 to 26 in obligate bisexual forms. (2) Structure of each chromosome is generally meta- or submetacentric. (3) Sex chromosome composition is XY in males, XX in females; both sex chromosomes are usually readily distinguishable from the autosomes by differences in size and structure. (4) In the thelytokous species complex, namely *L. platypenis*-subgroup, diploid and tetraploid forms are distinguished; tetraploid populations also contain numerous aneuploid forms (Tsurusaki, unpubl.).

2.2. Subgrouping of the *Curvipalpe*-group

Eleven species of the *curvipalpe*-group so far have been described and can be arranged into the following seven subgroups. Important criteria for these subgroupings are presented in Fig. 7 and Table 2.

- (1) *hikocola*-subgroup (1 species: *L. hikocola*)
Distribution: Kyushu (Mt. Hikosan), Is. Yakushima, Is. Amami-
ôshima.
- (2) *montanum*-subgroup (1 species: *L. montanum* with 6 races)
Distribution: Kyushu, Shikoku, Honshu (Chûgoku and Chûbu dis-
tricts).

Table 2. Diagnostic characters among seven

| Characters | <i>Hikocola</i> | <i>Montanum</i> | <i>Hiasai</i> |
|--|---|--------------------------------|-------------------------------------|
| <i>Male</i> | | | |
| 1. Labrum | | | |
| • Shape | Small and slender | Clavate, swollen | Clavate or square-shaped in profile |
| • Denticles on both sides | Present | Present | Present or absent |
| 2. Chelicera | | | |
| Distomesal denticles on distal segment | Absent (rarely present) | Present | Present or absent |
| 3. Palp | | | |
| • No. of ventral row(s) of tubercles on tarsus | 1 | 2 | 1 or 2 |
| • Tarsus | Very slightly curved | Moderately curved | Moderately curved |
| • Degree of incrasation of tibia | Low | Medium | Relatively low |
| • Coloration | Light brown | Light brown | Light brown |
| 4. Distal margin of genital operculum | Relatively distinct | Relatively distinct | Relatively distinct |
| 5. Penis | | | |
| • Membraneous alates | Absent | Present | Present |
| • A pair of lateral pouches | Present | Absent (present in some races) | Absent |
| <i>Female</i> | | | |
| 1. Labrum | Normal (=gradually narrowed toward tip) | Normal | Normal |
| 2. Dorso-lateral sides of abdomen | Spotted | Spotted | Spotted |

- (3) *hiasai*-subgroup (3 species: *L. hiasai*, *L. sadoense*, and *L. simplum*)
Distribution: Honshu (Chûbu district), Is. Sado.
- (4) *kohyai*-subgroup (1 species: *L. kohyai* with 2 races)
Distribution: Honshu (Kii Peninsula).
- (5) *hiraiwai*-subgroup (1 species: *L. hiraiwai* with 8 races)
Distribution: Kyushu, Honshu (excluding north-eastern part).
- (6) *curvipalpe*-subgroup (2 species: *L. tohokuense* with 3 races and *L. curvipalpe* with 3 races).

subgroups of *Leiobunum curvipalpe*-group.

| <i>Kohyai</i> | <i>Hiraiwai</i> | <i>Curvipalpe</i> | <i>Platypenis</i> |
|------------------------|-----------------------------------|---------------------------------|---------------------------------------|
| Clavate, slender | Clavate, swollen | Clavate, swollen | L- or T-shaped |
| Absent | Present | Present | Present |
| Present | Present | Present | Present or absent |
| 2 | 1 | 1 or 2 (2nd row less developed) | 1 or 2 (2nd row less developed) |
| Moderately curved | Moderately curved | Moderately curved | Considerably twisted or straight |
| High | Medium | Medium or high | Extraordinarily high |
| Light brown Obscure | Light or dark brown Obscure | Light or dark brown Obscure | Light brown Distinct |
| Absent | Absent but with lateral swellings | Absent | Absent |
| Present | Present | Present | Absent |
| Normal | Normal | Normal | Normal or distally widened in profile |
| Spotted | Spotted | Spotted | Not spotted |

Distribution: Honshu (Chûbu, Kantô, and Tôhoku districts).

- (7) *platypenis*-subgroup (2 species: *L. platypenis* with 2 chromosomal races and *L. globosum*).

Distribution: Honshu (Chûbu to Tôhoku districts), Hokkaido, Is. Ullung-do (Korea).

Of these, *curvipalpe*-subgroup comprising *L. tohokuense* and *L. curvipalpe* indubitably corresponds to one superspecies within which many geographic races have been differentiated. Likewise, *montanum*-subgroup and *hiraiwai*-subgroup

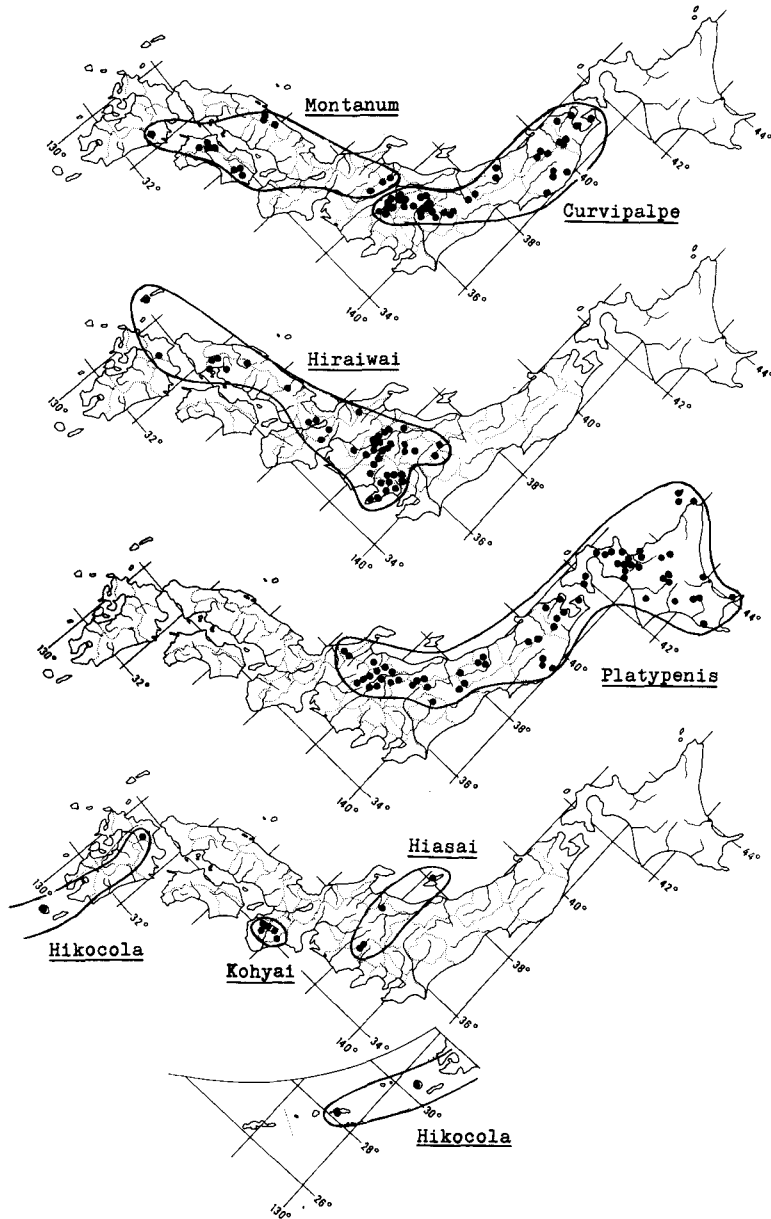


Fig. 7. Distribution of seven subgroups belonging to the *Leiobunum curvipalpe*-group.

can be regarded as two superspecies by including many geographic races in each. On the other hand, *hiasai*-subgroup may not be regarded as a superspecies. Although I have tentatively placed three species within this subgroup taking their relative resemblance of the penis into consideration, serious paucity of records in these three species makes detection of their closest sister species difficult. Further, *platypenis*-subgroup can not be considered as superspecies in normal sense, because *L. platypenis* and *L. globosum* are widely sympatric with each other in northern Honshu and Hokkaido. However, as they show close similarities in many morphological characters and biological characteristics, they should be treated as closely related "sister species" or a "species-complex".

Little information on phylogenetical interrelation among these subgroups could be obtained in spite of extensive comparison of various characters. It is difficult to analyze the phylogeny of this group by the morphological characters because useful diagnostic characters are scarce and discordant distribution of supposed apomorphic condition of various morphological characters among the species is prevailing. Probably analyses by karyological data or allozyme data using electrophoresis are more hopeful for the purpose of phylogenetic reconstruction.

2.3. Key to the Species of the *Curvipalpe*-group

- | | | |
|-------|---|-------------------|
| 1. | Males | 2 |
| | Females | 12 |
| 2(1). | Labrum L- or T-shaped in profile (Fig. 5L, M)..... | 3 |
| | Labrum club- of rod-shaped | 4 |
| 3(2). | Labrum L-shaped (Fig. 5L); palpal tarsus remarkably curved mesally (Fig. 6J); Hokkaido, Honshu (Aomori pref. south to Ishikawa and Nagano pref.), Is. Ullung-do (Korea) | <i>platypenis</i> |
| | Labrum T-shaped (Fig. 5M); palpal tarsus not curved mesally (Fig. 6K); Hokkaido, Tôhoku district..... | <i>globosum</i> |
| 4(2). | Labrum smooth | 5 |
| | Labrum laterally with teeth | 6 |
| 5(4). | Labrum small, square-shaped in lateral view (Fig. 5E); The Northern Japanese Alps | <i>simplum</i> |
| | Labrum large and clavate (Fig. 5F); penis shaft markedly elongated; southern Honshu (Kii Peninsula) | <i>kohyai</i> |
| 6(4). | Labrum small and pointed (Fig. 5A); Kyushu, Is. Yakushima, Is. Amami-ôshima | <i>hikocola</i> |
| | Labrum stout, markedly swollen | 7 |
| 7(6). | Penis shaft very narrow, spear-shaped except for basal swelling (Fig. 4E); southwestern Honshu, Shikoku, Kyushu | <i>montanum</i> |
| | Penis shaft not spear-shaped, moderately or considerably widened .. | 8 |
| 8(7). | Posterior margin of genital operculum indistinct; palpal tarsus | |

- ventromesally with a row of denticles 9
- Posterior margin of genital operculum distinct (Fig. 10A, G, L); palpal tarsus ventrally with two rows of denticles 11
- 9(8). Distal swelling of the penis corpus well differentiated (Fig. 4H-J); Honshu (Kantô to Chûgoku districts), Kyushu, Is. Tsushima *hiraiwai*
- Distal swelling of the penis corpus simple (Fig. 4K, L) 10
- 10(9). Palpal tibia ventrally with numerous denticles; palp usually dark brown and considerably thickened (Fig. 6I); central Honshu (eastern part of Nagano pref., Gumma and Tochigi pref.) *curvipalpe*
- Palpal tibia with several distomesal teeth; palp always bright brown, somewhat thickened (Fig. 6H); northern Honshu (Tôhoku district) *tohokuense*
- 11(8). Penis shaft slightly swollen at the middle, glans not elongated (Fig. 4D); Honshu (Southern Japanese Alps) *hiasai*
- Penis shaft consistently tapering to the apex, glans elongated (Fig. 4C); Is. Sado *sadoense*
- 12(1). Labrum bifurcate or trifurcate in profile (Fig. 17K-Q); central to northern Honshu (south to Ishikawa and Nagano pref.) *platypenis*
- Labrum simple, gradually narrowed toward tip 13
- 13(12). Abdomen laterally with no blotches or spots (Fig. 21S); Hokkaido, northern Honshu *globosum*
- Abdomen laterally with irregular spots and blotches; Honshu, Kyushu, Shikoku all the other members of *curvipalpe*-group

3. Descriptions and Records of Species and Races

Descriptions of species and races belonging to the following four subgroups are given in this section: *hikocola*, *hiasai*, *kohyai*, and *platypenis*. Remaining three subgroups, *montanum*, *hiraiwai*, and *curvipalpe*, all of which have a wide range of distribution and showing remarkable geographic variation in both external morphology and karyotypes, will be dealt with elsewhere. Before describing each species and race, the criteria for recognition of species and races are mentioned. I do not adopt "subspecies" for forms which are separable from other conspecific members by certain morphological characters and possess a distinct distribution range. Instead, I use the term "race" for such an infraspecific category. The reasons why I reject trinomials are as follows: (1) subspecific names often obscure the important pattern of geographic variation in characters and become an obstacle in the accurate understanding of speciation; and (2) we can avoid unnecessary burden which is inevitably associated with the formal description and preservation of type specimens (concerning the general argument against the use of the formal subspecies category, see Wilson and Brown, 1953; Futuyama, 1978, pp. 204-205; Key, 1981). On the other hand, species

recognition of allopatric forms in the *curvipalpe*-group is often difficult due to the remarkable variation in both external morphology and karyotypes. Suzuki (1957, 1976a, 1976b) stressed the usefulness of chromosomes as the important specific taxonomic character in this group. However, I do not treat two chromosomally distinct but morphologically indistinct allopatric forms as two separate species for the following reasons: (1) Although presence of particular chromosome rearrangements often suggests lineage independence by rendering hybrids between the chromosomally different forms sterile, or reduced fecundity, complete reproductive isolation is not always accomplished even by those ostensible obstacles. (2) Available chromosomal data for each form are mostly based on few materials from only one or two populations and variation within each taxon has not been fully analyzed.

