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A TAXONOMIC REVISION OF THE CHRYSOLINA  
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By TETSUO HASEGAWA

*Abstract*

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Three Japanese species of the *Chrysolina angusticollis*-complex, *C. angusticollis*, *C. aino* and *C. porosirensis*, are reexamined with respect to several characters newly studied. Intraspecific local variations and interspecific differences are shown as to the median lobe of the male genitalia, hind wing and coloration. Two distinct types are recognized in the sculpture of the elytral surface and their taxonomic value is discussed. The correlations among four (in the males) or three (in the females) characters are shown in a graph. The long adult life span is mentioned. The distribution of the species in Japan is shown on a map.

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## *Contents*

Introduction .....	3
Specimens examined .....	3
Characters of the hind wings .....	4
Sculpture on the elytral surface .....	6
Shape of the male genitalia .....	7
Coloration .....	7
Larval morphology .....	10
Character correlation .....	11
Life history .....	12
Distribution .....	15
Summary .....	16
Acknowledgements .....	16
References .....	16

## INTRODUCTION

The *Chrysolina angusticollis*-complex, a group of chrysomelid species, includes *C. aino* and *C. porosirensis* both recently described by Takizawa (1970) from Hokkaidô, and *C. angusticollis* distributed in northern Japan, Manchuria, etc. The characters used by Takizawa to distinguish *C. aino* from *C. angusticollis* are, however, variable locally, so that the specific distinction between them should be reexamined. The hind wings are degenerated in most species of the genus *Chrysolina*, and much reduced in the *angusticollis*-complex. In such species some infraspecific geographical variations may be expected. On the other hand, the specimens of this complex collected in the western half of Hokkaidô fall into two forms clearly distinguishable in two external features not examined by Takizawa, the structure of the hind wings and the sculpture of the elytral surface. As shown later, the two forms seem to correspond with his *C. angusticollis* and *C. aino*. A taxonomic revision of these two species and *C. porosirensis* will be given below from this point of view.

## SPECIMENS EXAMINED

### *C. angusticollis*

Honshû - 1: Jûni-kô (Aomori Prefecture), 2♂♂, 1♀, 22-VI-1970; 2: Kodomari (Aomori Prefecture), 1♂, 20-VI-1970.

Hokkaidô - 3: Sengen-dake, 35♂♂, 20♀♀, 3~5-VI-1976; 4(I): Shiriuchi (I), 20♂♂, 18♀♀, VI~VII-1976; 4(II): Shiriuchi (II), 11♂♂, 1♀, VI~VII-1976; 5: Ônuma, 1♂, 30-VI-1942; 6: Okushiri Is., 2♂♂, 2♀♀, 14~18-VII-1940; 7: Pirika, 15♂♂, 10♀♀, VII~IX-1976; 8: Niseko, 1♂, 2♀♀, 25~26-VII-1976; 9: Mt. Muine, 30♂♂, 21♀♀, VI~IX-1976, VII-1977; 10: Sapporo, 5♂♂, 7♀♀, VI-1976; 11: Nopporo, 1♀, 28-VII-1977; 12: Yupari-dake, 1♂, 1♀, VIII-1966; 13: Ikushumbetsu, 8♂♂, 6♀♀, 10-VII-1976; 14: Ashibetsu-dake, 1♂, 1♀, VII-1976.

### *C. aino*

Hokkaidô - 15: Tomari, 1♂, 10-VIII-1976; 16: Kozawa, 1♀, 20-IX-1977; 17: Mt. Haruka, 4♂♂, 3♀♀, VII-1976; 18: Jôzankei, 17♂♂, 21♀♀, VI~VII-1977; 19: Soranuma-dake, 15♂♂, 11♀♀, VI~VII-1976; 20: Chitose, 1♂, 1♀, VI-1976, VI-1977; 21: Nopporo, 1♂, 1♀, 7-VII-1964; 22: Yûpari-dake, 1♀, VIII-1969; 23: Urakawa, 1♀, 4-VIII-1942; 24: Motonakagoya, 6♂♂, 7♀♀, VI-1976, VI~IX-1977; 25: Shokambetsu, 10♂♂, 7♀♀, 4~7-VIII-1976; 26: Nukabira, 1♂, 2♀♀, 17-VI-1966, 3-VIII-1949.

### *C. porosirensis*

Hokkaidô - 27\*: Petegari-dake, 1♀, 29-VIII-1972; 28: Poroshiri-dake, 1♂, 1♀, 23-VII-1975; 29\*: Furano-dake, 1♀, 19-VII-1954; 30\*: Mt. Tomuraushi, 1♀, 9-VIII-1952; 31: Mt. Taisetsu (Aka-dake, Kuro-dake, Hakuun-dake) 7♂♂, 3♀♀, 27-VII-1964, VII-1968, 29-VII-1973, VII-1975, 21~26-VII-1977; 32\*: Sôun-kyô 2♀♀, 16-VI-1960, 15-VIII-1974; 33: Mt. Niseikaushuppe, 1♂, 14-VII-1976; 34\*: Aizankei, 3♀♀, 15-VII-1960, 22-VII-1966, 21-VII-1976; 35\*: Nukabira, 1♀, 17-VI-1966. (\* See under Distribution.)

CHARACTERS OF THE HIND WINGS

Owing to the much reduced hind wings the beetles of this complex may have poor ability to disperse and this must be responsible at least to some extent for the remarkable local variations observed in certain characters. Nevertheless, the characters of the hind wings show somewhat stable patterns, by which the individuals from the western half of Hokkaidô can be divided into two forms: in one of these forms the hind wings are quite slender, while in the other rather stumpy. Several examples of the hind wings are illustrated in Fig. 1.

