

MORPHOLOGICAL AND BIOGEOGRAPHICAL RELATIONSHIPS OF
CLOSELY RELATED SPECIES OF THE GENUS AMIOTA
(DIPTERA, DROSOPHILIDAE)

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Synopsis. Intraspecific and interspecific variations in quantitative characters, both meristic (clasper teeth number) and non-meristic (wing length) of two closely related drosophilid species, *Amiota furcata* and *A. subfurcata*, are analysed especially in relation to horizontal and vertical distributions. Correlations between these two characters are highly positive interspecifically, while very low intraspecifically. In each species, the larger flies are distributed higher and more northward than the smaller flies. Discussions are made of possible factors leading to these morphological and biogeographical variations.

Amiota furcata Okada and *A. subfurcata* Okada are so closely related as originally thought conspecific and put together under *A. alboguttata* forma *furcata* by me (1960). It was shown that this forma has a remarkable dimorphism in the number of clasper teeth, about 5-7 and 10-13, which was later interpreted as to represent two good species, *furcata* and *subfurcata*, respectively (Okada, 1971). The present study is intended to find further morphological and biogeographical relationships within and between the two species in question.

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Material and methods

About a hundred male specimens, two-thirds of which belong to *A. subfurcata* and the remaining one-third to *A. furcata*, were used. These are nearly all of the specimens thus far obtained during these ten years. The number of clasper teeth and the wing length (distance between distal cross suture on the base of vein R and wing apex) were examined by the mounted material.

Morphological comparison

The diagnostic characters of the two species were previously given by me (1971), which are summarized below.

Front (Figs. 4, 5) unicolorously brownish black and anteriorly not prominently narrowing in *subfurcata*, silvery pollinose in front view and anteriorly prominently narrowing in *furcata*. Genital arch (Figs. 6, 7) somewhat narrowing toward mid-dorsal line in *furcata*, not prominently narrowing in *subfurcata*. Aedeagus lobe plus anterior paramere (Figs. 8, 9) longer than broad in *subfurcata*, broader than long in *furcata*. Clasper teeth (Figs. 6, 7) more numerous in *furcata* than in *subfurcata*. Wings longer in *furcata* than in *subfurcata*.

The number of clasper teeth often differs between right and left sides in a single specimen, and in such case the higher value is adopted for the present analysis. The counts resulted as in Fig. 1 and as summarized below.

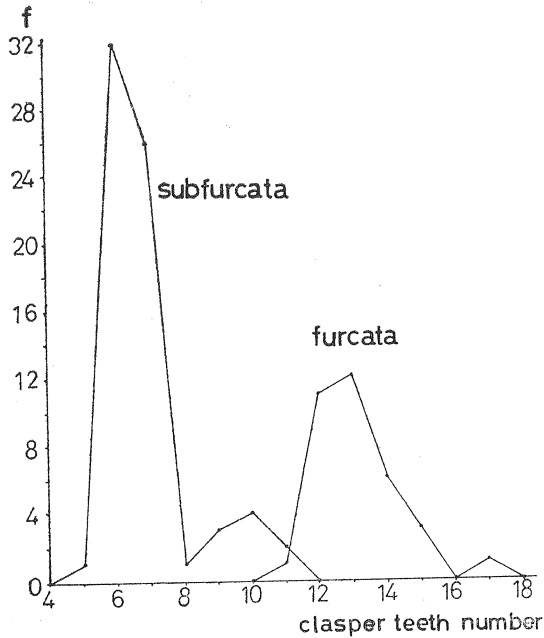


Fig. 1. Frequency diagrams of the number of clasper teeth in *Amiota furcata* and *A. subfurcata*. f. number of individuals.

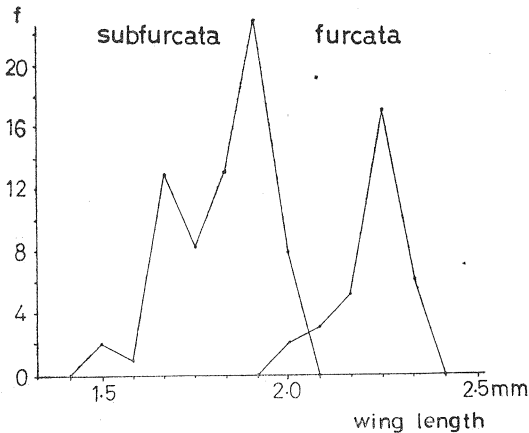


Fig. 2. Frequency diagrams of the wing length in *Amiota furcata* and *A. subfurcata*. f. number of individuals.