Remarks:

- 1) Asterisked: Species comprised by several geographical chromosomal variants.
- 2) When races are recognized, they are treated under "*Geographic variation and races*".

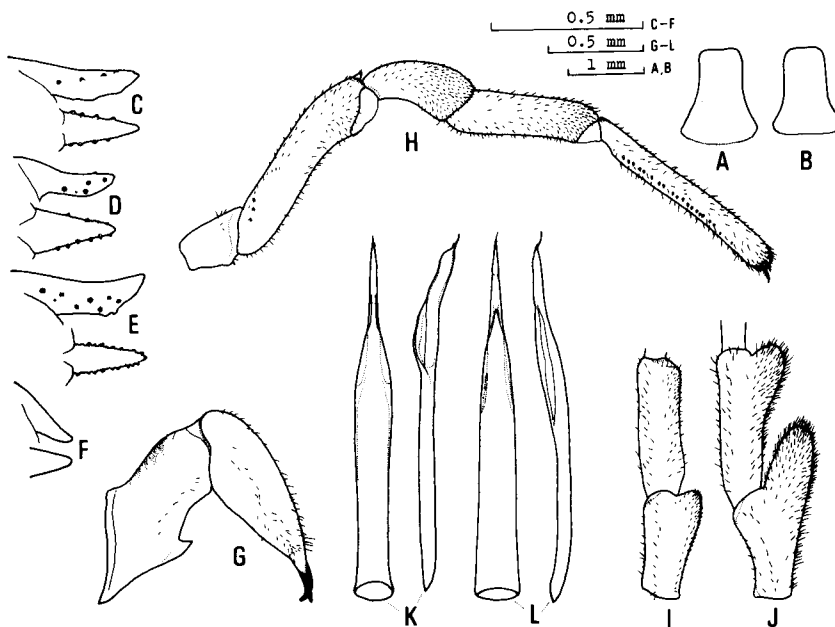


Fig. 8. *Leiobunum hikocola*. A-B, Genital operculum: A, male; B, female. C-F, Lateral (above) and ventral (below) views of labrum: C-E, male; F, female. G, Mesal view of chelicera, male. H, Mesal view of male palp. I-J, Dorsal view of palpal patella and tibia: I, male; J, female. K-L, ventral (left) and lateral (right) views of penis. (A-B, D, F, G-K: Shiratani-Unsuikyô, Is. Yakushima. C, L: Mt. Hikosan. E: Sumiyô-son, Is. Amami-ôshima)

Descriptions of races may be accompanied by brief synonymic lists to show the correspondence to previous classifications by other authors.

3) Collecting data are given by the following order: Locality, altitude of locality if available, number of individuals, date collected, collector, museum collection if different from NT personal collection.

4) Abbreviations: NT=N. Tsurusaki; ZLHU=Zoological Laboratory, Faculty of Science, Hiroshima University, Hiroshima; ZIHU=Zoological Institute (=Zoological Museum), Faculty of Science, Hokkaido University, Sapporo; SC=Personal Collection of Dr. S. Suzuki, Hiroshima; juv. =juveniles; Chrom. Obs. =specimens dissected for chromosome preparation.

1. *hikocola*-subgroup (1 species, monotypic)

Leiobunum hikocola Suzuki

(Figs. 8-9, 13a)

Leiobunum hikocola Suzuki, 1966, p. 160. figs. 1, 2A-E, G, 3A-E. (type: Mt. Hikosan, Fukuoka pref., Kyushu, in ZLHU, not examined); 1973, p. 258; 1976b, p. 227, figs. 25-27, 107.

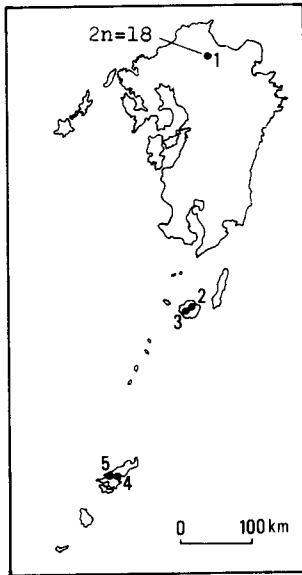


Fig. 9. Distribution and chromosome number of *Leiobunum hikocola*. Localities: 1, Mt. Hikosan; 2-3, Is. Yakushima (2, Shiratani - U n s u i k y ô ; 3, Hanayama); 4-5, Is. Amami-ôshima (4, Sumiyô-son; 5, Mt. Yuwan).

Diagnosis: Different from all other species of *curvipalpe*-group by having much smaller bodies. Males with unique distally tapered labrum with some tubercles laterally.

Description: Male: Body very small. Genital operculum as in Fig. 8A, posterior margin moderately distinct and slightly rounded backward. Labrum as in Fig. 8C-E, small, not swollen distally, with several tubercles laterally. Chelicera usually without distomesal denticles on distal segment, but rarely with a few denticles (cf. Suzuki, 1966). Palp (Fig. 8H) slender; femur slightly curved below; patella widened distally, with a small lobe at distomesal margin; tibia unarmed; tarsus with a definite row approximately twenty evenly spaced tubercles. Penis (Fig. 8K-L) short; shaft flattened dorsoventrally with both lateral sides nearly parallel through basal two-thirds; cortex of ventral side slightly extended laterally at near distal portion of shaft to form a pair of shallow pouches; glans with a small round thickening at distal end ventrally; stylus hook-shaped, bent to ventral side.

Female: Genital operculum as in Fig. 8B,

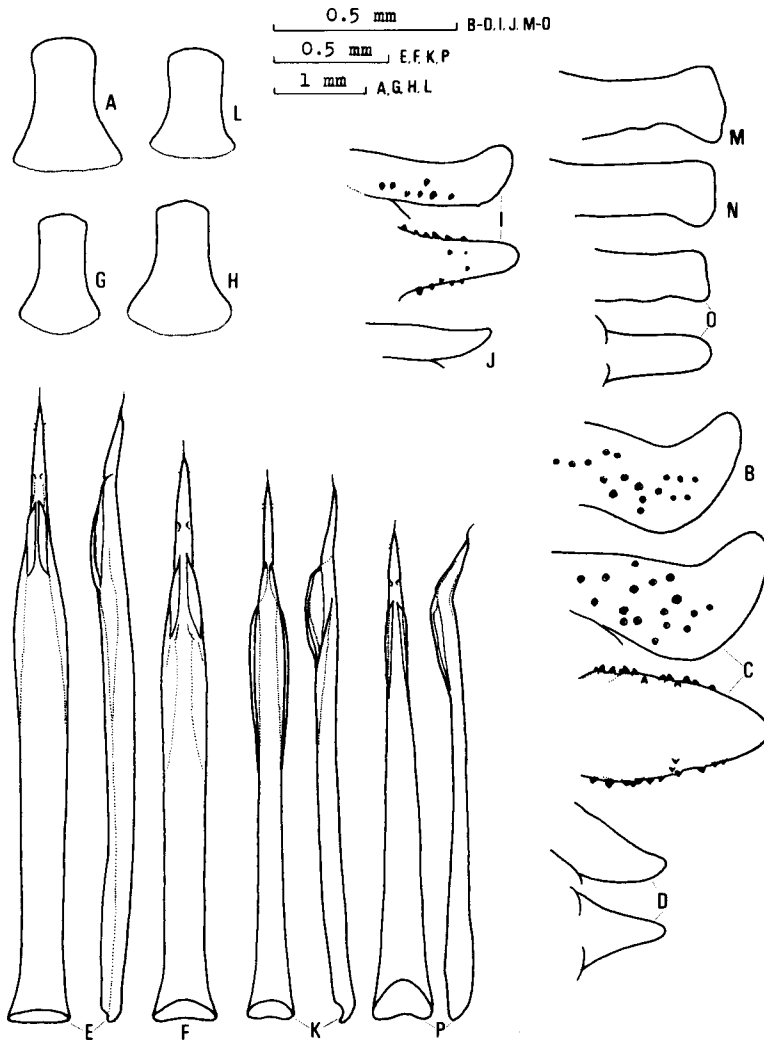


Fig. 10. A-F, *Leiobunum hiasai*. A, Genital operculum, male. B-D, Lateral and ventral (C-D, below) views of labrum: B-C, male; D, female. E-F, Ventral and lateral (E, right) views of penis. (A, C-E: Kitazawa Pass; B, F: Miike, Mt. Kitadake). G-K, *Leiobunum sadoense*. G-H, Genital operculum: G, male; H, female. I-J, Lateral and ventral (I, below) views of labrum: I, male; J, female. K, ventral and lateral (right) views of penis. (Mt. Myōken, Is. Sado). L-P, *Leiobunum simplum*. L, Genital operculum, male. M-O, Lateral and ventral (O, below) views of male labrum. P, Ventral and lateral (right) views of penis. (Mt. Shirouma).

boundary between operculum and third sternite distinct. Labrum as shown in Fig. 8F.

For further detailed descriptions of males and females, see Suzuki (1966).

Karyotype: $2n(\delta)=18$ (Mt. Hikosan population) (Fig. 13a). Materials used for chromosome preparation were two juveniles (1 δ and 1 η : see *Specimens examined*), but unfortunately I failed to obtain any chromosome spreads for the female. The autosomes are composed of 8 pairs of meta- or submetacentrics. The X chromosome is unequal-armed metacentric being the second largest in size, whereas the Y is the submetacentric similar to chromosome 6 in size.