The form with slender hind wings is widely distributed in western half of

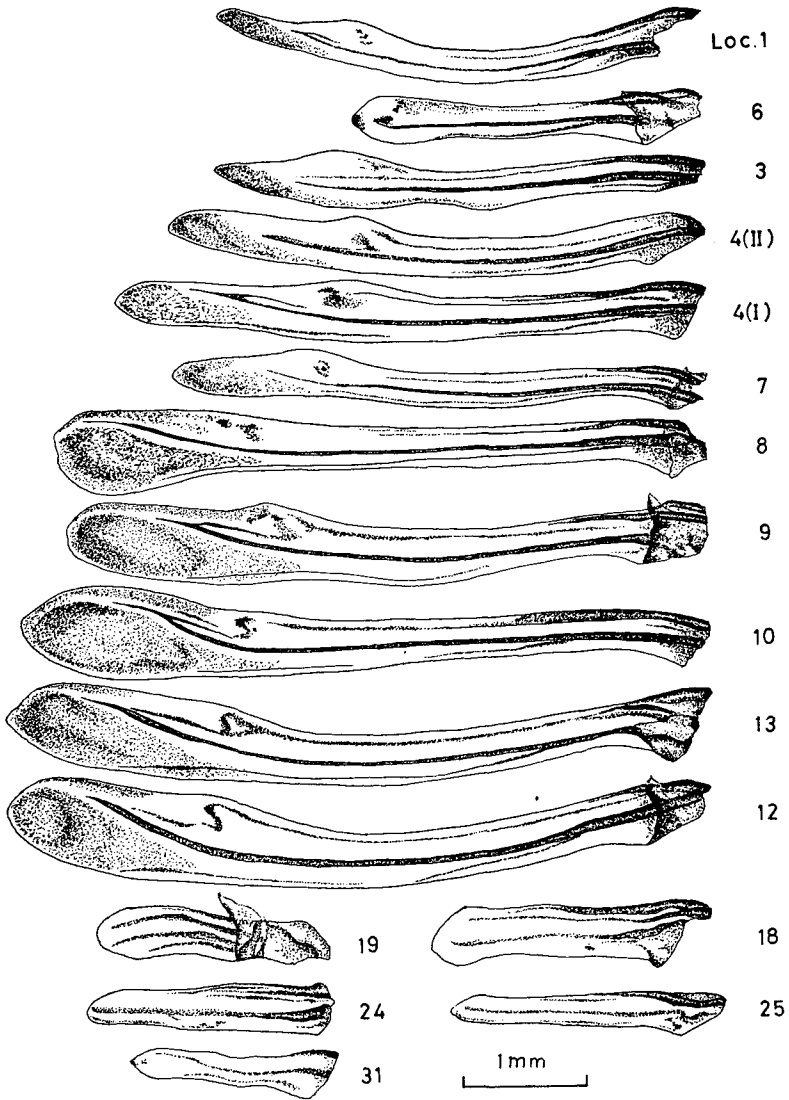


Fig. 1. Male hind wings of *C. angusticollis*, *C. aino* and *C. porosirensis*.  
Locality numbers, see text.

Hokkaidô. The local variation of the hind wing length and width in this form is shown in Fig. 2 and Fig. 3 where the localities (Loc. 1, 3, 4(II), 4(I), 7, 9, 10, 13) are arranged approximately from south to north. The hind wing length shows, though not obviously, a south to north gradient, while the width an abrupt change just north of Pirika. The costal margin of the wing more or less projects near the apical cell (Rc), which is located at the apical part of R1. The hind wing width was measured across this part of the wing. Although the sclerotization of Rc becomes weaker as the wing length decreases, the projection is usually distinct. In the individuals from south of Pirika the apical part of the wing tends to taper to a point (Fig. 1, Loc. 1, 3, 4(II), 4(I), 7), while in those from north of Pirika it obviously broadens (Fig. 1, Loc. 8, 9, 10, 13, 12).  $M_{3+4}$  is relatively well developed and m-m almost always apparent. The individuals from Aomori Prefecture are not particularly different in these characters, while those from Okushiri Island are somewhat different from the others in the reduced apical part of the wing (Fig. 1, Loc. 6).

The form with stumpy hind wings is not found in southern localities within the distributional range of this species complex in Japan. Its hind wing length and width are shown in Fig. 2 and Fig. 3 (Loc. 19, 18, 24, 25). In the hind wing width it is not clearly different from the slender form, while in the hind wing length it overlaps with only a part of the latter. Among the individuals from the four localities, those from Soranuma-dake are somewhat different from the others by the roundish shape of the hind wings. They also differ from the others by the veins C+Sc, R,  $M_{3+4}$  and  $Cu_1$  all clearly visible and especially by the latter three veins almost same in length. One specimen ( $\delta$ ) from Chitose and another ( $\varphi$ ) from Nopporo are quite similar to the individuals from Soranuma-dake in these hind wing characters. In all these individuals, the veins gradually disappear apically

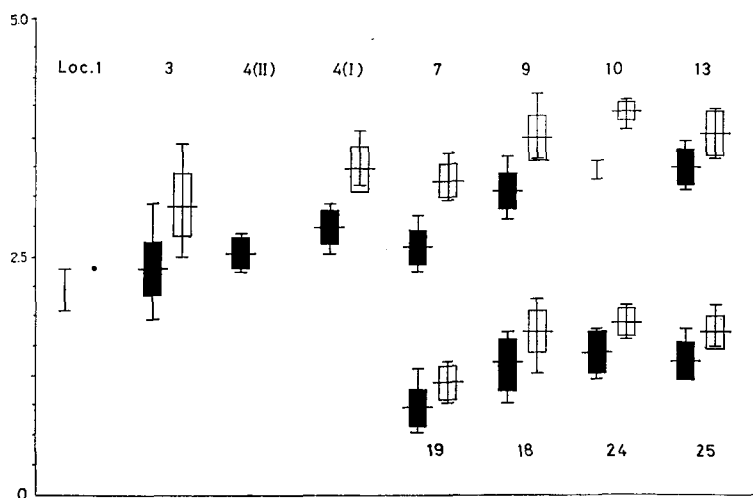


Fig. 2. Hind wing length (ordinate, in mm) in *C. angusticollis* and *C. aino*. In each bar diagram, the longer horizontal line indicates the mean, the solid (male) or open bar (female) the value of standard deviation on either side of the mean value, and the vertical line the range. When the number of individuals examined is five or less, only the range is shown. Locality numbers, see text.

and the costal margin does not project near  $R_c$ . In general the individuals from Jōzankei, Motonakagoya and Shokambetsu are characterized by  $M_{3+4}$  rather distinct, and  $R$  and  $Cu_1$  obscure.

