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On the colour polymorphism in *Chrysolina aurichalcea* (Mannerheim) (Coleoptera : Chrysomelidae) collected from four mountain districts

By SHIZUO FUJIYAMA

Department of Biology, Faculty of Science, Shinshu University

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Abstract

The adults of *Chrysolina aurichalcea* were collected from four mountain districts to examine the relationship between adult colour polymorphism and altitude.

The ratio of two colour forms was found to change with altitude. The cupreous–form dominated at high altitude, while the cyaneus–form dominated at low altitude. Detailed collections at the Utsukushigahara Heights and in their vicinity showed that the reducing proportion of the cyaneus–form did not occur gradually with increasing altitude but did so abruptly at a precise altitude for each site. This altitude was different for the south slope and the west slope. The increase in the percentage of the cupreous–form at high altitude is discussed in relation to three possible explanations.

Introduction

It is well known that many chrysomelid beetles have colour polymorphisms. The adults of *Chrysolina aurichalcea* (Mannerheim) have several colour forms, but they have been classified roughly into two groups according to the colouration of the dorsum: the cyaneus–form and the cupreous–form. The ratio of the two colour forms in Japan differs from locality to locality. Concerning this phenomenon, OHNO (1964) mentioned that the cyaneus–form dominates on the Japan Sea side and the cupreous–form on the Pacific side. SUZUKI *et al* (1975 ; 1976 ; 1977), and SUZUKI and SAKURAI (1977 ; 1978) studied the geographical distribution of the two colour forms and mentioned that OHNO's opinion seemed to be generally applicable to central and southwestern Honshu with some exceptions. Their results show that the cyaneus–form dominates in many places in Honshu. But they have not analysed the relationship between the ratio of two colour forms and altitude. Although KIMURA (1965) reported that about 30 individuals from different mountainous regions in Shikoku district were all of the cyaneus-form, the samples were too small to conclude any frequency relationship.

In the present study, larger samples have been collected at different altitudes from four mountains in Honshu, and the relationship between the ratio of two colour forms and altitude has been investigated.

Materials and Methods

Study sites

Table. 1. Locations and altitudes of collecting stations.

Code of station	Place name	Location	Altitude	Number of individuals collected
A	Asahimachi	See Fig. 1	620m	229
B	—	See Fig. 1	630	31
C	Kanzawa	See Fig. 1	640	84
D	Oineta	See Fig. 1	750	53
E	Yamada	See Fig. 1	840	54
F	Ibuka	See Fig. 1	720	68
G	Misayama	See Fig. 1	800	162
H	—	See Fig. 1	870	57
I	—	See Fig. 1	920	29
J	Misuzuko	See Fig. 1	1000	38
K	—	See Fig. 1	1310	28
L	—	See Fig. 1	1500	21
M	—	See Fig. 1	1590	43
N	Tsutsujigaoka	See Fig. 1	1710	48
O	Ōgahana	See Fig. 1	2000	368
P	Ōwago	See Fig. 1	920	106
Q	—	See Fig. 1	1350	120
R	—	See Fig. 1	1420	41
S	—	See Fig. 1	1450	38
T	—	See Fig. 1	1550	408
U	Bandokoro	*	1250	21
V	Suzuran	**	1600	131
W	Mt. Hiei	***	680	102
I	Nikko st. 1	See Fig. 2	640	27
II	Nikko st. 2	See Fig. 2	680	53
III	Nikko st. 3	See Fig. 2	700	91
IV	Senjōgahara	See Fig. 2	1300	86
V	Kōtokubokujō	See Fig. 2	1400	106
VI	Odashiro	See Fig. 2	1400	58
VII	Yumoto	See Fig. 2	1500	118

* Bandokoro lies halfway up the east slope of Mt. Norikuradake, which is about 40km west-south-west of Matsumoto City.

** Suzuran lies halfway up the east slope of Mt. Norikuradake and is about 5.5km east of the top and 4km west of Bandokoro.