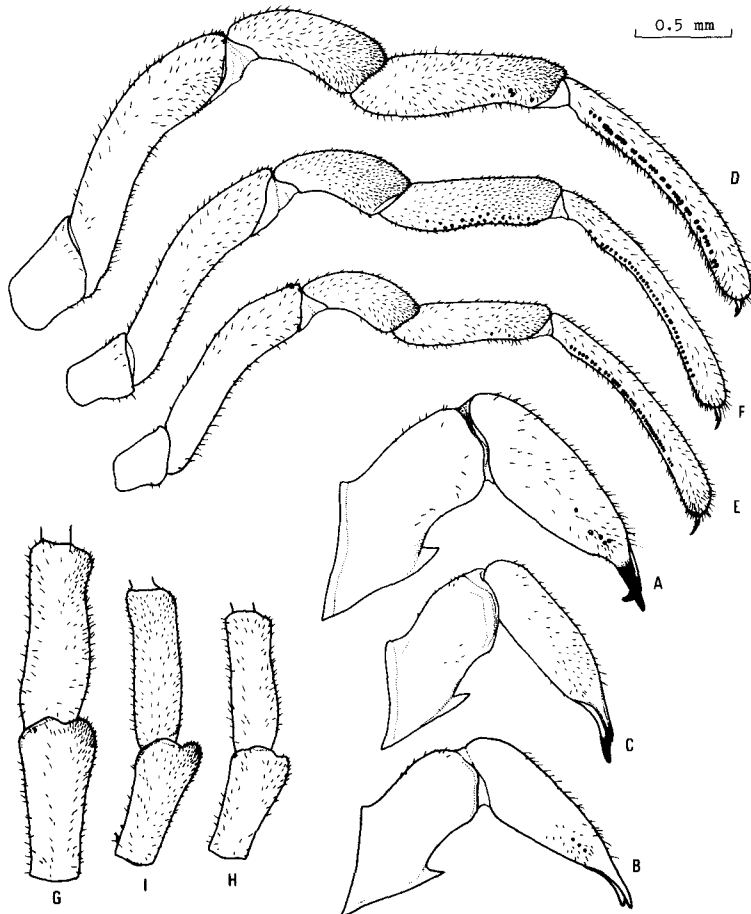


Fig. 11. *Leioibunum hiasai* (A, D, G), *L. sadoense* (B, E, H), and *L. simplum* (C, F, I). A-C, Mesal view of male chelicera. D-F, Mesal view of male palp. G-I, Dorsal view of male palpal patella and tibia. (K, D, G: Kitazawa Pass. B, E, H: Mt. Myōken, Is. Sado. C, F, I: Mt. Shirouma)

Distribution: Kyushu (known only from Mt. Hikosan in Fukuoka pref.), Is. Yaku, and Is. Amami-ôshima. (Fig. 9).

Biology: This species is sympatric with *L. hiraiwai* (Kyushu-Hiroshima race: Tsurusaki, in prep.) at Mt. Hikosan. Although both species show a similar life cycle, being univoltine with hibernation as eggs, collection data suggest that the emergence of adults is about two weeks later in *L. hikocola* than in *L. hiraiwai* at Mt. Hikosan.

Specimens examined: FUKUOKA PREF.- Mt. Hikosan: 1 ♂, 21-IX-1958, T. Inouye and M. Makihara (SC); 680 m, in *Cryptomeria* forest, 1 juv., 29-VII-1982, NT; 640~800 m in *Cryptomeria* forest, 2 juv. (both Chrom. Obs.), 31-VII-1982, NT. ——— KAGOSHIMA PREF.- Is. Yakushima: Hanayama Natural Forest, 1300 m, 1 juv. (collected by sweeping herbs), 19-VII-1983, Sk. Yamane; Shiratani-Unsuikyô to Mt. Miyanoura-dake, 2 ♂ 1 ♀, 2~5-VIII-1983, H. Okada. Is. Amami-ôshima: Sumiyôson, ca. 250 m, on tree trunks, 1 ♂, 22-VII-1965, S. Suzuki (SC); Mt. Yuwan, 1 juv., 25~29-VI-1981, H. Okada.

2. *hiasai*-subgroup (3 species)

This subgroup includes three species: *L. hiasai* Suzuki, *L. sadoense* Tsurusaki, and *L. simplum* Suzuki. The males of these species have similar penes, with shaft relatively short and slender, and laterally with alates (Fig. 4B-D). They are indubitably allopatric, but as stated earlier, this subgroup may not be a monophyletic superspecies (cf. section 2.2).

Leiobunum hiasai Suzuki

(Figs. 10A-F; 11A, D, G; 12; 13c-d)

Leiobunum hiasai Suzuki, 1976b, p. 226, figs. 46-47, 109, 221-224. (type-locality: Kitazawa Pass, ca. 2000 m in alt., Yamanashi pref., Honshu, in ZLHU, not examined)

Diagnosis: This species is similar to *L. sadoense* and *L. simplum* in the shape of penis, but unlike these two species, the male of this species has a well-developed labrum like Mt. Tsubakuro and Mt. Ontake races of *L. montanum* (cf. Tsurusaki, in prep.). The palpal tarsus of the male also indicates the close relationship of this species to *L.*

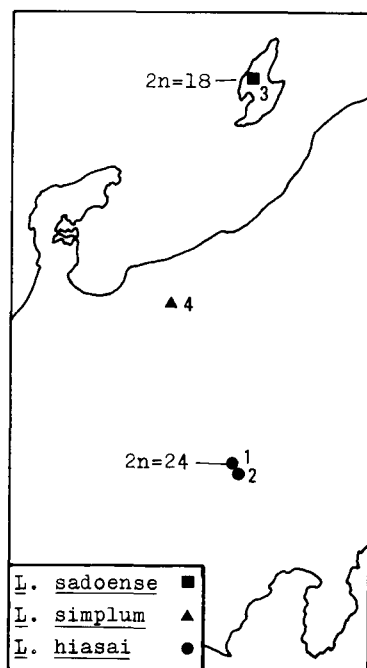


Fig. 12. Distribution and chromosome numbers of three species of *Leiobunum hiasai*-subgroup, *L. hiasai*, *L. sadoense*, and *L. simplum*. Localities: 1, Kitazawa Pass, 2, Mt. Kitadake, 3, Mt. Myôken; 4, Mt. Shirouma.

montanum.

Description: Male: Body relatively small. Genital operculum as shown in Fig. 10A, boundary between operculum and 3rd sternite distinct and only slightly curved. Labrum (Fig. 10B-C) considerably swollen and laterally with numerous dark colored denticles. Cheliceral distal segment distomesally with some denticles (Fig. 11A). Palp (Fig. 11D), femur fairly curved below; patella distally swollen with a small distomesal apophysis; distal one-third of tibia ventromesally with a few denticles; tarsus below with two distinct rows of tubercles.

Penis (Fig. 10E-F), shaft with sides semiparallel, somewhat flattened dorsoventrally; alate part consisting of two pairs of alates; lateral pair extending distal half of shaft, and another small pair located near the end of the shaft.

Female: Labrum as in Fig. 10D, small and pointed toward the tip.

Karyotype: $2n(\delta) = 24$ (Kitazawa Pass). All chromosome preparations were made by temporary squashes of the testes using acetic orcein. Although spermatogonial metaphases were not obtained, numerous first meiotic metaphases showed 12 bivalents without exception (Fig. 13c-d).

Distribution: Southern Japanese Alps (= Akaishi Mountains), central Honshu (Fig. 12).

Biology: This species seems to be confined to subalpine coniferous forests (Maries's Fir, *Abies Mariesii* Masters; Veitch's Silver Fir, *Abies Veitchii* Lindley). Adults emerge from early to mid August and usually are found on the trunks of coniferous trees.

Specimens examined: YAMANASHI PREF.- Nakakoma-gun: Kitazawa Pass, 2000 ~2030 m, in coniferous forest composed of Maries's Fir and Veitch's Silver Fir, 61 ♂ 17 ♀ 9juv. (6 ♂ Chrom. Obs.), 15/16-VIII-1981, NT; Mt. Kitadake, Miike, 2000 ~2240 m, in Maries's Fir and Veitch's Silver Fir forest, 2 ♂ 22juv., 5-VIII-1980, NT.

Leiobunum sadoense Tsurusaki

(Figs. 10G-K; 11B, E, H; 12; 13e-f)

Leiobunum sadoense Tsurusaki, 1982, p. 105, Figs. 1-27. (Male holotype and two male, seven female, and two juvenile paratypes from Mt. Myōken, Sado Is., in ZIHU, examined)

Diagnosis: Males are separable from the other members of the *curvipalpe*-group by having spear-shaped penis with well-developed alates.

Description: The following description is supplementary to Tsurusaki (1982).

Penis (Fig. 10K) with alate part consisting of two pairs of thin membranes, both extending to approximately distal half of the shaft; inner (ventral) membranes narrower than those of outer (dorsal) alates in width, their anterior ends attaching to the base of glans.

Karyotype: $2n(\delta) = 18$ (Mt. Myōken population). All chromosome slides

were prepared by temporary squashes of testes using acetic orcein. No spermatogonial metaphase plates were obtained. However, in the metaphase plates of first division 9 bivalents were observed (Fig. 13e-f).

Distribution: Known only from Is. Sado (Niigata pref.).

Specimens examined: NIIGATA PREF.- Is. Sado, Mt. Myōken, 850~940 m, in beech forest, 9 ♂ 7 ♀ 2juv. (6 ♂ Chrom. Obs.), 21-VII-1980, NT (3 ♂, 7 ♀, 2juv. ZIHU - 6 ♂ NT).

Leiobunum simplum Suzuki

(Figs. 10L-P; 11C, F, I; 12)

Leiobunum simplum Suzuki, 1976b, p. 223, figs. 42, 108?, 217-220, 330-331, 333? (in part, figs. 43-45, 332 belong to *L. platypenis* Suzuki). (Male holotype and 34 ♂ 21 ♀ paratypes from Mt. Shirouma, Nagano pref., H. Sako and N. Nakamura coll., in ZLHU; most of these paratypes were reexamined and all were found to be misidentified females of *L. platypenis*)

Diagnosis: The male is easily separable from those of the other species of the *curvipalpe*-group by having a square-shaped labrum with smooth surface. The female is distinguished from that of *L. platypenis*, with which this species is sympatric throughout its range in Mt. Shirouma, by the difference in the maculation pattern of body. Now tell how they differ.

Description: *Male*: Body relatively small. Genital operculum (Fig. 10L) with posterior margin relatively distinct. Labrum (Fig. 10M-O) approximately rectangular in profile, with somewhat widened end, lacking lateral tubercles. Cheliceral distal segment with no denticles on mesal surface (Fig. 11C). Palp (Fig. 11F) slender; femur slightly curved below; patella with a small apophysis on distomesal margin; tibia with numerous evenly spaced teeth ventrally; tarsus with a definite row of dark colored teeth.

Penis (Fig. 10P) relatively short, gradually tapered toward tip; alate part composed of two pairs of thin membranes, extending the distal quarter of the shaft.

Female: see "Remarks" below.

Karyotype: Unknown.

Distribution: Mt. Shirouma, Nagano pref., central Honshu (Fig. 12). Suzuki (1976b) reported one male and one female of this species from Yokoo Hütte (Kamikōchi) in Nagano pref. However reexamination of these two specimens revealed that they are not *L. simplum* but are actually *L. hiraiwai* (Kamikōchi race).

Biology: Collection data of the type specimens suggest that this species is widely sympatric with *L. platypenis* on slopes between ca. 1,250 and 1,750 m alt. of Mt. Shirouma. Although I have visited this place twice, I failed to collect any specimens of *L. simplum*. Therefore, this species may have somewhat different

habitat preference from other congeners.

Remarks: In the present study, most of the type specimens used in the original description by Suzuki were reexamined together with unidentified materials which were collected with the type specimens by Messrs. H. Sako and N. Nakamura. As a result, it became evident that the majority of female paratypes are misidentified *L. platypenis* and that figs. 43-45 and 332 in Suzuki's original description were drawn and photographed from female specimens of *L. platypenis*. The females of both species seem to be distinguishable from each other by pattern of abdominal maculation (compare figs. 332 and 333 in Suzuki, 1976b). Unfortunately, I could not examine labrum of female *L. simplum*, since no females of this species were contained in the material examined in the present study.

Specimens examined: NAGANO PREF.- Mt. Shirouma, 950~1,750 m, 34 ♂, 13~21-VIII-1968, H. Sako and N. Nakamura (ZLHU).