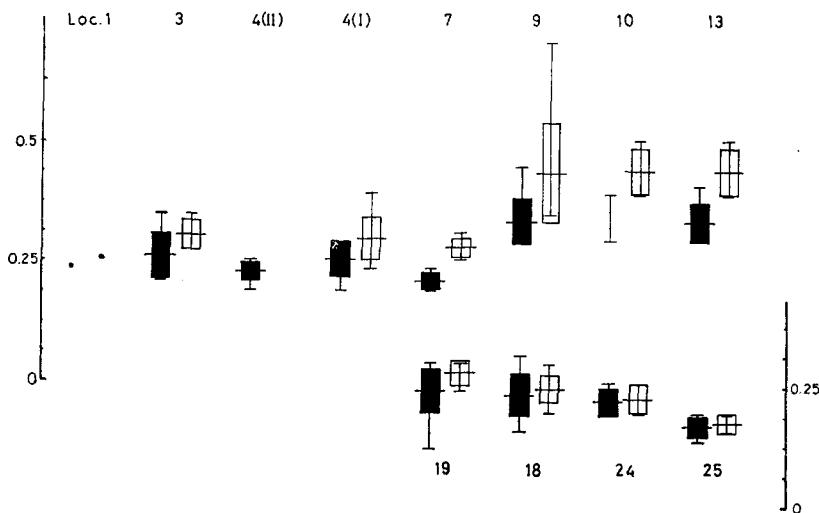


Fig. 3. Hind wing width (ordinate, in mm) in *C. angusticollis* and *C. aino*. Symbols as in Fig. 2. Locality numbers, see text.

#### SCULPTURE ON THE ELYTRAL SURFACE

The two forms treated in the preceding section are also sharply divisible by the structure of the elytral surface. One of them is characterized by finely reticulated, while the other by smooth, elytra. Scanning electron microscope studies show that the reticulation is due to a network of scale-like processes on the elytral surface (Fig. 4 and Fig. 5). In the male these processes are obscure and only partially distributed on the elytra, but in the female they are very conspicuous and found on the whole surface. On the smooth elytra there is no structure other than simple punctures, which are also present on the reticulate ones. The division based on the elytral characters exactly coincides with that based on the hind wing characters. The form with stumpy hind wings and smooth elytra agrees thereby (and also by the male genital characters, which will be treated in the succeeding section) with the type of *C. aino*, whereas the form with slender hind wings and reticulated elytra may rightly be identified with *C. angusticollis*. In the latter species the elytral processes tend to be denser in the individuals from north of Pirika and are especially conspicuous in northern localities (Yūpari-dake, Ikushumbetsu and Ashibetsu).

Furthermore, the third species of the complex, *C. porosirensis*, shows much reduced hind wings which are in general more reduced than in *C. aino*. It is allied to *C. aino* by the elytral surface being smooth.

#### SHAPE OF THE MALE GENITALIA

In Fig. 6 the length of the median lobe of the male genitalia is shown for *C. angusticollis* and *C. aino*. In *C. angusticollis* the apical part of the median lobe is usually bow-shaped as shown in Fig. 7 (Loc. 1, 3, 4(I), 9, 10, 13). In the individuals from Shiriuchi (II) (Fig. 7, Loc. 4(II)) and Pirika (Fig. 7, Loc. 7), however, the median lobe is small and straight in its apical part. These characters agree with those of *C. aino*. After Kimoto and Hiura (1970), *C. aino* occurs at Kumaishi-mura, Hiyama district. This locality is situated in the range of *C. angusticollis* as here understood. Their record may in reality be referred to the variation of *C. angusticollis* just mentioned. The individuals from Okushiri Island and Aomori Prefecture show the usual characteristics of *C. angusticollis*.

In *C. aino*, the median lobe is somewhat variable in length but always straight in the apical part. In the individuals from Soranuma-dake, the apex of the median lobe clearly broadens on both sides, but in the other specimens examined such a characteristic is not recognized. In *C. angusticollis* the apical part of the median lobe is nearly parallel or somewhat narrowed to a point (Fig. 8). In female genitalia no obvious difference is found between the two species.

*C. porosirensis* is quite different from *C. angusticollis* and *C. aino* in the shape of the male genitalia as described by Takizawa (1970).

#### COLORATION

After Takizawa (1970), *C. aino* is characterized by the entirely cupreous dorsal surface. However, among the individuals referred here to *C. aino* only those from Jôzankei and its vicinity are cupreous in both the pronotal surface and the elytral surface. Also in *C. angusticollis* the coloration is variable locally. The color range in these two species is tentatively divided into six classes — Class I: copper with a golden tinge; Class II: copper with a purplish tinge; Class III: reddish purple; Class IV: purple; Class V: indigo blue; Class VI: greenish purple. The number of individuals belonging to each class is shown in Fig. 9 for the pronotum and elytra separately.