2.22 mm in *furcata* and 1.83 mm in *subfurcata*, are confined in distribution to Hokkaido and the high lands of central Honshu.

	n	m	s	range
<i>furcata</i>	34	13.09	1.22	11-17
<i>subfurcata</i>	67	6.90	1.21	6-11

The results of measurement of the wing length are as shown in Fig. 2 and as summarized below.

	n	m	s	range
<i>furcata</i>	33	2.22mm	0.09mm	2.0-2.3mm
<i>subfurcata</i>	67	1.83mm	0.77mm	1.5-2.0mm

The correlation coefficient between the number of clasper teeth and the wing length calculated with thirty-three specimens of *furcata* is -0.072 , which shows that the correlation is very low. The same is true for *subfurcata*, the correlation coefficient calculated with sixty-seven specimens being -0.235 . If, however, a total of a hundred specimens, thirty-three *furcata* and sixty-seven *subfurcata*, are combined, the resulted correlation becomes highly positive, r being 0.789 (Fig. 3).

Horizontal and vertical distributions in relation to the wing length

Thus far found, *furcata* is horizontally distributed from Hokkaido to Kyushu, and *subfurcata* from Hokkaido to Taiwan. They are often found coexistent, e.g., at Nuruyu, Miyagi Pref., Takanosu, Niigata Pref., Kitakaruizawa, Gumma Pref., and Kumotoriyama, Tokyo (Figs. 10, 11). Concerning the vertical distribution, *subfurcata* extends from low lands to high, while *furcata* is confined to high lands.

It is also found that the flies having wing length more than the mean values of the total flies of the respective species thus far examined,

Discussion

The mean number of the clasper teeth of *furcata* ($m_f=13.09$) is nearly twice that of *subfurcata* ($m_s=6.90$). The percentage test for assuming $P=1/2$ was proved as below.

$$t = \frac{(m_s/m_f - P)\sqrt{m_f}}{\sqrt{P(1-P)}} = 1.19 < 1.96$$

Likewise, the assumption that $P=1/\sqrt{2}$, which refers to that the wing length of *furcata* ($m_f=2.22$ mm) is $\sqrt{2}$ times that of *subfurcata* ($m_s=1.83$ mm), or that the wing area of the former is twice that of the latter, was proved:

$$t = 0.18 < 1.96$$

The parallel duplication of clasper teeth number and wing area between the two related species might be ascribed to the phenomenon of cell division, similarly as in the case of "cephalization constant" of

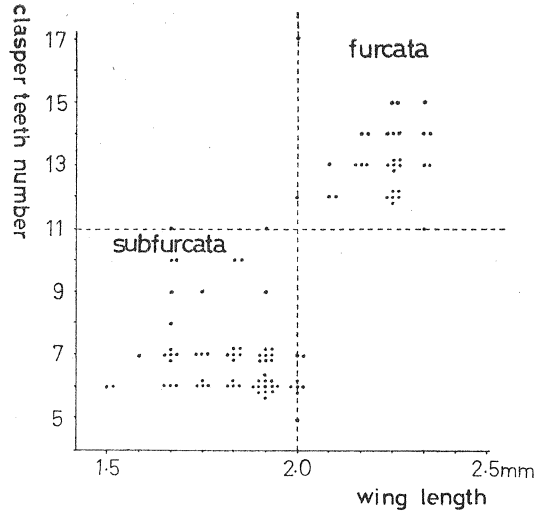
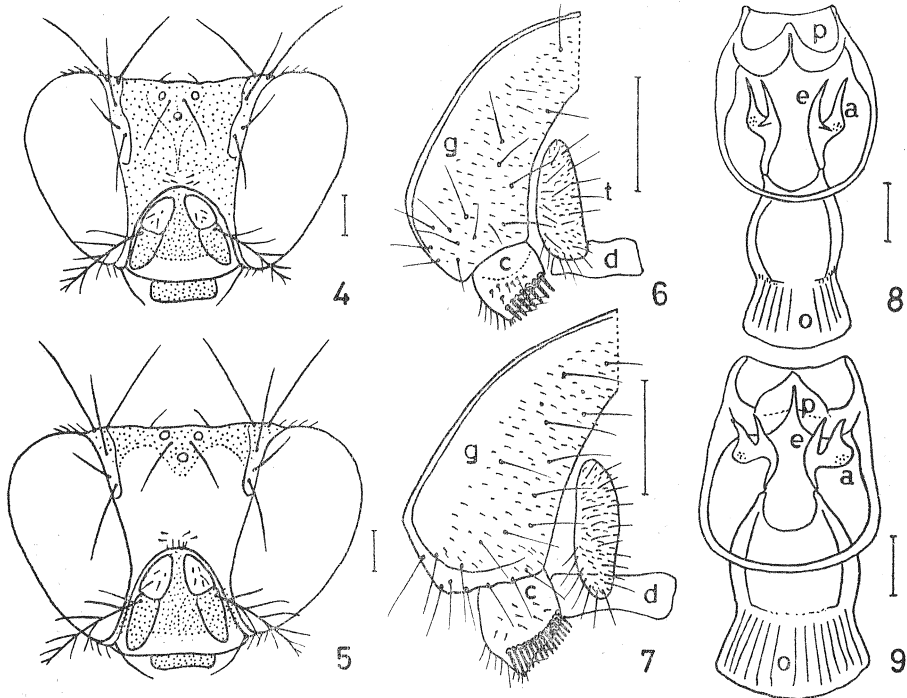