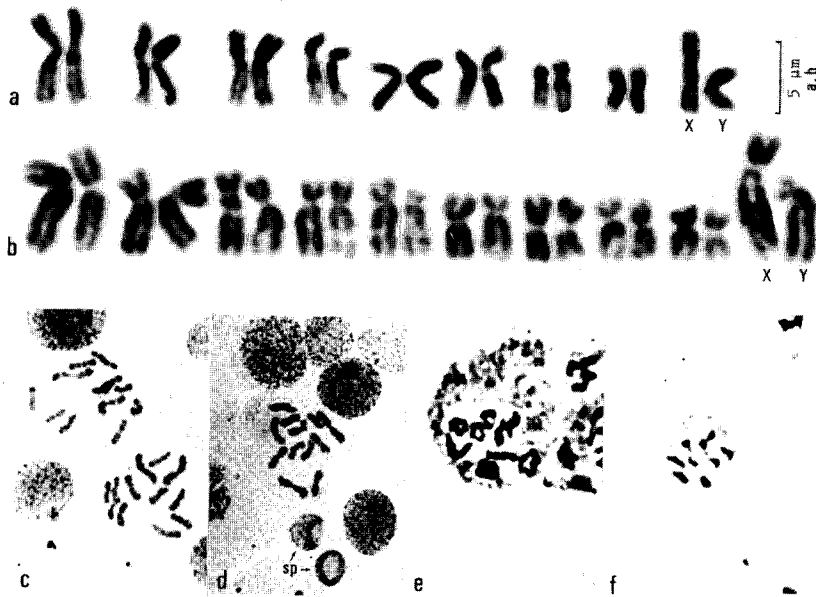


Fig. 13. Chromosomes of *Leioibunum hikocola* (a), *L. kohyai* (b), *L. hiasai* (c-d), and *L. sadoense* (e-f). a, Representative karyotype with $2n=18$ (XY) from spermatogonial metaphase in *L. hikocola*. b, Representative karyotype with $2n=20$ (XY) from the same stage in *L. kohyai*. c-d, First spermatocytes with 12 bivalents in *L. hiasai*. Two mature spermatids (sp) can be seen in the bottom of d. e-f, *L. sadoense*: e, metaphase I with 9 bivalents; f, anaphase of second spermatocyte.

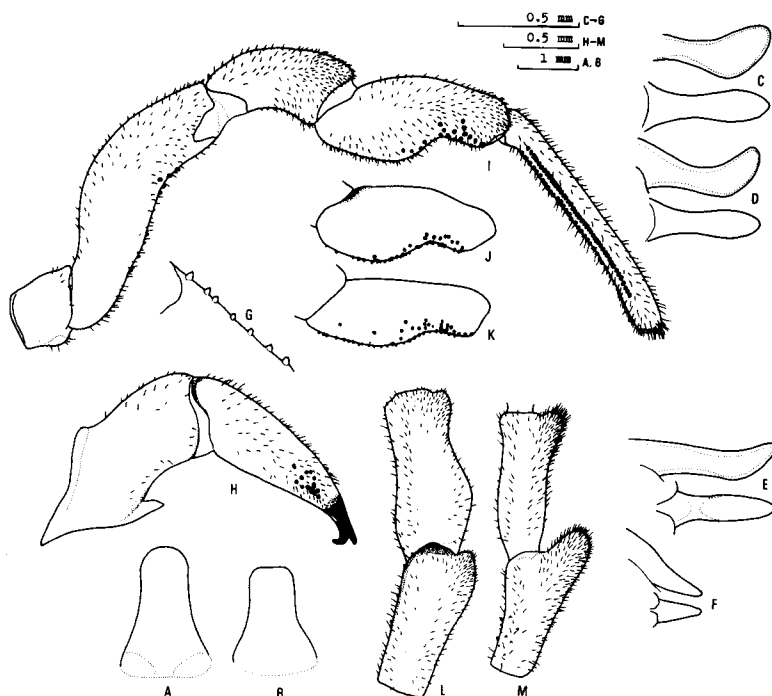


Fig. 14. *Leiobunum kohyai*. A-B, Genital operculum; A, male; B, female. C-F, Lateral (above) and ventral (below) views of labrum: C-E, male; F, female. G, Marginal row of tubercles on frontal side of right coxa I in male. H, Mesal view of male chelicera. I, Mesal view of male palp. J-K, Mesal view of male palpal tibia. L-M, Dorsal view of palpal patella and tibia: L, male; M, female. (A-B, E-F, H-I, L-M: Mt. Kôya. C, K: Mt. Ôdaigahara. D, G, J: Mt. Yoshino)

3. *kohyai*-subgroup (1 species, 2 races)

**Leiobunum kohyai* Suzuki

(Figs. 13b, 14-16)

Leiobunum kohyai Suzuki, 1953, p. 196, figs. 11-12 (type: Mt. Kôya, Wakayama pref., Honshu, in ZLHU, not examined).

Leiobunum kohyai: Suzuki, 1976a, p. 134, figs. 1-2; 1976b, p. 221, figs. 67-69, 121, 209-216, 325-329.

Diagnosis: In male, this species differs from all other species of the *curvipalpe*-group by lacking lateral denticles on the labrum and by having unique penis with long concavo-convex shaft.

Description: Male: Body relatively large. Genital operculum (Fig. 14A) somewhat extended, with anterior margin considerably rounded; boundary between operculum and 3rd sternite indistinct. Labrum (Fig. 14C-F), smooth, widened distally, distal end warped above. Cheliceral distal segment distomesally with a cluster of black teeth (Fig. 14H). Palp stout and thickened (Fig. 14I-K); femur swollen, widest at approximately middle position, distolaterally with several teeth; patella with a small but prominent apophysis on inner distal margin; tibia enormously thickened on proximal two-thirds, with numerous dark colored teeth throughout the ventral surface; tarsus ventrally with two distinct

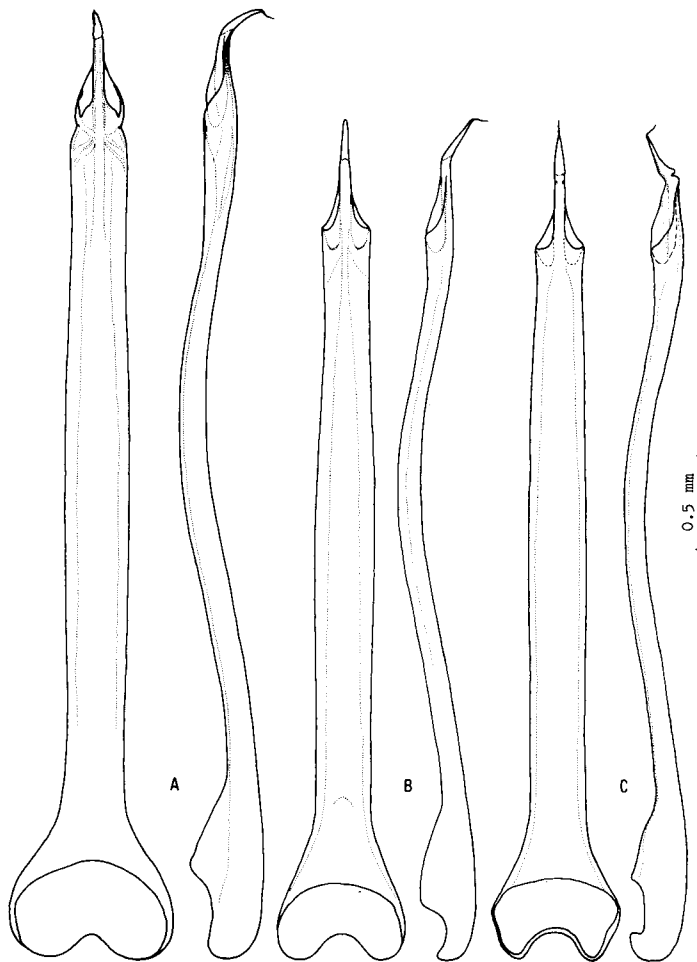


Fig. 15. *Leibunum kohyai*. Ventral (left) and lateral (right) views of penis. A, Mt. Kôya; B, Mt. Yoshino; C, Mt. Ôdaigahara.

rows of teeth.

Penis (Fig. 15) shaft long, spatula-shaped, flattened dorsoventrally and concavo-convex, with a pair of pouches near the distal end.

Female: Labrum (Fig. 14F) slender and projected below.

Karyotype: $2n(\delta) = 20$ (Mt. Kôya population (Fig. 13b). Autosomes are composed of 8 pairs of meta- or submetacentrics. The X is submeteta- or subtolocentric, and the largest. The Y chromosome is subtolocentric that is similar in size to chromosome 1.

Suzuki (1976a) reported that the chromosome number of males of this species is $2n = 20$, on the basis of observation of specimens from Mt. Ôdaigahara by the squash method. Although he stated that the karyotype consisted of 4 acrocentrics and 16 metacentrics, it is probably due to observational error. No acrocentric chromosomes were observed in *curvipalpe*-group preparations in the present study.

Distribution: Mountainous areas of Kii Peninsula, southern Honshu (Fig. 16).

Geographic variation and races: The penes of Mt. Kôya population members differ slightly from those of further east. Namely in Kôya population, distal pouches of the shaft are differentiated from the remaining portion of shaft by a shallow but distinct constriction, whereas in Mt. Yoshino and Mt. Ôdaigahara specimens the distal portion of penis shaft is fairly simple in shape (Fig. 14, compare A with B and C). In view of this, it seems appropriate to recognize provisionally two races, the "Kôya" and "Ôdaigahara" races, for the Mt. Kôya and the eastern two populations respectively. In addition to the above three localities, two sites (Mt. Kôjin-dake, 1 ♂; Mt. Gomadan, 1 ♀) have been listed in Suzuki (1976b). As I could not examine any specimens from these localities, it cannot be determined which races these two populations belong to. However, in Fig. 16, I tentatively refer them to "Kôya race", considering the fact that these two populations are located in the same mountain range as Mt. Kôya.

Specimens examined:

Kôya race.—WAKAYAMA PREF.— Okunoin, Mt. Kôya, 820 m, 6 ♂ 4 ♀ (4 ♂ Chrom. Obs.), 26-VII-1983, NT.

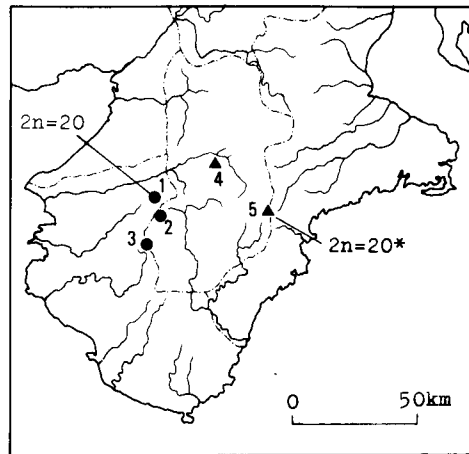


Fig. 16. Distribution and chromosome numbers of two races of *Leiobunum kohyai* (circle: Kôya race, triangle: Ôdaigahara race). Localities: 1, Mt. Kôya; 2, Mt. Kôjin-dake; 3, Mt. Gomadan; 4, Mt. Yoshino; 5, Mt. Ôdaigahara. Asterisked: from Suzuki (1976 a).

Ôdaigahara race.— NARA PREF.- Mt. Yoshino, Okusenbon, 740~780 m, in *Cryptomeria* forest, 2 ♂, 25-VIII-1981, NT. Mt. Ôdaigahara, 1,560~1,695 m, 8 ♂ 18 ♀, 26-VIII-1981, NT.

4. *platypenis*-subgroup (2 species)

This subgroup contains two species: *L. platypenis* Suzuki and *L. globosum* Suzuki, and is characterized by: (1) unique L- or T-shaped male labrum (Fig. 5L-M), (2) considerably thickened palpal tibia of male (Figs. 6J-K; 18), (3) relatively simple candle-shaped penis lacking any prominent alates (Fig. 4F-G), (4) thelytokous mode of reproduction by some females.

**Leiobunum platypenis* Suzuki¹⁾

(Figs. 17, 18A-D, 19A-D, 20)

Leiobunum platypenis Suzuki, 1953, p. 192 (in part), figs. 8-10 except for fig. 9L. (Type: Utsukushigahara, Nagano pref., Honshu, in ZLHU, not examined)

Leiobunum platypenis: Suzuki, 1976b, p. 220, figs. 80-83, 189-190, 319-320; Suzuki and Tsurusaki, 1982, p. 220, figs. 12-19.

Leiobunum esoense Suzuki, 1976b, p. 245 (in part), figs. 92-93, 285-286.