In *C. angusticollis* the individuals from Aomori Prefecture are entirely cupreous and those from Okushiri Island greenish with a golden tinge. Thus they are remarkable in their coloration in comparison with the individuals from the mainland of Hokkaidô.

In *C. aino* the individuals from Soranuma-dake and Nukabira have the pronotum and the elytra different in coloration. The other individuals examined also show local patterns, and the color range tends to be limited in each locality.

Concerning the coloration an interesting phenomenon has been observed. *C. watanabei* is distributed in Hokkaidô and Sakhalin and belongs to another subgenus, *Anopachys*. Their hind wings are almost vestigial. The only host plant known for *C. watanabei*, *Aster glehni*, is also one of the host plants of *C. angusticollis*-complex. *C. watanabei* and either of *C. angusticollis* or *C. aino* may feed on the same host species, sometimes even on a single plant, in all localities where they occur together. In fact *C. watanabei* has always been found together with *C. angusticollis* or *C. aino*. The coexistence was observed at Mt. Muine, Jôzankei, Motonakagoya and Shokambetsu. In each of these localities the paired species are similar to each other in coloration (Fig. 10). The coloration seems to be fixed

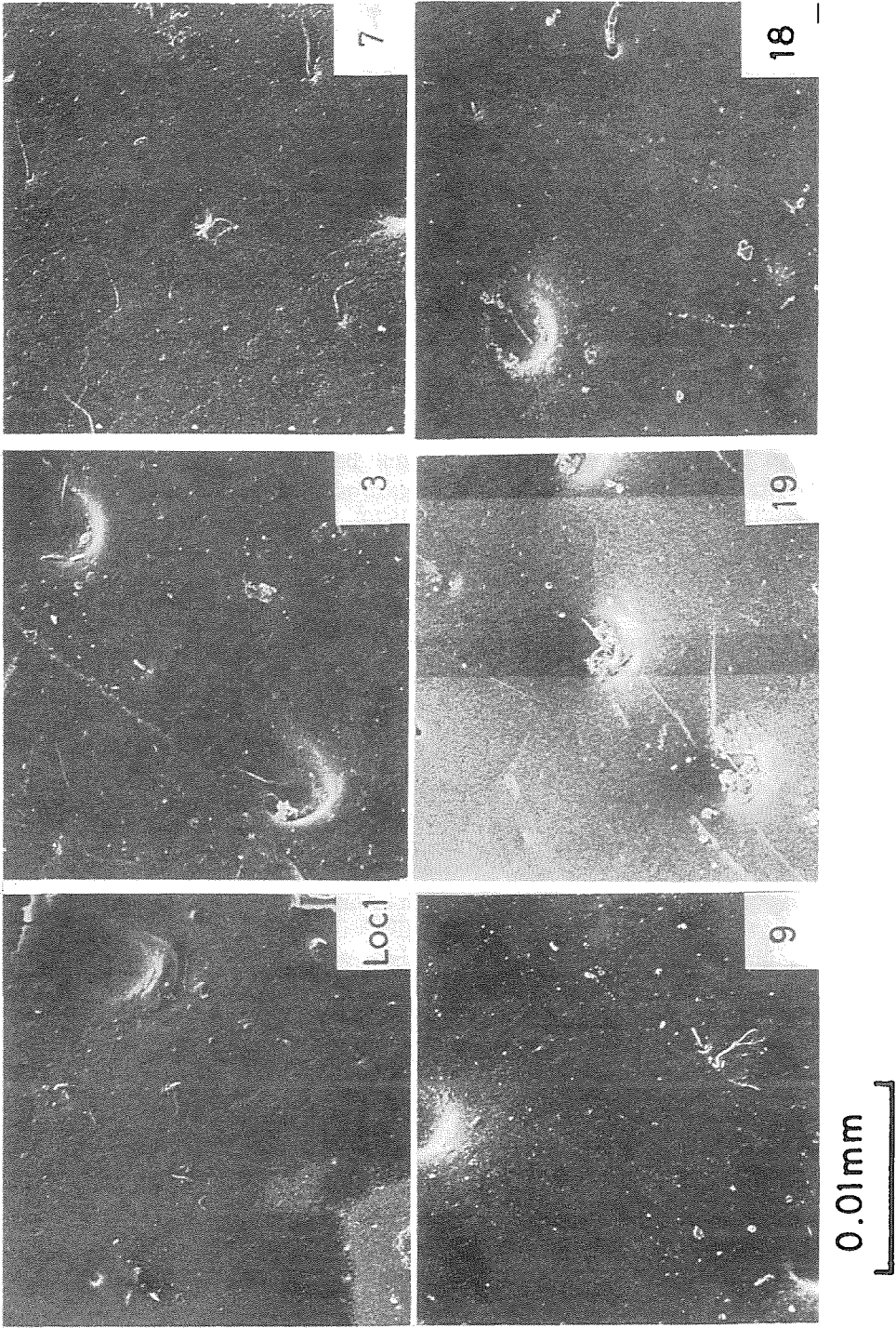


Fig. 4. Sculpture on elytral surface in male. Locality numbers, see text.

