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A Note on the Food Resources of Domestic *Drosophila* in Northern Japan[1]

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Abstract

The domestic species of *Drosophila* are all polyphagous and utilize a wide variety of food substrates in northern Japan. However, differences in the food preferences among species were unequivocal. *D. melanogaster*, the best-known domestic drosophilid, and its sibling *D. simulans* preferred fermenting fruits, and *D. busckii* and *D. funebris* decayed vegetables and fungi. Adult flies of the latter two species were also attracted to decayed animal matter. *D. immigrans* utilized many kinds of food substrates (fruits, vegetables, fungi, tree sap and so no), whereas *D. virilis* fed on only decayed bark and brewery matter.

Introduction

A number of field surveys on the feeding habits of wild and domestic drosophilids have been performed in many countries, since knowledge of the food substrates of *Drosophila* is necessary when studying the adaptation and evolution of the species (Sturtevant, 1921 ; Carson and Stalker, 1951 ; Carson, 1965, 1971 ; Atkinson and Shorrocks, 1977 ; Parsons and Stanley, 1981). In Japan, little data are available on the food

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substrate of domestic drosophilids, especially for the oriental domestic species, *D. virilis*. The present paper provides feeding and breeding records of domestic drosophilids in Hokkaido and Tohoku, northern Japan.

Methods of the Field Survey

Organic materials suspected to contain eggs or larvae of drosophilids were collected in the field. The samples were placed in milk bottles (180 ml in vol.) or jars (1000 ml) with the tops covered with cotton or gauze. Small pieces of tissue paper were placed in the bottles and jars to offer suitable pupation sites for the drosophilid larvae. These bottles and jars were kept at room temperature, and emerged flies were collected and identified. The feeding habits of the adult flies were studied by collecting them on substrates.

Results and Discussion

A total of 21 of the organic samples yielded domestic *Drosophila*, and all the feeding and breeding records are listed in Appendix 1. As the collection was not quantitative, a comparison of the number of individuals reared from each substrate is not made, and the feeding habits are discussed separately by the food item (Fig. 1). Larvae and adults of some wild species have been known to show different food preferences (Carson and Stalker, 1951; Kimura *et al.*, 1977), but this need not be the case for domestic species, since most substrates visited by adult flies were used for breeding.

Fig 1. Resource utilization of domestic drosphilids in feeding (open circles) and breeding (closed ones).

	Fruit	Vegetables	Wild herbaceous plants	Tree sap and bark	Mushrooms	Animal matter
D. melanogaster	●	○	●	○	●	–
D. simulans	●	–	–	–	–	–
D. busckii	●	●	●	●	●	○
D. immigrans	●	●	●	●	●	–
D. virilis	○	–	–	●	–	–
D. funebris	–	●	–	○	●	○
D. hydei	–	○	–	○	–	–

Generally, the domestic species are polyphagous and their food preference ranges are wider than those of wild drosophilids (Carson, 1971; Kimura *et al.*, 1977 and its references). *D. immigrans* has been reported to utilize a great variety of substrates for feeding and breeding (Carson, 1965). In the present study *D. immigrans* was observed

to utilize all kinds of substrates excluding animal matter. This species utilizes wild fruits found commonly in the forests of Hokkaido, silvervine *Actinidia arguta*, grape *Vitis Coignetiae,* and yew *Taxus cuspidata*. This may be related to the presence and abundance of, *D. immigrans* there (Watabe, 1984).

D. busckii fed on all substrates, including animal matter: adult flies have been observed to be attracted to human feces at Tokachi-Mitumata, eastern Hokkaido and to rotten fish at Kikonai, southern Hokkaido (cf. Watabe, 1990). *D. busckii* may be said to be truly associated with man. It is also notable that adult flies of *D. busckii* were relatively rare on fresh fruit but became abundant with the proceeding decay: four adults were collected on tomatoes discarded in an experimental field of the University on September 22, 1985, but after one week thirty three flies were obtained on the same substrate.