Leiobunum tohokuense: Suzuki, 1976a, p. 230 (in part), figs. 78-79.

Leiobunum globosum: Suzuki, 1976b, p. 219 (in part), fig. 88.

Leiobunum simplum: Suzuki, 1976b, p. 233 (in part), figs. 43-45, 332.

Leiobunum sp.: Suzuki, 1976b, p. 246, figs. 94, 125, 357. (2 ♀ from Ullung-do Is., Korea, I. H. Shon leg. 5-VIII-1955, in SC, examined.)

Diagnosis: Male *L. platypenis* is characterized by unique L-shaped labrum, markedly developed palp with mesally twisted tarsus, and relatively simple candle-shaped penis. Female is easily separable from all other species of the *curvipalpe*-group by its unique bifurcate or trifurcate labrum.

Description: *Male:* Body relatively large. Genital operculum with distinct contour (Fig. 17B-C). Labrum (Fig. 17E-J) L-shaped, laterally with several dark colored denticles. Cheliceral distal segment with no distomesal denticles (Fig. 17R-S). Palp (Fig. 18A-D) with femur distally widened, moderately curved below; patella with small apophysis having several minute setae on distomesal margin; tibia conspicuously swollen, especially at the middle part of ventral side, ventromesal surface of distal half with numerous black-tipped denticles; tarsus curved below and strongly twisted mesad, ventromesally with a distinct row of black tubercles.

1) According to Dr. Suzuki (pers. comm.) this name is a junior synonym of *Leiobunum manubriatum* Karsch, 1881. Therefore, usage of *L. platypenis* should be considered as provisional. For details, see Suzuki (in press).

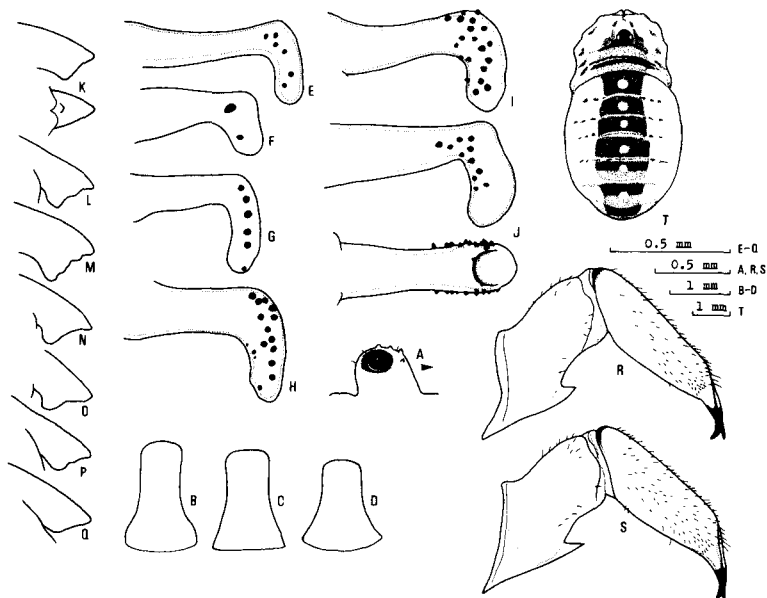


Fig. 17. *Leiobunum platypenis*. A, Lateral view of eye tubercle, male. B-D, Genital operculum: B-C, male; D, female. E-Q, Lateral and ventral (J, K-below) views of labrum: E-J, male; K-Q, female. R-S, Mesal view of male chelicera. T, Dorsal view of female body. (A, C, I-J, R: Lake Misuzu. B, H, S: Chûgû Spa, Mt. Hakusan. D, K: Ullung-do Is. E, Aoyama-chûô. F, Mt. Hakkenzan. G, Oirase. L-O, Nenokuchi. P-Q, Maruyama. T, Kuromatsunai)

Penis (Fig. 19A-D), elongated and candle-shaped; lateral sides nearly parallel; ventrally with membranous bowtie-like accessory at the basal joint of glans; glans very large, symmetrical.

Female: Dorsum as shown in Fig. 17T. Genital operculum (Fig. 17D) with posterior margin distinct, moderately curved backward. Labrum (Fig. 17K-Q), bifurcate or trifurcate in profile.

Distribution: Hokkaido, Honshu (From Aomori pref. south to Ishikawa and Nagano pref.), Is. Ullung-do, Korea (Fig. 20).

Remarks: Two chromosomal races (diploid and tetraploid) were recognized in this species. Details on this subject, together with data on the biology of this species, will be published elsewhere.

Specimens examined: Only newly collected and recently reexamined materials are listed below. Other materials examined are in Suzuki and Tsurusaki (1983).

HOKKAIDO- Tokoro-gun, Tokoro-chô, Tokoro River, 3 juv. (♀), 28-VII-1983, M. Suwa. Asahigawa-shi, Kamuikotan, 2 ♀, 17-VIII-1984, NT. Hamamasu-gun, Hamamasu-mura, Gokibiru, ca. 50 m, 1 ♀, 17-VIII-1984, NT. Tôbetsu-chô, Aoyama-chûô, 18 juv. (♀) (all Chrom. Obs.), 18-VII-1982, NT. Sapporo-shi: Maruyama, 52 juv. (♀) (all Chrom. Obs.), 23-VI-1982,

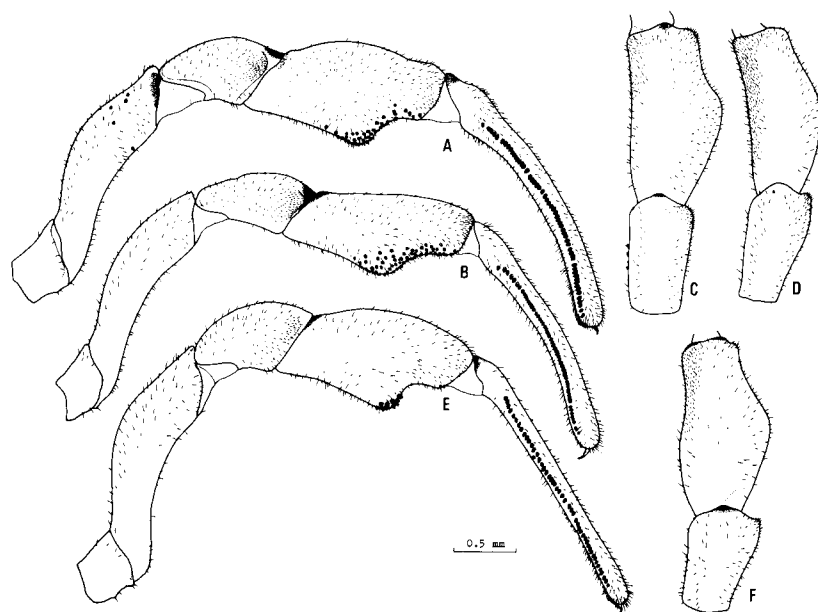


Fig. 18. *Leibunum platypenis* (A-D) and *L. globosum* (E-F). A-B, E: Mesal view of male palp. C-D, F: Dorsal view of palpal patella and tibia, male. (A, C: Chûgû Spa. Mt. Hakusan. B, D: Lake Misuzu. E-F, Nukumidaira, Mt. Iide)

NT; Mt. Hakkenzan, 5 juv. (♀) (all Chrom. Obs.), 25-VI-1982, NT. Tomakomai-shi, Tomakomai Exptl. Forest, Hokkaido Univ., 3 juv. (♀) (all Chrom. Obs.), 15-VII-1983, NT. —AOMORI PREF.- Asamushi, Asamushi Hachiman-gû, 20~80 m, 25 juv. (♀) (all Chrom. Obs.), 2-VII-1982, NT. Lake Towada, Nenokuchi, 6 juv. (♀) (all Chrom. Obs.), 11-VII-1982, NT. —IWATE PREF.- Shimohei-gun, Kawai-mura, Kuzakai, Mt. Kabutomiyôjin, 760~1,000 m, 4 ♀, 29-IX-1984, NT. Miyako-shi, Jôdogahama, 10 m, 1 ♀, 28-IX-1984, S. Ishimaru. —AKITA PREF.- Towada, Hakka, camping grounds (= Oide-en), 405 m, 40 ♀ 36 juv. (16 juv. Chrom. Obs.), 10-VII-1982, NT. —YAMAGATA PREF.- Nishiokitama-gun, Oguni-chô, Mt. Iide: Kawairi, 310 m, 11 ♀, 29-VIII-1980, NT; Nukumidaira, 400~500 m, in beech forest, 2 ♂ 27 ♀, 30-VIII-1980, NT. Yonezawa-shi, Shirabu Spa, 820~880 m, 2 ♀, 31-VIII-1980, NT. —FUKUSHIMA PREF.- Urabandai, Goshikinuma, 790~830 m, 1 ♂ 15 ♀, 1-XI-1980, NT. Mt. Hiuchi-ga-take, Miike, 1,500~1,520 m, 4 ♂ 13 ♀, 2-IX-1980; 9 ♀, 4-IX-1980, NT. Same area, 1,500~1,600 m, 1 ♂ 33 ♀; 1,600~2,000 m, 46 ♀, 3-IX-1980, NT. —TOCHIGI PREF.- Shioya-gun, Fujiwara-chô, Mt. Takahara, Shirataki Fall, 1,180 m, 1 ♀, 24-VII-1981, NT. —NIIGATA PREF.- Minami-Uonuma-gun, Tsuchitaru, 620 m, 35 ♀, 27-VIII-1982, NT. —GUMMA PREF.- Mt. Tanigawa-dake, Tenjin-daira Tenjin-one, 1,560 m, 1 ♀, 28-VIII-1982, NT. —NAGANO PREF.- Shiga-kôgen, Hasu-ike, 1,490 m, 1 ♂ 10 ♀ 1 juv. (♀), 25-VII-1982, NT. Sugadaira-kôgen: Bessôchi, 1,420 m, in Japanese Larch forest, 1 ♂, 23-VIII-1982, NT; Reserch Institute for Physical Education, 1,360 m, 16 ♂ 1 ♀, 23-VIII-1982, NT. Togakushi-kôgen: Togakushi-Bokujô, 1,190 m, 26 ♂ 11 ♀, 23-VII-1977, NT(SC); Koshimizugahara, 1,200~1,210 m, 1 ♂, 23-VII-1977, NT(SC); Mt. Iizuna, 1,200~1,500 m, 4 ♀, 24-VII-

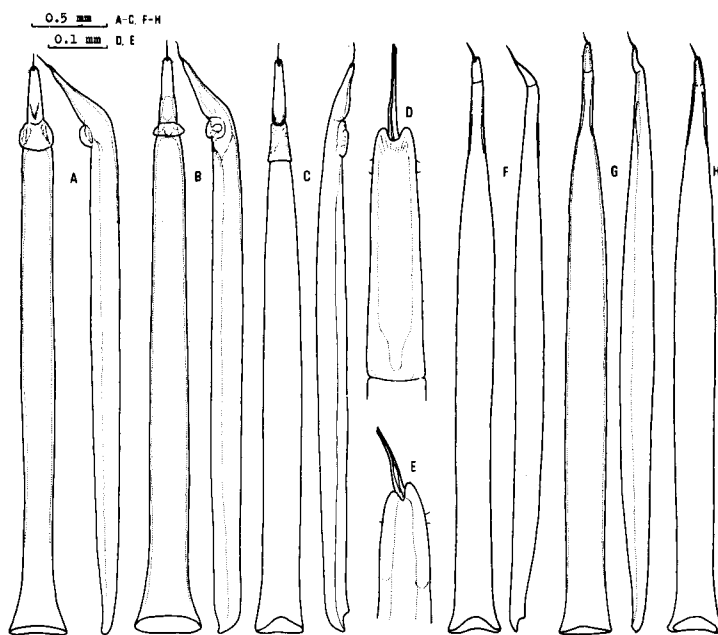


Fig. 19. *Leiobunum platypenis* (A-D) and *L. globosum* (E-H). A-C, F-H: Ventral and lateral (right) views of penis. D, E: Ventral view of distal part of C and F, respectively. (A, Lake Misuzu; B, Chûgû Spa, Mt. Hakusan; C-D, Aoyama-chûô; E-F, Nopporo; G, Nukumidaira, Mt. Iide; H, Sukayu)