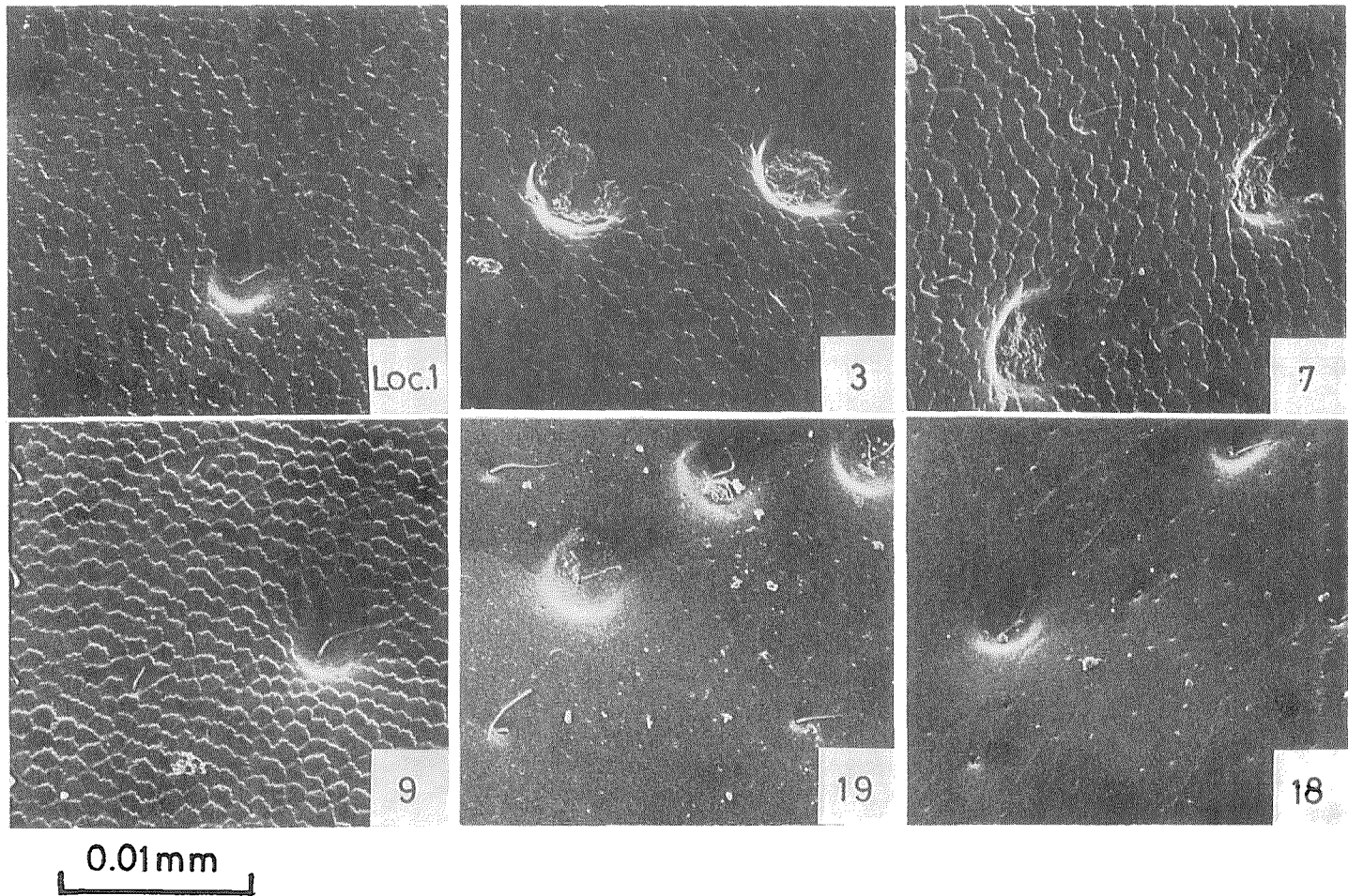


Fig. 5. Sculpture on elytral surface in female. Locality numbers, see text.

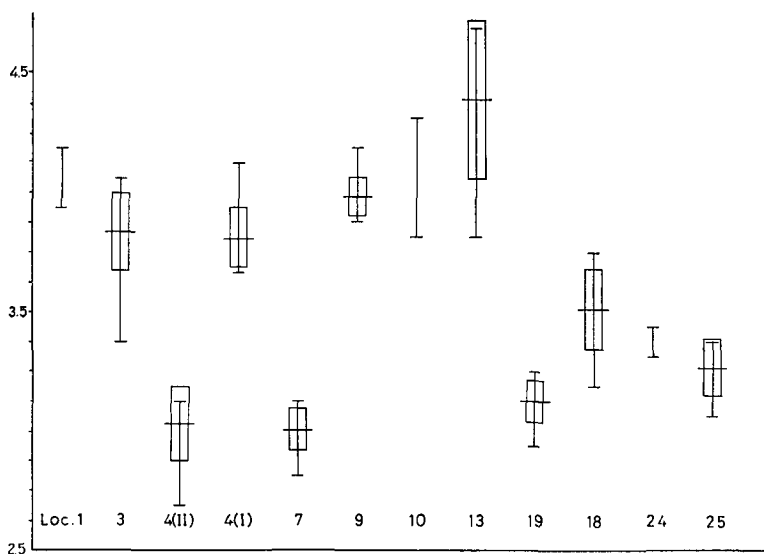


Fig. 6. Length of the median lobe of the male genitalia (ordinate, in mm). Symbols as in Fig. 2. Locality numbers, see text.

genetically, because beetles bred from larvae in laboratory always show the same coloration as that in their native localities.

Eleven beetles of these chrysomelid species were tested for palatability by a grey starling kept in cage and a hen. They were all readily accepted by the birds. However, Jones (1932) reported that the adults of several chrysomelid species such as *Chrysochus auratus*, *Crioceris duodecimpunctata*, *Labidomera clivicollis* and *Trirhabda canadensis* were hardly accepted or perfectly refused by birds. *C. auratus* was found to possess an ant-deterrent. According to him, the brilliant metallic color or conspicuous coloration of beetles is to some extent aposematic. Recently Pasteels et al. (1977) detected some defensive secretions containing cardenolides in several species of the genus *Chrysolina*. Judging from these facts, it may not be ruled out that the coincidence in coloration between *C. watanabei* and *C. aino* or *C. angusticollis* is due to mimicry.