*** Mt. Hiei lies about 10km northeast of Kyoto City.

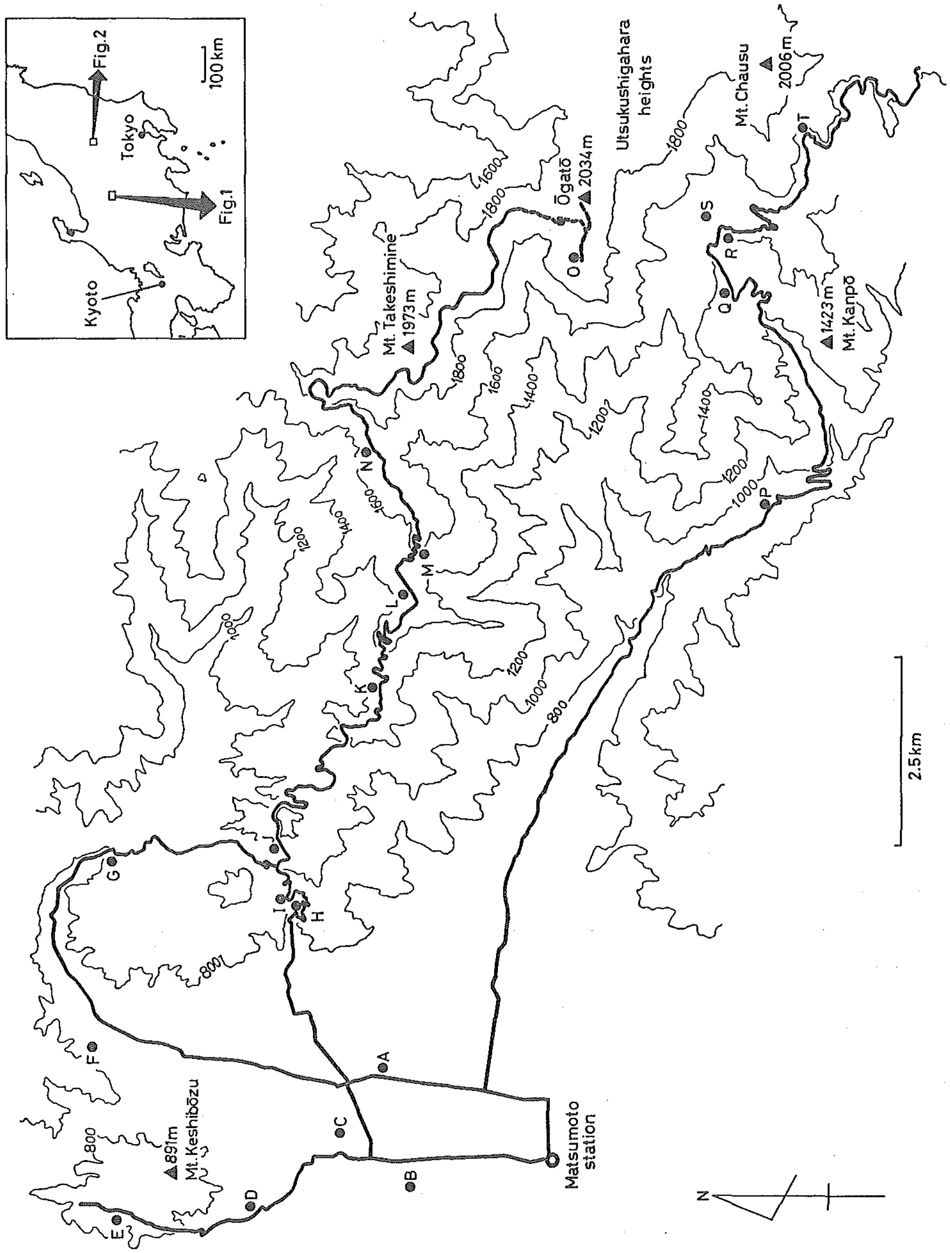

Fig. 1 Map showing the collecting stations at the Utsukushigahara Heights and in their vicinity. Stations are designated by alphabetical coding.

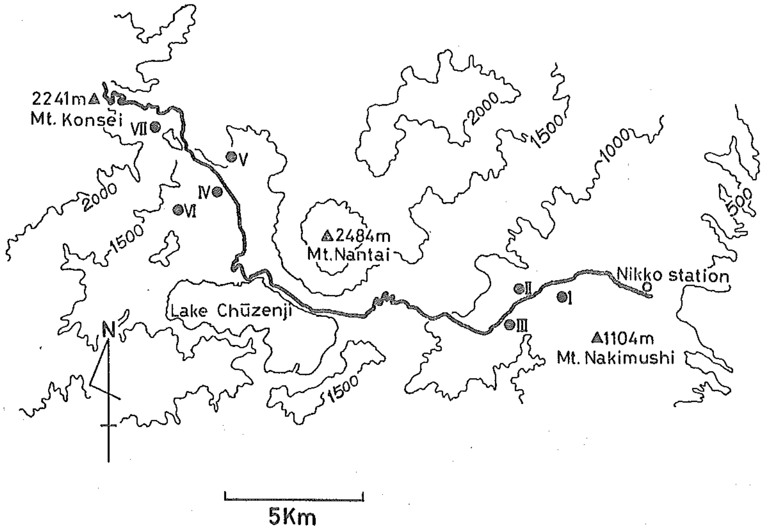

Fig. 2 Map showing the collecting stations in the vicinity of Nikko City. Arabic figures show the codes of stations.