1977, NT(SC). Same area: Chûsha, 1,200~1,240 m, 3 ♀, 23-VII-1980, NT; Togakushi-Bokujô, 1,180~1,190 m, 12 ♂ 8 ♀; Nenbutsu-ike, 1,200~1,210 m, 1 ♂ 36 ♀; Koshimizugahara, 1,220~1,230 m, 34 ♀; Shinrin-kôen, 1,220~1,240 m, 13 ♀; all 24-VII-1980, NT. Higashi-chikuma-gun, Hijirikôgen, Lake Hijiri, 970 m, 7 ♂ 7 ♀, 19-VIII-1981, NT. Mt. Utsukushigahara, Lake Misuzu: Site I, 980 m, 21 ♂ 71 ♀, 13-VII-1977, H. Komatsu and NT(SC); Site II, 980~1,000 m, in Hinoki Cypress forest, 78 ♂ 13 ♀, 2-VIII-1980, NT; same site, 6 ♂ 26 ♀ 71juv. (1 ♂ 1 ♀ 23juv., Chrom. Obs.), 6-VII-1982, NT; Site III, 980 m, in deciduous broad leaved forest, 2 ♂ 39 ♀ 46juv. (1 ♂ 12juv. Chrom. Obs.), 6-VII-1982, NT. Okaya-shi, Shiojiri Pass, 1,000~1,020 m, 73 ♀, 31-VII-1981, NT; same locality, 58 ♀ 1juv. (♀) (12 ♀ 1juv. Chrom. Obs.), 7-VII-1982, NT. Mt. Shirouma: Sarukura, ca. 1,300 m, in beech forest, 9 ♂ 43 ♀, 19-VII-1977, H. Komatsu and NT (SC); Sarukura~Yari Spa, 1,250~1,800 m, 18 ♂ 81 ♀ 88juv. (♀), 26/27-VII-1980, NT. Mt. Harinoki, Ôgisawa ~ Harinoki Pass (Ôsawa Hütte), 1,400~1,600 m, 102 ♂ 92 ♀ 6juv. (♀), 31-VII-1980, NT. Ômachi-shi: Yashiro, 1 ♀, 6-IX-1981, T. Yoshida; Hotokezaki, 1juv. (♀), 22-VI-1980, T. Yoshida. Minami-azumi-gun, Nakabusa Spa, 1,400~1,460 m, 1 ♀, 19-VIII-1981, NT. Mt. Norikura, Norikura-kôgen, Suzuran, ca. 1,500 m, 1 ♀, 18-VII-1977, H. Komatsu and NT (SC). Mt. Ontake, Hakkaisan, 1,650~1,670 m, 4 ♂ 20 ♀, 29-VII-1981, NT. —TOYAMA PREF. Mt. Tateyama: Bijodaira, 970~1,100 m, 7 ♂ 21 ♀ 2juv. (♀), 30-VII-1980, NT; Midagahara, 1,940~2,000 m, in Maries's Fir forest, 1 ♀, 31-VII-1980, NT. —ISHIKAWA PREF. Ishikawa-gun, Oguchi-mura, Hakusan-Ichirino, 550~560 m, in Japanese Red Cedar forest, 1 ♂ 4 ♀, 28-VII-

1980, NT. Mt. Hakusan, Chūgū Spa; 780~810 m, in beech forest, 4 ♂ 11 ♀; 935~1,000 m, 2 ♀, in beech forest, 29-VII-1980, NT. —KOREA.- Is. Ullung-do, 2 ♀, 5-VIII-1955, I.H. Shon (SC).

Leiobunum globosum Suzuki

(Figs. 18E-F, 19E-H, 20, 21)

Leiobunum platypenis: Suzuki, 1953, p. 192 (in part), fig. 9L.

Leiobunum globosum Suzuki, 1976b, p. 219 (in part), figs. 84-87, 89, 120, 191-198, 203-208, 321-324 (Type: Nenokuchi, Towada, Aomori pref., Honshu, in ZLHU, not examined); 1980, p. 111; Suzuki and Tsurusaki, 1983, p. 221, figs. 12-19.

Leiobunum tohokuense: Suzuki, 1976b, p. 230 (in part).

Leiobunum esoense: Suzuki, 1976b, p. 245 (in part), figs. 90-91.

Diagnosis: T-shaped labrum; highly swollen palpal tibia ventrally with a projection; nearly straight palpal tarsus; any of these sets off males of this species from the other species of *curvipalpe*-group. Females are separable from all the other species but *L. platypenis* by having characteristic abdominal maculation and by having genital operculum with distinct posterior margin. From *L. platypenis*, female *L. globosum* is distinguished by having simple tapered labrum.

Description: Male. Body relatively large. Genital operculum (Fig. 21B-C) with posterior margin well delimited, slightly rounded backward. Labrum

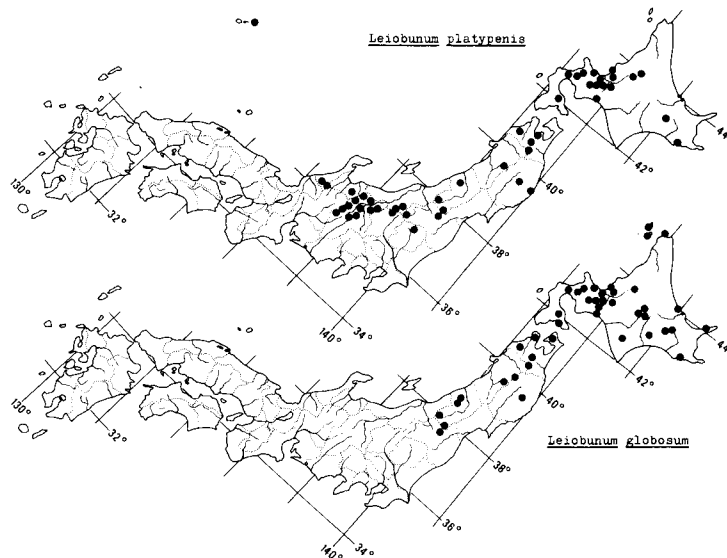


Fig. 20. Distribution of *Leiobunum platypenis* and *L. globosum*.

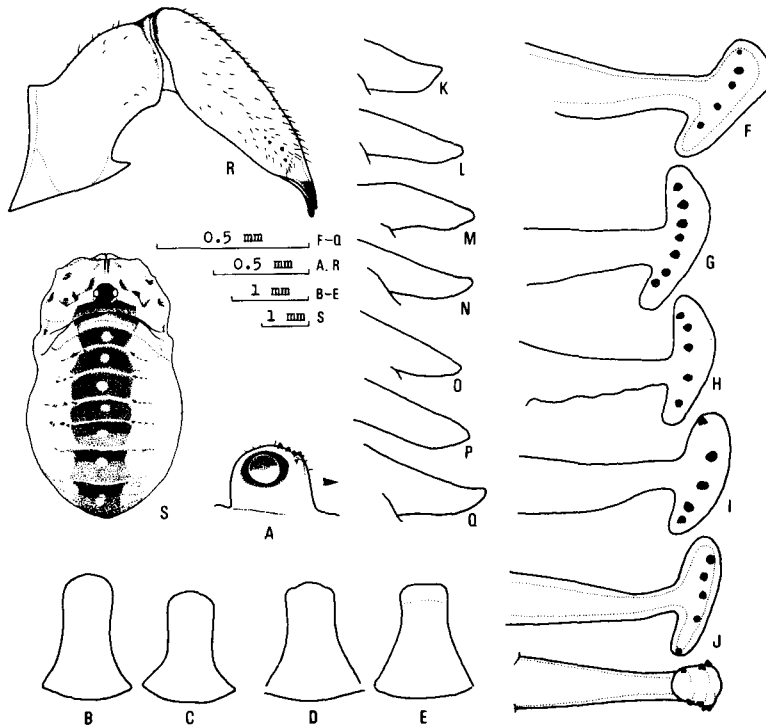


Fig. 21. *Leiobunum globosum*. A, Lateral view of eye tubercle, male. B-E, Genital operculum: B-C, male; D-E, female. F-Q, Lateral and ventral (J-below) views of labrum: F-J, male; K-Q, female. R, Mesal view of male chelicera. S, Dorsal view of female body. (A-B, J, R: Nukumidaira, Mt. Iide. C, E, I, O-P: Sukayu. D, S: Mt. Hayachine. F, Aoyama-chûô. G, K-L: Noppero. H, Mt. Hakkenzan. M-N: Maruyama, Sapporo)

(Fig. 21F-J) T-shaped in lateral view, with some dark colored denticles laterally. Chelicera (Fig. 21R) normal; distal segment with a few denticles on distomesal surface. Palp (Fig. 18E-F) enormously extended and swollen; femur thickened distally, arched dorsally; patella relatively short but widened, with an indistinct apophysis whose surface is finely setose; tibia remarkably swollen, its ventral swelling forms a globular mound, the head of which is armed with several denticles, distal end also with few denticles ventrally; tarsus relatively elongated and straight, ventromesally with a distinct row of tubercles extending its entire length and with an additional short row of small tubercles along the first row.

Penis (Fig. 19E-H) very similar to that of *L. platypenis* in general form, but with much narrower distal part; shaft lacking conspicuous alates or accessories, glans very short, asymmetrical at distal end, left antimere always extending

beyond right antimere (ventral view-Fig. 19E).

Female: Labrum as shown in Fig. 21K-Q. Posterior margin of genital operculum distinct and moderately curved backward (Fig. 21D-E).

Distribution: Hokkaido, northern Honshu (Tôhoku district: from Shimokita Peninsula south to Urabandai-kôgen, Fukushima pref.), Is. Rebun, Is. Rishiri (Fig. 20).

Remarks: Some topics concerning karyotypes and biology of this species will be dealt with in separate papers (in prep.), together with those of *L. platypenis*.

Specimens examined: Only materials newly collected are listed below. Other materials used are listed in Suzuki and Tsurusaki (1983).

HOKKAIDO- Is. Rebun, Kabuka~Momoiwa, ca. 50 m, 1juv. (♀), 10-VII-1984, NT. Is. Rishiri, Oshidomari, ca. 30 m, 2juv. (♀) (Chrom. Obs.), 8-VII-1984, NT. Wakkanai-shi, Wakkanai Shinrin-kôen, 120 m, 1♀, 11-IX-1984, NT. Tokoro-gun, Tokoro-chô, Lake Saroma, 1juv. (♀), 26-VII-1983, M. Suwa, Abashiri-shi, Lake Ponto-numa, 1juv. (♀), 29-VII-1983, M. Suwa. Asahigawa-shi, Kamuikotan, 2♀, 17-VIII-1984, NT. Atsuta-gun, Atsuta-mura, Hattari, ca. 160 m, 1♀, 17-VIII-1984, NT. Tôbetsu-chô, Aoyama-chûô, 28♀ 10juv. (♀) (5♀ 5juv. Chrom. Obs.), 16-VII-1982, NT. Ebetsu-shi, Nopporo, 30juv. (2♂ 28♀) (all Chrom. Obs.), 29/30-VII-1982, NT. Sapporo-shi, Maruyama, 2juv. (♀) (all Chrom. Obs.), 23-VI-1982, NT. Tomakomai-shi, Tomakomai Exptl. Forest of Hokkaido Univ., 3juv. (♀) (all Chrom. Obs.), 15-VII-1983, NT. Saru-gun, Biratori-chô: Mt. Tottabetsu, Rokunosawa, ca. 1,100 m, 1♀, 21-VIII-1983, NT; Nukabira-rindô, 720~750 m, 1♀, 22-VIII-1983, NT. — AOMORI PREF.- Sukayu Spa, 8juv. (♀) (all Chrom. Obs.), 11-VII-1982, NT. Nenokuchi, ca. 400 m, 3♂ 11♀ 3juv. (♀) (all Chrom. Obs.), 11-VII-1982. — YAMAGATA PREF.- Mt. Haguro, 120~420 m, 5♀, 27/28-VIII-1980, NT. Nishiokitama-gun, Oguni-chô, Mt. Iide: Kawairi, 310 m, 1♂ 1♀, 29-VIII-1980, NT; Nukumidaira, 400~500 m, in beech forest, 1♂ 11♀, 1 gynandromorph, 30-VIII-1980, NT. Yonezawa-shi: Shirabu Spa, 820~880 m, 1♀, 31-VIII-1980, NT; Mt. Nishi-Azuma, Shirabu route, 860~1,100 m, 3♀, 31-VIII-1980, NT. — FUKUSHIMA PREF.- Urabandai, Lake Goshiki-numa, 790~830 m, 1♀, 1-IX-1980, NT.