Fig. 3. A diagram showing correlation between the number of clasper teeth and the wing length in *Amiota furcata* and *A. subfurcata*.



Figs. 4-9. *Amiota subfurcata* (4, 6, 8) and *A. furcata* (5, 7, 9). 4,5. Head; 6,7. Peripheral phallic organs; 8,9. Phallic organs, ventral aspect. a. anterior paramere; c. clasper; d. decasternum or bridge connecting claspers; e. aedeagus; g. genital arch; o. apodeme of aedeagus; p. posterior paramere; t. anal plate.

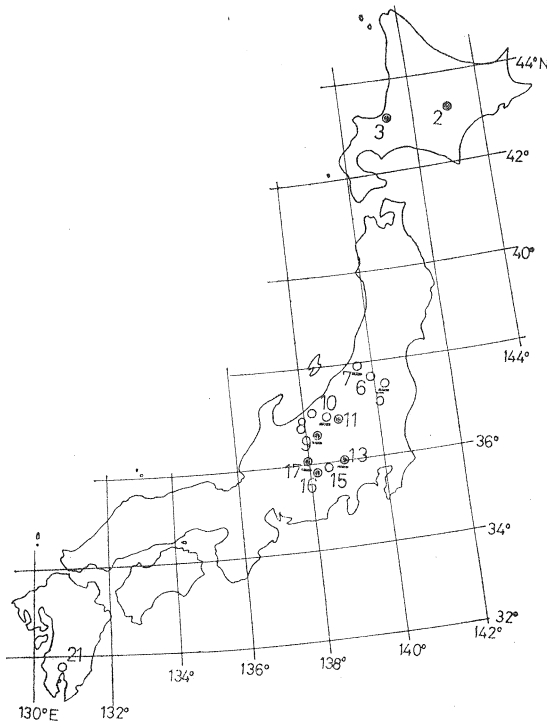


Fig. 10. Geographical distribution (circles) of *Amiota furcata* in relation to the wing length. Locality number corresponds to that in Table 1. Double circle shows the average wing length to be larger than total mean. A cross bar under a circle means coexistence of *A. furcata* and *A. subfurcata*.

Dubois and Brummerkamp in vertebrates. This constant refers to a constant proportion, $\sqrt{2^k}$, of the growth index, $b\sqrt{2^k}$, in the allometric formula:

$$v = b\sqrt{2^k} x^a$$

where v is the weight of cerebral hemisphere, x is body-weight, b is the initial growth index in *Homo sapiens*, and a is allometric constant. The value k is a whole number or zero, varying according to the kinds of mammals (after de Beer, 1940).

The correlation between the number of clasper teeth and the wing length is very low, r being -0.072 and -0.235 in *furcata* and *subfurcata*, respectively. Similar low correlations between these two organs are known by *Drosophila subobscura* Collin (Prevosti, 1935) and *D. bifasciata* Pomini (Okada, unpublished). It can therefore be assumed that low correlation between these two organs is characteristic of species at least in the family Drosophilidae. This is one of the reasons why *furcata* and *subfurcata* are treated as different species.

Table 1. Distribution of *Amiota furcata* in relation to the wing length.
* as large as or larger than the mean.

No.	Locality	Number of specimens	Mean wing length (mm)
2	Nukabira, Hokkaido	3	2.30*
3	Nopporo, Hokkaido	2	2.22*
5	Nuruyu, Miyagi Pref.	4	2.07
6	Takayu, Yamagata Pref.	1	2.13
7	Takanosu, Niigata Pref.	1	2.03
8	Tsubameonsen, Niigata Pref.	3	2.17
9	Sugadaira, Nagano Pref.	1	2.22*
10	Kitakaruzawa, Gumma Pref.	1	2.15
11	Hoshionsen, Gumma Pref.	1	2.22*
13	Kumotoriyama, Tokyo	3	2.28*
15	Kitadake, Yamanashi Pref.	2	2.20
16	Masutomi, Yamanashi Pref.	10	2.27*
17	Kiso-Komayu, Nagano Pref.	1	2.23*
21	Kirishimaonsen, Kagoshima Pref.	1	2.00
		Total 34	Mean 2.22

The results of observation reveal that the flies of *furcata* and *subfurcata* having wings longer than or as long as the mean values, 2.22 mm and 1.83 mm, respectively, are restricted in distribution in the northern area (Hokkaido) and the higher lands of central Honshu (Figs. 10, 11).