The locations and altitudes of sites are listed and coded in Table 1. The locations relating to the Utsukushigahara Heights and the vicinity of Nikko City are shown in Figs. 1 and 2, respectively. In some cases, the distances between collecting stations were only a few hundred meters apart. As the food plants, mainly *Artemisia princeps*, stand discontinuously and the adults of *C. aurichalcea* have small dispersal ability due to their reduced wings, close stations such as these are treated as different populations.

Classification

The specimens collected at high altitude were identified by Dr. S. KIMOTO as *C. aurichalcea.*

The two colour forms were decided by the colour of the dorsum as done by SUZUKI *et al* (1975), *i. e.* the cupreous-form comprises only the individuals of which dorsum is all cupreous colour, and the cyaneus-form comprises all other colour forms.

All specimens were collected from May to December, 1977, and are assumed to belong to the same generation because the species has a univoltine life cycle.

Results and Discussion

Fig. 3 shows the relationship between the ratio of two colour forms over the different altitudes of the Utsukushigahara Heights and in their vicinity. The cupreous-form dominates at high altitude (70–80%), while the cyaneus-form dominates at low altitude. At low altitude, the cupreous-form was less than 10%, except at

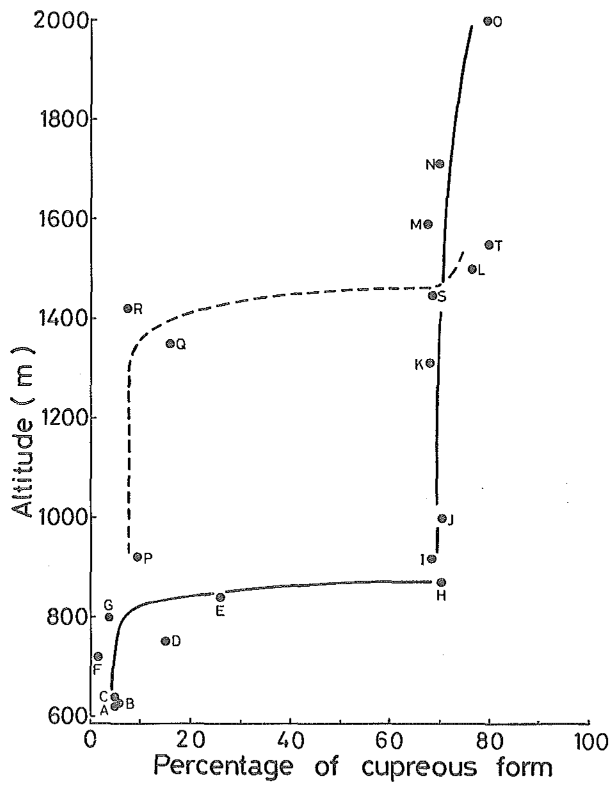

Fig. 3 The relationship between the altitude and the percentage of the cupreous-form in *C. aurichalcea* collected at the Utsukushigahara Heights and in their vicinity. The solid line refers to the west slope and the dotted line to the south slope.

D and Q stations. The change in the ratio of the two forms does not occur gradually with the increase of altitude but does so abruptly at precise altitudes, depending on aspect. On the west slope, this occurs between 800m (G) and 870m (H), as shown by solid line in Fig. 3, and on the south slope, 1420m (R) and 1450m (S) as shown by dotted line. The distance between G and H, and between R and S are short, *i. e.* about 2.5km, and less than 500m, respectively (Fig. 1).

Three possible explanations for the abrupt transition of dominant forms are considered : first, that the direction of selection pressure is different between the upper and lower part of the boundary; second, that the populations from the upper altitudes belong to different strains than those of the lower altitudes; third, that the difference is due to genetic drift.

The habitats were slightly different above and below the altitudinal boundary. Lower altitudes are comparatively open areas while upper altitudes are comparatively closed areas, being usually wooded regions. Therefore the direction of selection pressure may be different above and below the boundary. But even at higher altitudes, almost all beetles were collected from small open forest clearings, and in addition, the cupreous-form dominated the cyaneus-form in larger open areas *e. g.* 0 and T. Consequently, it is difficult to conclude whether or not the ratio of the two colour forms is influenced greatly by the habitat vegetation.