The breeding of *D. melanogaster* has been reported from four kinds of substrates, fruit, vegetables, tree-sap and mushrooms (Burla, 1951; Carson, 1965). In the present survey, feeding and/or breeding of *D. melanogaster* was further confirmed on three man-made products, vinegar, beer and fermenting rice-bran. Atkinson and Shorrocks (1977) have surveyed the emergence of the domestic species from fruits and vegetables discarded at a market in England, and they observed that *D. melanogaster* is associated with the fermentation of fruit, whether under natural or artificial conditions. The breeding of *D. simulans* was confirmed only on fruit. As its breeding has been observed mainly on fruit (Carson, 1965), it appears that the food range of *D. simulans* is narrower than that of *D. melanogaster.*

Sturtevant (1921) has described the *D. funebris* larva as a scavenger feeding on rotting vegetables. In the present study, its breeding was confirmed on decayed fleshy fungi as well as decayed vegetables, and on human feces at Tokachi-Mitsumata as well as on tree sap at a timberyard in Ashoro in eastern Hokkaido. The adult flies of *D. hydei* were collected on rotten tomatoes and pumpkins in southern Hokkaido, but breeding was not confirmed.

D. virilis shows the narrowest range of breeding substrates. Its breeding has been confirmed on two kinds of substrates, man-made matter (beer, vinegar and so on) and decayed bark at timberyards (Kaneko *et al.*, 1966; Watabe, 1984). However, *D. virilis* is also attracted to artificial banana bait, and it was observed to gather on wild fruits (*Plunus mume*) on the ground near a brewery in Sapporo. Further, this species can be cultured with tomatoes in the laboratory. These data suggest the possibility of breeding of *D. virilis* on fruit. The other members of the *virilis* species-group are all monophagous and utilize decayed bark or tree sap for breeding and feeding (Throckmorton, 1975; Watabe and Higuchi, 1979; Watabe, 1986). Like wild members of this group, *D. virilis* may originally have utilized such substrates before its adaptation to man-made environments with high concentrations of ethanol and acetic acid.

The following considers the "*habitats*" and "*ecological niches*" of domestic drosophilids, two terms of which have been used without clear distinction. As mentioned elsewhere (cf. Watabe, 1990), a "domestic environment" has been considered as a comparison with various natural environments (cf. Dobzhansky, 1965 ; Minami *et al.*, 1979) and the term "domestic niche" is frequently used. This implies a single homogeneous ecolgical man-made niche. On such an ecological basis, a large number of laboratory experiments have been carried out on interspecific competition, as most domestic drosophilids are distributed sympatrically and inhabit restricted areas. The best-focussed interspecific relationship has been found in a pair of sibling species *D. melanogaster* and *D. simulans*. Moore (1952a, b) used population cages at 25 °C to find that *D. simulans* is usually eliminated by *D. melanogaster* in mixed cultures of these two species. Similar experiments, which are rather difficult to assess on an ecological basis in the wild, have been carried out from the 1950s to the early 1970s. Tantawy and El-Wakil (1970) found that *D. funebris* is rapidly eliminated by *D. virilis* in mixed cultures of the two species. However, these two species have rarely been collected together anywhere. This kind of indefinite assessment of laboratory experiments is mainly due to insufficient knowledge of the biology of domestic drosophilids in the wild and partially due to confusion over "habitat" and "ecological niche".

The *habitat* of an organism is the place where it lives, whereas an *ecological niche* is a more inclusive term combining the physical space occupied and its functional role and position in the community (cf. Odum, 1976 ; Pianka, 1978). Most domestic drosophilids coexist in restricted areas, and this only indicates that the domestic species have the same habitat (=microdistribution), whereas it is uncertain if niche overlap is complete or partial. *D. funebris* and *D. virilis* share neither habitat nor niche, at least in Japan, as they show different food preferences and different microdistribution (Watabe, 1990). *D. melanogaster* and *D. funebris* share the same habitat but occupy separate niches, as they are sympatrical in some districts but show different food preferences. Confusion about "habitat and niche" has been often developed in the domestic species of *Drosophila*, as these two samples show.

In the interspecific relationships of domestic drosophilids, it is important to compare feeding and breeding substrates, as Carson (1971) has clearly stated: "the major specificity of ecology of *Drosophila* relates to the niche in which the females of the species deposit their eggs". All domestic drosophilids are polyphagous, but there are great differences in food preferences.