Summary

1. A taxonomic revision, based on both morphology and karyotypic analysis, was presented of the *curvipalpe*-group in the genus *Leiobunum* (Opiliones, Phalangida, Leiobuninae), which is almost wholly endemic to the Japanese Islands. This group was treated as comprising the following seven subgroups and eleven species: (1) *hikocola*-subgroup: *hikocola*; (2) *montanum*-subgroup: *montanum* (6 geographic races within the species); (3) *hiasai*-subgroup: *hiasai*, *sadoense*, *simplum*; (4) *kohyai*-subgroup: *kohyai* (2 geo. races); (5) *hiraiwai*-subgroup: *hiraiwai* (8 geo. races); (6) *curvipalpe*-subgroup: *tohokuense* (3 geo. races), *curvipalpe* (3 geo. races); (7) *platypenis*-subgroup: *platypenis* (2 chromosomal races), *globosum*. Among these subgroups, (2) to (6) are polytypic and their distribution ranges are mosaic of many small ranges occupied by races. Some races are almost certainly parapatric and these subgroups are considered as superspecies, whose races or species may be actually semispecies.

2. Diagnosis of the *curvipalpe*-group was given together with some comments on its relationship to the other members of *Leiobunum*. It was suggested that this group is closer to some species of *Leiobunum* (e.g. *L. calcar*, *L. leiopenis*, etc.) known from eastern part of North America rather than to the other congeneric species inhabiting East Asia or Europe.

3. A key to the species was prepared. And seven species belonging to following four subgroups were redescribed with new information: *hikocola*-, *hiasai*-, *kohyai*-, and *platypenis*-. Descriptions and records of remaining three subgroups, *montanum*-, *hiraiwai*-, and *curvipalpe*-, will be dealt with separately in subsequent papers in a series together with some discussions about their modes of speciation or riation process.

4. The male labra of New World and European *Leiobunum* species were illustrated for the first time. Usefulness of this structure for the separation of the *curvipalpe*-group from other groups of *Leiobunum* was confirmed.

Acknowledgements

I wish to express my sincere gratitude to Prof. Mayumi Yamada and Dr. Haruo Katakura, Zoological Institute, Hokkaido University, for their pertinent guidance throughout the present study and critical reading of the manuscript. Cordial thanks are also due to Dr. Seisho Suzuki, Prof. emerit. of Hiroshima University, for his kindness in lending me many valuable specimens in his personal collection and for his expert advices and constant encouragement; Mr. James C. Cokendolpher, Texas Tech University, for his extensive reviewing of the manuscript, helpful suggestions, and gift of many valuable specimens of North American *Leiobunum* and related species; Dr. Jürgen Gruber, Naturhistorisches Museum, Wien, Austria, for his gift of many excellent specimens of European Leiobuninae species and kind advices; Prof. Motomichi Sasaki and Dr. Nobuo Takagi, Chromosome Research Unit, Hokkaido University, for their kind guidance for the chromosome preparation. Special thanks are also extended to the following persons who provided facilities during collection of the material used in the present study and/or during my chromosome surveys: Dr. T. Okino and the staff of Suwa Hydrobiological Station, Shinshu Univ.; Dr. M. Yamamoto (Shinshu Univ.); Dr. T. Ito and the staff of the Seto Marine Biological Laboratory, Kyoto Univ.; Dr. M.T. Chûjô and the staff of the Hikosan Biological Laboratory, Kyushu Univ.; Dr. Y. Mochida (Mt. Hakkôda Botanical Laboratory, Tôhoku Univ.); The staff of the Asamushi Marine Biological Station, Tôhoku Univ.; Dr. M. Takahashi (Rishiri Marine Biological Station, Sapporo Medical College); Dr. M. Sato (Kagoshima Univ.); Mr. H. Komatsu (Osaka). Following persons kindly provided me with some valuable specimens of *Leiobunum* used in this paper: Mr. Sk. Yamane (Kagoshima Univ.); Drs. H. Katakura, M. Suwa, Messrs. N. Ichijô, A. Otaka, S. Ishimaru (Hokkaido Univ.); Dr. T. Yoshida (Shinshu Univ.); Messrs. T. Hayashi (Gumma), K. Ishii (Dokkyô University School of Medicine), H. Okada (Osaka), T. Ohtani (Nagasaki), Y. Sugino (Ehime Univ.).

References

- Davis, N.W. 1934. A revision of the genus *Leiobunum* (Opiliones) of the United States. Amer. Midl. Natur. **15**: 662-705.
- Futuyma, D.J. 1978. Evolutionary Biology. 565 pp. Sinauer Associates, Inc., Mass.
- Karsch, F. 1881. Diagnoses Arachnoidarum Japoniae. Berliner Entomol. Zeitschrift, **25**: 35-40.
- Key, K.H.L. 1981. Species, parapathy, and the morabine grasshoppers. Syst. Zool. **30**: 425-458.
- Martens, J. 1978. Weberknechte, Opiliones. Die Tierwelt Deutschlands. 64. Teil, 464 pp. Gustav Fischer, Jena.
- McGhee, C.R. 1975. The *politum* group (bulbate species) of *Leiobunum* (Arachnida: Phalangida: Phalangiidae) of North America. J. Arachnol. **3**: 151-163.
- Roewer, C. Fr. 1910. Revision der Opiliones Plagiostethi (= Opiliones, Palpatores) 1 Teil: Familie der Phalangiidae (Subfamilien: Gagrellini, Leiobunini, Leptobunini). Abh. naturw. Ver. **19**: 1-294, T. 1-6.
- 1923. Die Weberknechte der Erde. 1,116 pp. Gustav Fischer, Jena.
- 1957. Über Oligolophinae, Caddoinae, Sclerosomatinae, Leiobuninae, Neopilioninae und Leptobuninae (Phalangiidae, Opiliones, Palpatores). (Weitere Weberknechte XX). Senckenbergiana biol. **38**: 323-358.
- Sato, I. and S. Suzuki 1939. Zwei neue *Nelima*-Arten aus Japan. Annot. Zool. Japon. **18**: 35-41.
- Shear, W.A. and J. Gruber 1983. The opilionid subfamily Ortholasmatinae (Opiliones, Trogluloidea, Nemastomatidae). Amer. Mus. Novitates, no. **2757**, pp. 1-65.
- Suzuki, S. 1953. Studies on the Japanese harvesters. VI. Some new and little known species of the genus *Liobunum* C.L. Koch from Japan, with special reference to the comparative study of penis. J. Sci. Hiroshima Univ., Ser. B. Div. 1, **14**: 173-200.
- 1957. On the three closely related forms of the genus *Liobunum* (Phalangiidae, Opiliones). Jour. Fac. Sci. Hokkaido Univ., Ser. VI, Zool. **13**: 109-117.
- 1966. Two new species of the genus *Leiobunum* (Leiobunidae, Opiliones) from East Asia. Annot. Zool. Japon. **39**: 160-168.
- 1972. On the discontinuous distribution in some Opiliones. Acta Arachnol. **24**: 1-8. (In Japanese with English Résumé)
- 1973. Opiliones from the South-west Islands, Japan. J. Sci. Hiroshima Univ., Ser. B, Div. 1, **24**: 205-279.
- 1976a. Cytotaxonomy in some species of the genus *Leiobunum* (Opiliones, Arachnida). Proc. Japan Acad., **52**: 134-136.
- 1976b. The genus *Leiobunum* C.L. Koch of Japan and adjacent countries (Leiobunidae, Opiliones, Arachnida). J. Sci. Hiroshima Univ., Ser. B, Div. 1, **26**: 187-260.
- 1980a. Four gynandromorphous specimens of the harvestman *Leiobunum globosum* Suzuki. Zool. Mag. (Tokyo), **89**: 111-117. (In Japanese with English abstract)
- 1980b. A taxonomic revision of some geographic forms of *Leiobunum hiraiwai*. Jap. Soc. Syst. Zool., Circ. no. **53**: 13. (abstract from the 16th annual meeting of Jap. Soc. Syst. Zool.) (In Japanese)
- , Tomishima, K., Yano, S. and N. Tsurusaki 1977. Discontinuous distribution in relict harvestmen (Opiliones, Arachnida). Acta Arachnol. **28** (Special number): 121-138. (In Japanese with English synopsis)

- and N. Tsurusaki 1983. Opilionid fauna of Hokkaido and its adjacent areas. Jour. Fac. Sci. Hokkaido Univ. VI. Zool. **23**: 195-243.
- Takagi, N. and M. Oshimura 1973. Fluorescence and Giemsa banding studies of the allocyclic X chromosome in embryonic and adult mouse cells. Exptl. Cell Res. **78**: 127-135.
- Tsurusaki, N. 1982. A new species of the genus *Leiobunum* (Arachnida, Opiliones) from Sado Island, Japan. Annot. Zool. Japon. **55**: 105-109.
- White, M.J.D. 1973. Animal Cytology and Evolution. 3rd ed. 961 pp. Cambridge University Press, Cambridge.
- 1978. Modes of Speciation. 455 pp. W.H. Freeman and Co., San Francisco.
- Wilson, E.O. and W.L. Brown 1953. The subspecies concept and its taxonomic application. Syst. Zool. **2**: 97-111.

Appendix

List of specimens of *Leiobunum* (except those belonging to *L. curvipalpe*-group) and a few specimens of one related genus (*Hadrobunus*) examined during the present study: Data for each sample are given by the following order: Locality, altitude of locality if available, number of individuals, date collected, collector (NT=N. Tsurusaki), museum collection (other than personal collection of NT).

Japanese material

Maximum-group

1. *Leiobunum japonense japonicum* (Suzuki) (Fig. 3A)

WAKAYAMA PREF.- Higashimuro-gun, Nachi-Katsuura-chô, Mt. Nachi, Seigantoji, 340 m, 1 ♀, 28-VII-1983, NT. — HIROSHIMA PREF.- Saeki-gun, Mt. Gokurakuji, 1 ♀, 25-V-1975, NT. Sandan-kyô, 1 ♂ 1 ♀, 3-VII-1977, NT and H. Komatsu. Asa-gun, Uga-kyô, 2 ♀, 30-V-1976, NT. — EHIME PREF.- Mt. Takanawa, 1 juv., 5-V-1972, NT. Matsuyama-shi: Yuyama-Aonami, 2 ♂, 3-VI-1973, NT; Mt. Sugitate, 1 juv., 5-V-1970, NT; Mt. Saragamine, 950 m, 1 juv., 5-XI-1974, NT. Mt. Ishizuchi: Mt. Omogôsan, 1,360~1,500 m, 3 ♂ 2 ♀, 3-VIII-1982, Y. Sugino; Tsuchigoya ~ Mt. Iwakuro, 1,600 m, 1 ♂, 5-VIII-1982, NT. — FUKUOKA PREF.- Mt. Hikosan, 1,100~1,190 m, 1 ♀, 30-VII-1982, NT.

Rubrum-group

2. *Leiobunum rubrum* Suzuki (Fig. 3B)

NAGASAKI PREF.- Is. Tsushima, 1 ♂ 3 ♀, ?-X-1969, K. Fujikawa (SC).