#### LARVAL MORPHOLOGY

After Takizawa (1970), *C. aino* is distinguishable from *C. angusticollis* in the larval stage by having dense setae and well-developed tubercles on the dorsal surface. In the present study, the larvae belonging to the form with stumpy hind wings and smooth elytra and from Soranuma-dake and Motonakagoya were examined. They are supposed to belong to *C. aino*, yet they do not hold the characters assumed by Takizawa to be diagnostic to *C. aino* but are rather similar in those features to *C. angusticollis*. The first instar larvae from Soranuma-dake are glabrous dorsally except on the tubercles; the last instar larvae are glabrous dorsally, with Da, Dp and DL almost obsolete, and Es, Ps and SS reduced. The last instar larvae from Motonakagoya have the tubercles obsolete

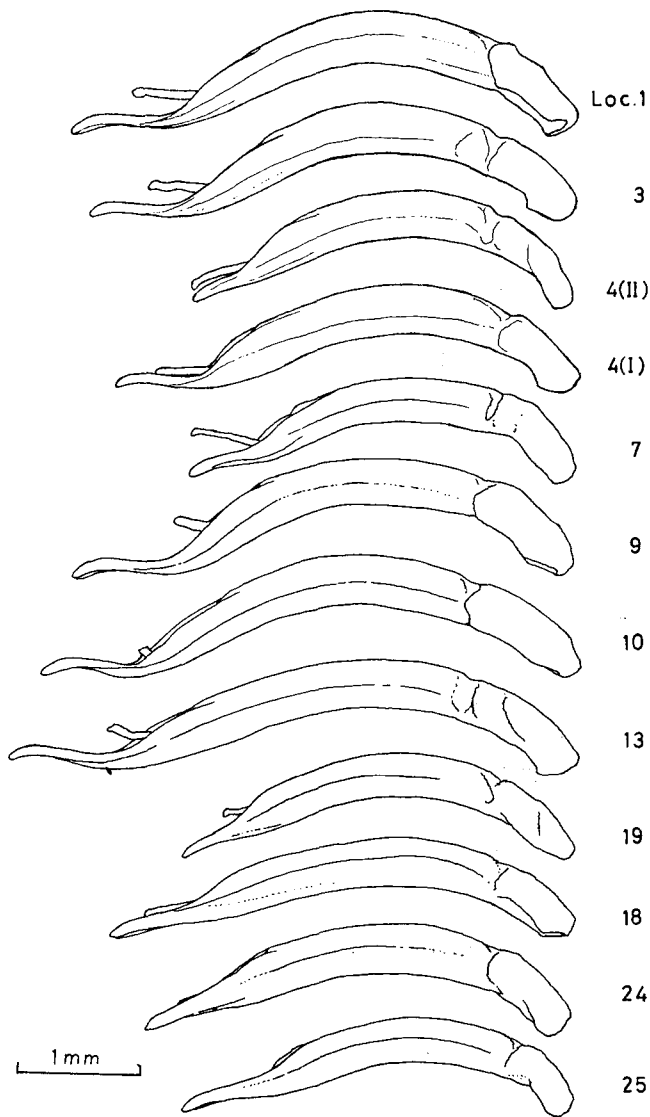


Fig. 7. Median lobe of the male genitalia, lateral view. Locality numbers, see text.

as in Soranuma-dake, with Da, Dp and DL ill developed, and are almost glabrous on the dorsal surface.

Studies of the larval characters are still limited to a few localities. The infraspecific geographical variations in these species should be surveyed before any conclusion is drawn concerning the larval characters of the complex.

#### CHARACTER CORRELATION

Fig. 11 shows the correlations among four (in the males) or three (in the females) characters in the *C. angusticollis*-complex.

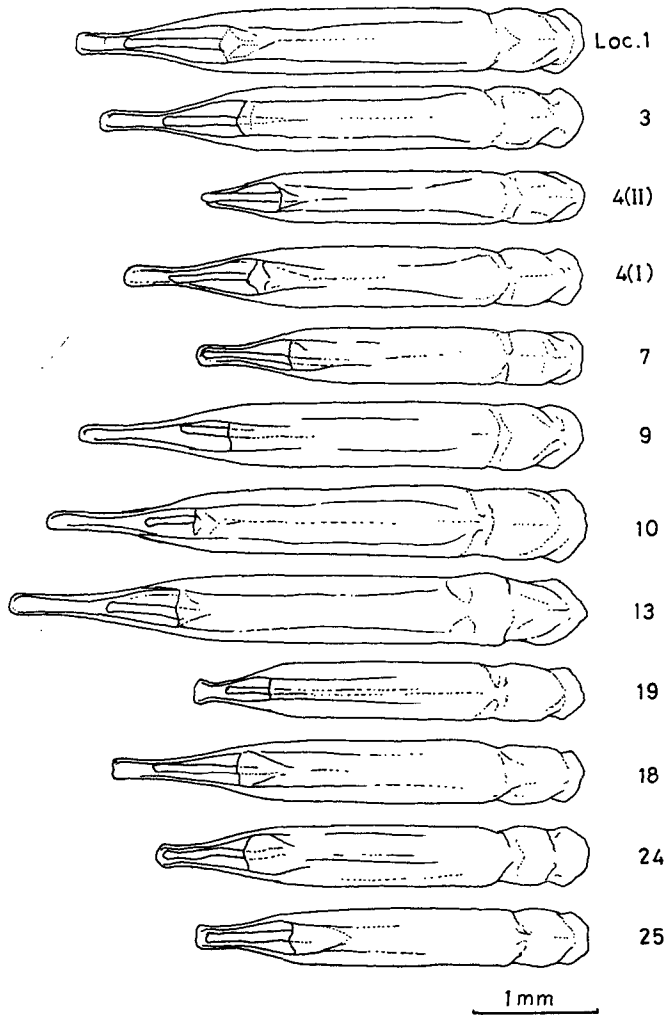


Fig. 8. Median lobe of the male genitalia, dorsal view. Locality numbers, see text.