Humans utilize numerous kinds of organic materials, and they are found in kitchens, cultivated fields, and dumps. In breweries, man produces substrates with much ethanol or acetic acid. Many drosophilids live in this kind of man-made environments, with preferences for different biotic and abiotic components (Watabe, 1990, 1991). Generally domestic drosophilid niches overlap only partially, with some resources shared and others used exclusively by different species. This may allow domestic

species to coexist in proximity.

This discussion clearly shows that the so-called "domestic environment" is not a single homogeneous environment but that it consists of quite heterogeneous eclogical components.

References

Atkinson, W. B. and B. Shorrocks, 1977. Breeding site specificity in the domestic species of *Drosophila*. Oecologia, **29**: 223-232.

Burla, H., 1951. Systematik, Verbreitung und Oekologie der *Drosophila*-Arten der Schweiz. Rev. Suisse Zool., **58**: 23-175.

Carson, H. L., 1951. Breeding sites of *D. pseudoobscura* and *D. persimilis* in the transition zone of the Sierra Nevada. Evolution, **5**: 91-96.

———, 1965. Chromosomal morphism in geographically wide-spread species of *Drosophila*. *In* "The Genetics of Colonizing Species" (H. G. Baker and G. L. Stebbins, eds.), pp. 503-521. Academic Press, New York.

———, 1971. The ecology of *Drosophila* breeding sites. Harold L. Lyon Arboretum Lecture, Number **2**: 1-27.

——— and H. D. Stalker, 1951. Natural breeding sites for some wild species of *Drosophila* in the eastern United States. Ecology, **32**: 317-330.

Dobzhansky, Th., 1965. "*Wild*" and "*domestic*" species of *Drosophila*. *In* "The Genetics of Colonizing Species" (H. G. Baker and G. L. Stebbins, eds.), pp. 533-546. Academic Press, New York.

Kaneko, A., M. Kawakami and H. Takada, 1966. *Drosophila* Survey of Hokkaido, XXII. Drosophilid flies collected in breweries. J. Fac. Sci., Hokkaido University, Ser. VI (Zool.), **16**: 31-37.

Kimura, M. T., M. J. Toda, K. Beppu and H. Watabe, 1977. Breeding sites of drosophilid flies in and near Sapporo, northern Japan, with supplementary notes on adult feeding habits. Kontyû, Tokyo, **45**: 571-582.

Merrell, J., 1951. Interspecific competition between *Drosophila funebris* and *D. melanogaster*. Amer. Nat., **85**: 159-169.

Minami, N., M. J. Toda and K. Beppu, 1979. Ecological structure of drosophilid assemblage in Tomakomai Experimental Forest, Hokkaido University. Res. Bull. Coll. Agr., Hokkaido University, **36**: 479-508. (In Japanese with English summary.)

Moore, J. A., 1952a. Competition between *Drosophila melanogaster* and *Drosophila simulans*. I. Population cage experiments. Evolution, **6**: 407-420.

———, 1952b. Competition between *Drosophila melanogaster* and *D. simulans*. The improvement of competitive ability through selection. Proc. Natl. Acad. Sci., U. S. A., **38**: 813-817.

Odum, E. P., 1976. Fundamentals of Ecology (3rd edition). xiv+574pp. Saunders Co., Philadelphia.

Parsons, P. A. and S. M. Stanley, 1981. Domesticated and widespread species. *In* "The Genetics and Biology of *Drosophila*" (M. Ashburner, H. L. Carson and J. N. Thompson, Jr. eds.), **3a**: 349-393. Academic Press, London.

Pianka, E. R., 1978. Evolutionary Ecology (2nd edition). xii+397pp. Harper and Row Publ., New York.

Sturtevant, A. H., 1921. The North American species of *Drosophila*. Carnegie Inst. Wash. Publ., **301**: 1-150.

Tantawy, A. O. and H. M. El-Wakil, 1970. Studies on the natural Populations of *Drosophila*. XI. Fitness components and competition between *Drosophila funebris* and *D. virilis*. Evolution, **24**: 528-530.