Asahina (1950) considered that the insect species having the center of distribution in the southern area tend to become larger in body size northward and that the species having the center in the northern area to become larger southward. The species of the genus *Amiota* seem to have their center of distribution in the temperate or subtropical regions of the world. They are rich in number in Japan, North America (according to Dr. G. C. Steyskal's personal information), and Europe (according to Dr. E. B. Basden's personal information). In this context, the patterns of distribution of *furcata* and *subfurcata* might fit to Asahina's rule. The phenomenon of the wings

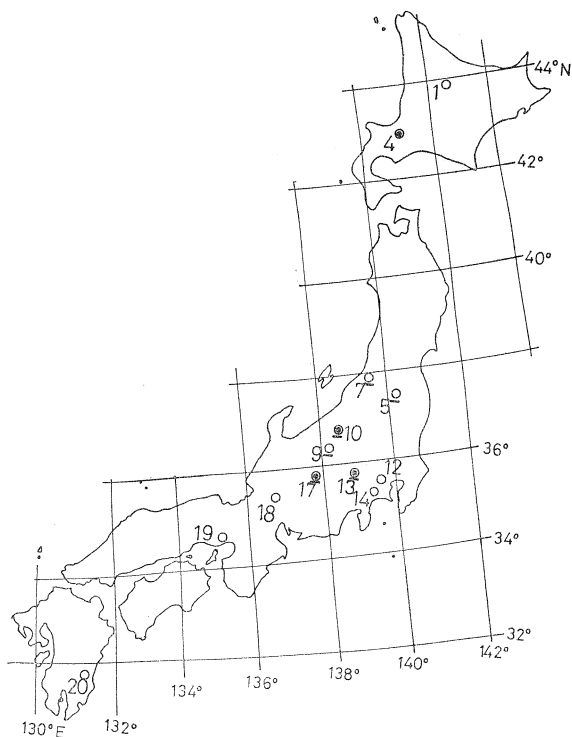


Fig. 11. Geographical distribution (circles) of *Amiota subfurcata* in relation to the wing length. Locality number corresponds to that in Table 2. Double circle and cross bar as in Fig. 10.

Table 2. Distribution of *Amiota subfurcata* in relation to the wing length.

* as large as or larger than the mean.

No.	Locality	Number of specimens	Mean wing length (mm)
1	Sounkyo, Hokkaido	1	1.80
4	Sapporo, Hokkaido	1	1.95*
5	Nuruyu, Miyagi Pref.	1	1.75
7	Takanosu, Niigata Pref.	2	1.57
9	Sugadaira, Nagano Pref.	13	1.80
10	Kitakaruizawa, Gumma Pref.	22	1.91*
12	Asakawa, Tokyo	1	1.80
13	Kumotoriyama, Tokyo	2	1.95*
14	Susugaya, Kanagawa Pref.	9	1.65
17	Kiso-Komayu, Nagano Pref.	1	1.87*
18	Tanigumi, Gifu Pref.	1	—
19	Kiyotaki, Kyoto Pref.	3	1.65
20	Saitoshi, Miyazaki Pref.	10	1.75
22	Wulai, Taiwan	1	—
		Total 68	Mean 1.83

becoming larger in the cooler regions can be interpreted by the fact of relative growth of soma and gonads. The growth of gonads would delay under low temperature and that of soma prolonged as far as the gonads mature, resulting thus larger soma (Rensch, 1954).

Summary

Amiota furcata Okada and *A. subfurcata* Okada, closely related drosophilid species, are compared morphologically and biogeographically. Duplications in the number of clasper teeth and the wing area of *furcata* as compared to those of *subfurcata* are perceived and interpreted by the phenomenon of "cell division". The correlation between these two organs is highly positive interspecifically, while it is very low intraspecifically. *A. furcata* is distributed mainly in the northern regions of Japan and higher lands of central Honshu, while *subfurcata* in lower lands and more southward. The distributional range of the flies of each species having comparatively large wings is apt to be confined to Hokkaido and the higher lands of central Honshu. This size difference is interpreted from standpoint of adaptation.

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