Individuals with scale-like processes on the elytral surface always possess long elytra and hind wings in comparison with those without scale-like processes. The male genitalia of the former are usually bow-shaped and those of the latter are always straight or belong to the *porosirensis*-type. In the forms with smooth elytra *C. aino* is somewhat larger than *C. porosirensis* with respect to the elytral and hind wing lengths, but it is not certain whether the two species can always be separated by these characters (for the numbers of the specimens examined are too small).

#### LIFE HISTORY

No obvious difference has been found between *C. angusticollis* and *C. aino* with respect to their life history. Both species overwinter in the egg stage and the

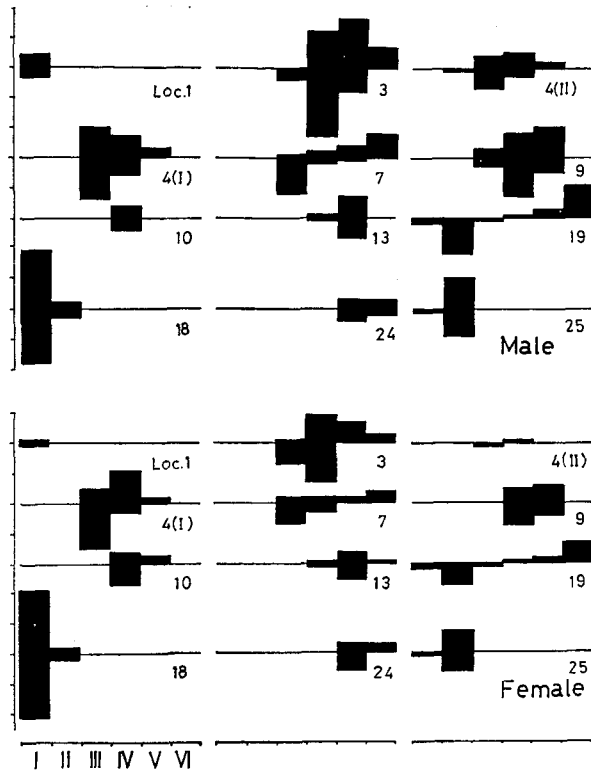


Fig. 9. Number of individuals belonging to classes of coloration. In each histogram, the coloration of pronotum is shown above, and that of elytra below, the horizontal line. Six classes of coloration are arranged from left to right. Each scale in ordinate represents ten individuals. Classes of coloration and locality numbers, see text.

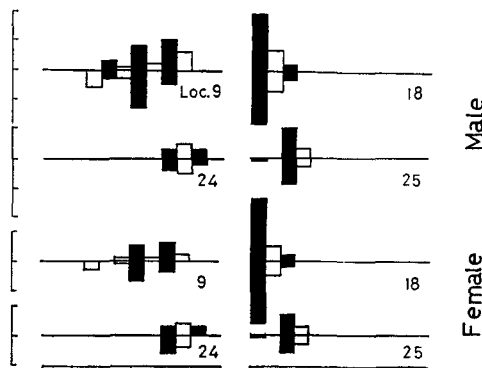


Fig. 10. Correspondence in coloration between *C. watanabei* and *C. angusticollis* or *C. aino*. The number of individuals of *C. angusticollis* or *C. aino* is represented by a solid bar and that of *C. watanabei* by an open bar. Classes and scale as in Fig. 9. Locality numbers, see text.

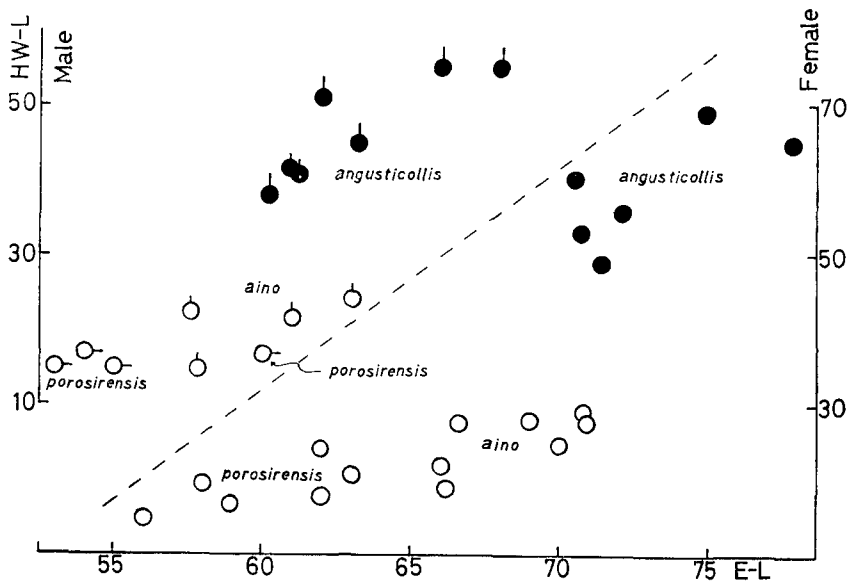


Fig. 11. Pictorial scatter diagram showing character correlations in the species of the *C. angusticollis*-complex. Mean hind wing length (HW-L) is plotted against mean elytral length (E-L). Solid circle represents reticulate, and open circle smooth, elytra. A long vertical bar at the top of a circle represents the bow-shaped (or *angusticollis*-type) male genitalia, and a short vertical bar the straight (or *aino*-type) male genitalia; a horizontal bar represents the *porosirensis*-type male genitalia.