On Mt. Norikuradake and its vicinity, sampling was conducted at seven different altitudes but samples of not less than twenty were obtained at only two stations (U and V in Table 1). At Bandokoro (U), the cupreous-form comprised 38.1% and at Suzuran (V), 64.1%. The difference between these percentages is significant at the 0.05 level. At low altitude around Mt. Norikuradake, *e. g.* Matsumoto City (see footnote, Table 1) and Takayama City, about 30km west of Suzuran, the corresponding frequencies were less than 10% (plots A to G in Fig. 3; also see SUZUKI *et al.*, 1977). Thus the percentage of cupreous-form is higher at high altitude than at low altitude in this locality.

On the halfway up to Mt. Hiei (W in Table 1), the ratio was 34.3% cupreous-form, while on a nearby low altitude, Oiwake (alt. 50m; 6km southwest of Mt. Hiei), the ratio was low, 0% (in 12 samples taken by present author) or 2.4% (in 202 samples taken by SUZUKI and YAMADA in 1975 : see SUZUKI *et al.*, 1977). Consequently the ratio of cupreous-form appears to be higher at high altitude than

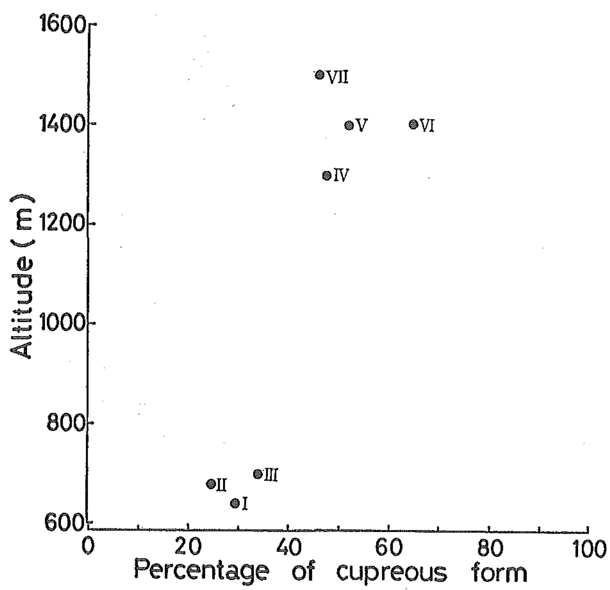

Fig. 4 The relationship between the altitude and the percentage of the cupreous-form in *C. aurichalcea* collected in the vicinity of Nikko City.

at low altitude in this locality.

Fig. 4 shows the percentages of the cupreous-form at seven places in the vicinity of Nikko City. The frequency of the cupreous-form was higher at high altitude above 1300m (about 50%) than at low altitude, 600-800m (about 30%). Again, these results suggest that the ratio of the cupreous-form is higher at high altitude than at low altitude.

Thus all results show an increase in the ratio of the cupreous-form at high altitude. The three explanations above can now be formulated more specifically: (1) there are some selection pressures changing with the increase of the altitude as in the first case discussed in the results of the Utsukushigahara Heights; (2) the strains from the mountain districts or closed area are different from the strains from the lowlands; (3) the differences are due to genetic drift.

The third explanation seems to be excluded because the higher ratio of the cupreous-form was consistently maintained at the high altitude of the Utsukushigahara Heights in spite of small dispersal ability. The second explanation seems unlikely because the main food plant, *A. princeps* is a pioneer plant. That is unlikely to sustain sufficient populations of *A. princeps* to maintain *C. aurichalcea* in the mountainous districts which are usually covered with woods. The first explanation is therefore considered to be the most probable.

According to the reports of KIMURA (1965) and SUZUKI *et al* (1975), all specimens from the Loochoo Islands, southwest of the Japanese Islands, belonged to cupreous-form. In the Japanese Islands, the cyaneus-form usually dominates, and further, the ratio of cupreous-form gradually decreases from southwest to northeast in southwestern Honshu (SUZUKI *et al*, 1977). These records suggest that the geographical cline in the ratio of two colour forms shows a decrease in the cupreous-form with an increase in latitude. Given that this is true, and given that the ratio of the cupreous-form is higher at high altitude than at low altitude, it is difficult to explain these phenomenon by the differences of habitat temperature as suggested to the colour polymorphism in *Harmonia axyridis* by KOMAI (1963) because the habitat temperature usually decreases with an increase in latitude and altitude.

MANI (1968) stated that pronounced dark pigmentation of the body was one of the most striking characters of nearly all high altitude insects. The present results may be linked with this phenomenon, but an adequate explanation must await further investigation.

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