Japonicum-group

3. *Leiobunum japonicum japonicum* Müller (Fig. 3C)

Materials from Hokkaido and northernmost of Honshu (Aomori, Akita, and Iwate pref.) dealt with in Suzuki and Tsurusaki (1983) are not listed here.

IWATE PREF.- Shimohei-gun, Kawai-mura, Kuzakai, Mt. Kabutomiyôjin, 760~1,000 m, 2 ♂ 1 ♀, 29-IX-1984, NT. — YAMAGATA PREF.- Mt. Haguro, 120~420 m, 15 ♂ 18 ♀, 27/28-VIII-1980, NT. Obanzawa-shi, Obanzawa, 1 ♂ 2 ♀, 29-VIII-1983, A. Otaka. — FUKUSHIMA PREF.- Urabandai, Goshiki-numa, 790~830 m, 4 ♂ 8 ♀, 1-IX-1980, NT. — TOCHIGI PREF.- Funyû Exptl. Forest of Utsunomiya Univ., 2 ♂ 2 ♀, 15-X-1980, N. Ichijô. Yaita-shi, Tamanyû, 1 juv., 11-VII-1981, N. Ichijô. Nasu, Yumoto Spa, 810 m, 2 ♀, 31-VIII-1982, NT. Shimotsuga-gun, Mibu-chô, 8 juv., 14-VI-1983, K. Ishii. — GUMMA PREF.- Yamada-gun, Ômama, Kanbai, 400 m, 1 ♀, 2-XI-1980, T. Hayashi. Nitta-gun, Yabuzukahonchô, Mt. Kan-

non, 140 m, 1 ♀, 3-IX-1983, T. Hayashi. — CHIBA PREF.- Awa-gun, Mt. Kiyosumi, 2 ♀, 18-IX-1983, K. Ishii. Same area, Kiyosumi-ji, 300~320 m, 8 ♂ 7 ♀, 27-VIII-1984, NT. — YAMANASHI PREF.- Kobuchizawa, 900~940 m, 5 ♂ 6 ♀, 17-VIII-1981, NT. — NIIGATA PREF.- Nishikanbara-gun, Mt. Yahiko, 1 ♀ 13 juv., 22-VII-1980, NT. Minami-Uonuma-gun, Tsuchitaru, 620 m, 2 ♂ 4 ♀, 27-VIII-1982, NT. — NAGANO PREF.- Togakushi-kôgen, Chûsha, 1,200~1,240 m, 1 juv., 23-VII-1980, NT. Lake Misuzu, 980~1,000 m (Site II), 1 ♀ 2 juv., 2-VIII-1980, NT. Shiojiri Pass, 1,000~1,020 m, 5 juv., 31-VII-1981, NT. Lake Tadeshina, 1,220 m, 1 juv., 1-VIII-1981, NT. Suwa-gun, Fujimi-chô, Fujimigaoka, 950~970 m, 1 ♀, 21-VIII-1982, NT. Takatô, Hokomochi-jinja, 780~800 m, 4 ♀, 17-VIII-1981; 5 ♂ 7 ♀ 1 juv., 20-VIII-1982, NT. Komagane-shi, Kôzen-ji, 840~860 m, 4 ♀, 18-VIII-1981, NT. — SHIZUOKA PREF.- Itô-shi, Yawatano, Kinomiya-jinja, 120 m, 4 ♂, 7-X-1980, NT. — AICHI PREF.- Mt. Hôraijisan, 460~600 m, 7 ♀, 31-VIII-1981, NT. — ISHIKAWA PREF.- Ishikawa-gun, Oguchi-mura, Hakusan-Ichirino, 550~560 m, 2 juv., 28-VII-1980, NT. — SHIGA PREF.- Ôtsu-shi, Sakamoto, 180~300 m, 1 ♂ 4 ♀, 12-VIII-1982, NT. — NARA PREF.- Mt. Yamato-Katsuragi-san, 720~950 m, 2 ♂ 1 ♀, 28-VIII-1981, NT. Mt. Yoshino, Okusenbon, 740~780 m, 2 ♂ 3 ♀, 25-VIII-1981, NT. — SHIMANE PREF.- Mt. Sanbe, 700~1,200 m, 2 juv., 27~29-VII-1975, S. Konishi. — HIROSHIMA PREF.- Shiraki-chô, Mt. Shiraki, 1 juv., 20-VI-1976, NT. Asa-gun, Mt. Aratani, 2 juv., 15-VI-1975, NT. Itsukaichi-chô, Mt. Madogatake, 2 juv., 16-VI-1974, NT. — EHIME PREF.- Mt. Saragamine, 3 juv., 25-VII-1974, NT; 1,160 m, 1 ♂ 2 ♀, 7-X-1983, NT. Ônogahara, 1,100~1,400 m, 1 ♂ 1 ♀ 1 juv., 15/16-VIII-1972, NT. — NAGASAKI PREF.- Is. Tsushima: Kamitsushima-chô, Hidakatsu, 50~60 m, 2 ♂ 4 ♀, 26-VII-1982, NT; Mitsushima-chô, Naira Beech, 1 ♂ 3 ♀, 25-VII-1975, T. Teramoto; Izuhara, Mt. Ariake, 200~530 m, 2 ♂ 7 ♀ 7 juv., 27-VII-1982, NT. Hirado-shi, Mt. Yasuman, 2 juv., 5-VII-1981, T. Ohtani. Matsuura-shi: Yunoki-Kawauchi, 1 juv., 8-VII-1981, T. Ohtani; Mt. Kunimi, 1 ♂, 22-VIII-1981, T. Ohtani. — FUKUOKA PREF.- Mt. Hikosan, 680~740 m, 3 juv., 29/31-VII-1982, NT. — MIYAZAKI PREF.- Nishi-usuki-gun, Takachiho-jinja Takachiho-kyô, 240~340 m, 5 ♂ 4 ♀ 2 juv., 1-VIII-1982, NT.

4. *Leiobunum japonicum uenoi* Suzuki

KAGOSHIMA PREF.- Is. Amami-ôshima, Mt. Yuwan, 1 ♂ 2 ♀ 4 juv., 25~29-VI-1981, H. Okada.

European material

1. *Leiobunum rotundum* (Latreille) (Fig. 3D)

AUSTRIA: Purgstall (western Lower Austria), 300 m, 4 ♂ 7 ♀ 3 juv., 1957~1970, F. Ressler; Wien XIV., Rosental, 230~310 m, 3 ♂ 5 ♀, 25-IX-1975, J. Gruber.

2. *Leiobunum limbatum* L. Koch (Fig. 3E)

AUSTRIA: Scheibbs (southwestern Lower Austria), 3 ♂ 1 ♀, 10-XI-1965, F. Ressler; Wien XIV., Hütteldorf, 7 ♂ 3 ♀, 7-X-1972, J. Gruber.

3. *Leiobunum rupestre* (Herbst) (Fig. 3F)

AUSTRIA: Purgstall, 300 m, 7 ♂, 8-X-1965, F. Ressler; Scheibbs, 1 ♂ 3 ♀, 10-VIII-1966, F. Ressler.

4. *Leiobunum ghigi* Di Caporiacco (Fig. 3G)

GREECE: Rhodos, Lindos, 4 ♂ 2 ♀ 1 juv., 6-V-1963, O. Paget, E. Kritscher, and K. Bilek.

North American material

1. *Leiobunum ventricosum* (Wood) (Fig. 3H)
USA: MAINE, Penobscot Co., 1 ♂ 1 ♀, 6~15-VI-1978, S.B. Hydorn.
2. *Leiobunum aldrichi* Weed (Fig. 3I)
USA: KENTUCKY, Bell Co., Cumberland Gap State Park, 1 ♂ 1 ♀, 4-VIII-1981, O.F. Francke.
3. *Leiobunum politum* Weed (Fig. 3J)
USA: TENNESSEE, Davidson Co., West bank of Percy Priest Lake, Elm Hills Park (about 8 miles SE Nashville), 1 ♂ 1 ♀, 12-IX-1980, W.D. Sissom and C. McReynolds.
4. *Leiobunum brachiolum* McGhee (Fig. 3K)
USA: MAINE, Penobscot Co., 1 ♂ 1 ♀, 3~11-VIII-1978, S.B. Hydorn.
5. *Leiobunum nigripes* Weed (Fig. 3L)
USA: ILLINOIS, Grundy Co., 4 miles ESE Morris on Pine Bluff Road, 1 ♂, 26-VII-1982, J.C. and J.E. Cokendolpher.
6. *Leiobunum gordonii* Goodnight and Goodnight (Fig. 3M)
USA: ILLINOIS, Jackson Co., Giant City State Park, 1 ♂ 1 ♀, 11-IX-1979, J.C. and J.E. Cokendolpher.
7. *Leiobunum townsendi* Weed (Fig. 3N)
USA: TEXAS, Bardera Co., 12 miles E of Bandera, 10 ♂ 10 ♀, 27-V-1981, J.C. Cokendolpher.
8. *Leiobunum flavum* Banks (Fig. 3O)
USA: TEXAS, Polk Co., Lake Livingston, 7 miles W of Livingston, 5 ♀, 16-V-1980, D.C. Rudolph and J.A. Matos; TEXAS, Nacogdoches Co., Etoile, 6 ♂, 15-X-1979, D.C. Rudolph.
9. *Leiobunum viridorsum* Goodnight and Goodnight (Fig. 3P)
MEXICO: SAN LUIS POTOSI, Cave entrance, 2.5 miles W of El Naranjo, 1 ♂ 1 ♀, 9-VIII-1981, D.C. Rudolph, J.A. Matos, and R. Collins.
10. *Leiobunum relictum* Davis (Fig. 3Q)
USA: OKLAHOMA, Comanche Co., Wichita Mountains Wildlife Refuge, 1 ♂ 1 ♀, 15-V-1981, D.K. Hoffmaster.
11. *Leiobunum crassipalpe* Banks (Fig. 3R)
USA: MISSOURI, Greene Co., 23 miles WSW Springfield, 1 ♂ 2 ♀, 26-VIII-1979, J.C. and J.E. Cokendolpher.
12. *Leiobunum vittatum* (Say) (Fig. 3S)
USA: ILLINOIS, Marion Co., 3 miles NW of Brubaker, 5 ♂ 5 ♀, 6-IX-1979, J.C. and J.E. Cokendolpher; TEXAS, Sabine Co., Red Hills Lake, 3 miles N of Milam, 5 ♂ 5 ♀, 1-XI-1979, D. C. Rudolph and J.A. Matos; TEXAS, Erath Co., 9 miles S Stephenville, 1 ♂ 2 ♀, 23-IX-1979, J. C. and J.E. Cokendolpher; OKLAHOMA, Comanche Co., Wichita Mountains Wildlife Refuge, Sunset Rec. Area, 2 ♂ 2 ♀, 28-X-1977, J.C. Cokendolpher and D.C. Parmley; MICHIGAN, Oakland Co., Troy, 1 ♂ 3 ♀, 1-IX-1979, J.C. and J.E. Cokendolpher.
13. *Leiobunum calcar* (Wood) (Fig. 3T)
USA: MAINE, Piscataquis Co., DENSE Line V, Stn. 2 T5 R11, Wels. 10.1 km NNE of Soubunge Mtn, 7 ♂ 11 ♀, 28-VII-1977, N.W. Houseweart and D.T. Jennings. Same area, STRIP-

CUT Line V, Stn. 4 T5 R11, Wels. 10.4 km NNE of Soubunge Mtn., 9 ♂ 29 ♀, 21-VII-1977, M.W. Houseweart and D.T. Jennings.

14. *Leiobunum leiopenis* Davis (Fig. 3U)

USA: KENTUCKY, Bell Co., Cumberland Gap State Park, 2 ♂, 4-VIII-1981, O.F. Francke.

15. *Hadrobunus* sp. (spp. ?) (Fig. 3V)

USA: TENNESSEE, Davidson Co., Nashville, 1 ♀, 4-IX-1981, G. Polis and C.N. McReynolds; VIRGINIA, Franklin Co., Smith Mountain Lake, 2 ♂, 10-VIII-1977, J. Walke.