eggs hatch in early to middle May immediately after thaw. The larvae lie hidden in the terminal buds of the host plants during daytime and generally feed during the night. In laboratory the first instar stage takes one or two days, the second two, the third three or four, the fourth four or five, the prepupal stage ten or eleven, and the pupal stage twelve or thirteen, thus adults emerge in thirty-four or thirty-five days after hatching. The reproductive period is rather long: copulation is observed from early June to early September and oviposition from middle July to early October. In contrast *C. aurichalcea* has a relatively short period of reproduction: the adults emerge in July and oviposit in middle September to middle October. Judging from the number of the individuals collected in the field, aestivation does not occur in the *C. angusticollis*-complex. After Suzuki (1974) the ovariole number is much smaller in *C. angusticollis* than in *C. aurichalcea*; this may be associated with the difference in the duration of reproduction between these species. In the *C. angusticollis*-complex the life span seems to be rather long. One male and one female of *C. aino*, which had been kept in snow, were alive even in late March. One female of *C. angusticollis* was collected in late April at Maruyama, Sapporo. But it is unknown whether the adults again contribute to egg production after hibernation. Little is known as to oviposition; in laboratory one female was observed to injure the tissue of the host plant by using the terminal process of her abdomen before ovipositing.

## DISTRIBUTION

The species of the *C. angusticollis*-complex are distributed in northeastern Asia including Manchuria, eastern Siberia, southern Kurile Islands (Kunashiri Is., after Kuwayama, 1967) and northern Japan. They have not been known from Korea, northern Kurile Islands and Sakhalin. In Japan they are distributed in Hokkaidō and Aomori Prefecture, the northernmost part of Honshū. The median lobe of the male genitalia illustrated by Chen and the hind wing by Jolivet show that the individuals recorded from Manchuria by them undoubtedly belong to *C. angusticollis* as here understood. The known localities for the three species in Japan are given in Fig. 12. *C. porosirensis* and *C. aino* are so closely similar in the females that it is not easy to identify material consisting only of females. The localities asterisked under Specimens examined, for which only female specimens

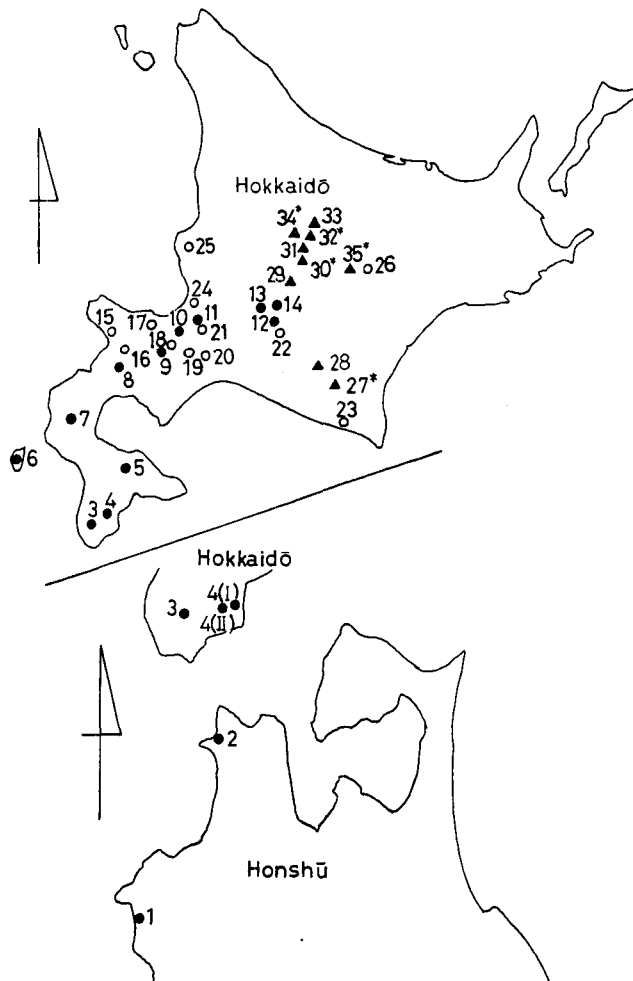


Fig. 12. Geographical distribution of the *C. angusticollis*-complex in Japan. Solid circle represents *C. angusticollis*, the open circle *C. aino* and the solid triangle *C. porosirensis*. Locality numbers, see text.

are available, are rather tentatively included in the range of *C. porosirensis*. Owing to lack of sufficient data not only from foreign countries, but also in Japan, it is still early to discuss the distribution of the species of this complex.

#### SUMMARY

1) *C. angusticollis* is characterized by having a network of scale-like processes on the elytral surface, which are especially conspicuous in the female, and which tend to be denser and more conspicuous in northern districts. *C. aino* and *C. porosirensis* lack them in both sexes.

2) The reduction of hind wings also shows an obvious difference between *C. angusticollis* and *C. aino*. In *C. angusticollis* the hind wings are smaller in southern localities. In *C. aino* and *C. porosirensis* they are more reduced.

3) The shape of the median lobe of the male genitalia is relatively stable in each of *C. angusticollis* and *C. aino*, though it is variable in some localities.

4) The coloration of the dorsal surface is considerably variable locally in each of the three species. In the localities where either of *C. angusticollis* or *C. aino* coexists with *C. watanabei*, the coloration is very similar between the paired species.

5) Larval characters also seem variable locally, especially in the development of the setae and tubercles.

6) There are obvious correlations among several characters of the adult beetles. However, the difference between *C. aino* and *C. porosirensis* is not remarkable except for the male genitalia.

7) In Japan, *C. angusticollis* occurs in the western half of Hokkaidô and Aomori Prefecture, Honshû, whereas *C. aino* is distributed in central Hokkaidô. The *C. angusticollis*-complex is also distributed in Manchuria, E. Siberia and S. Kurile Islands. The records of *C. angusticollis* from Manchuria seem correct.

#### ACKNOWLEDGEMENTS

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