Watabe, H.,1984. Microdistribution and phenology in domestic species of *Drosophila* in and near a brewery in Sapporo, northern Japan. J. Hokkaido University of Education, Sec. IIB, **34**: 41-52.

———, 1984. Niche breadth and seasonal changes in domestic of *Drosophila* collehted at Fujino in the Suburbs of Sapporo City. J. Hokkaido University of Education, Sec. IIB, **35**: 1-17.

———, 1986. Some ecological studies of drosophilid flies in the vicinity of the Mogami River, Tohoku district, northern Japan. J. Hokkaido University of Education, Sec. IIB, **36**: 75-80.

———, 1990. Geographic distribution and habitats of domestic drosophilids in Hokkaido, northern Japan. J. Hokkaido University of Education, Sec. IIB, **40**: 81-87.

———, I. Koshi-ishi and F. Yakushi, 1991. Effects of temperature on eco-physiological properties of domestic *Drosophila* species. J. Hokkaido University of Education, Sec. IIB, **42**: 1-25.

Appendix 1. Breeding and feeding records of domestic drosophilids. Numbers in parentheses are the number of adults eclosed.

〈Breeding or feeding substrates

Fruit: F_1=plum *Prunus mume*, F_2=wild plum *Actinidia arguta*, F_3=water melon *Citrullus Battich*, F_4=melon *Cucumis Melo* var. *Makuwa*, F_5=tomato *Lycopersicon esculentum*, F_6=waltnut tree *Juglans mandshurica*, F_7=mulberry *Morus bombycis*.

Vegetables: V_1=cabbage *Brassica oleracea* var. *capitata*, V_2=onion *Allium Cepa*, V_3=potato *Solanum tubesosum*, V_4=pumpkin *Cucumis Pepo*, V_5=cucumber *Cucumis sativus*.

Decayed leaves or stems of wild herbaceous plants: L_1=*Trifolium repens*.

Tree-sap: T_1=white cedar *Thujopsis dolabrata* var. *hondae*, T_2=conifer *Picea glehnii*, T_3=cedar *Cryptomeria japonica*, T_4=beech *Fagus crenata*, T_5=elm *Ulmus davidiana*, T_6=birch *Bentula platyphylla* var. *japonica*, T_7=linden tree *Tilia japonica*.

Decayed bark: B_1=cedar *Cryptomeria japonica*, B_2=coniferous trees imported from Siberia (tree species could not be identified).

Mushrooms: M_1=*Armillariella mella*, M_2=*Polyporellus squamosus* (?), M_3=*Coprinus atrementarium*.

Other: O_1=beer, O_2=vinegar, O_3=human feces, O_4=rotten fish and mollusk, O_5=fermenting rice bran.

〈*Drosophila* species〉

D. melanogaster: **F_1** (48),**F_3** (49),**F_4(5)**, **F_5**, **F_7**, **V_1**, **T_1**, **T_2**, **O_1** (2), **O_2** (many), **O_5**.

D. simulans: **F_5** (2)

D. busckii: **F_3 (85)**, **F_4** (11), **F_5** (90), **V_1** (26), **V_2** (18), **V_3** (26), **V_4**, **V_5**, **T_1**, **T_3** (23), **T_4**, **T_5** (1), **T_6** (7), **B_1** (12), **M_1** (4), **O_3**, **O_4**, **O_5**.

D. immigrans: **F_1** (73), **F_2** (4), **F_4** (5), **F_5** (64), **F_6** (23), **F_7**, **V_1** (4), **V_4**, **V_5**, **L_1** (2), **T_5** (27), **T_7**, **M_1** (12), **M_2** (5), **M_3**, **O_5**.

D. virilis: **F_1**, **T_1**, **T_2**, **T_3**, **T_4**, **B_1** (14), **B_2** (65), **O_1** (many), **O_2** (many), **O_5**.

D. funebris: **V_1** (19), **V_3** (40), **T_5**, **T_7**, **M_2** (4), **O_3**, **O_4**, **O_5**.

D. hydei: **V_4**, **T_1**, **T_4**, **O_5**.