HOKKAIDO UNIVERSITY

Title	A Preliminary Note on winter Drosophilid Flies in Southern Japan, with Special Reference to Reproductive Conditions
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Citation	Low temperature science. Ser. B, Biological sciences, 37, 39-45
Issue Date	1980-03-15
Doc URL	https://hdl.handle.net/2115/17846
Type	departmental bulletin paper
File Information	37_p39-45.pdf

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Low Temp. Sci., Ser. B 37 : 39-45, 1979

A Preliminary Note on Winter Drosophilid Flies in Southern Japan, with Special Reference to Reproductive Conditions[1]

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Abstract Small samples of winter drosophilid flies obtained at three localities in southern Japan are recorded. According to the ovarian conditions and diapause physiology, southern temperate species are suggested to be classified into four groups regarding their bionomics, especially hibernation.

Introduction

Bionomical studies on northern temperate drosophilid flies have been recently advanced by using reproductive condition as an indicator of physiological age (1, 6, 9, 11, 20). However, such an approach has never been adopted in phenological studies of drosophilid flies inhabiting other climatic regions. Comparable information of the bionomics in different climates, especially in southern temperate and subtropical regions, is indispensable to consider seasonal adaptations of temperate species in the process of speciation and evolution.

I had an opportunity to obtain small samples of drosophilid flies in southern Japan in winter, which is a critical season for temperate species. The present paper gives some preliminary information on their reproductive conditions as the first step to comprehensive bionomical studies in future, together with a review of previous winter collection records in southern Japan.

Collection Localities and Methods

1) Kariya, Aichi Prefecture (35°N, 137°E). Collections were made by fruit traps and net sweeping for four days, January 6 to 9, 1978. Two "milk can" traps baited with fermented banana were set around houses. These were visited once or twice in the daytime in fine and warm weather. Sweeping was made with an insect net at various vegetations, on and around blooming trees of *Camellia sasanqua*, around planted trees of *Musa Basjoo*, etc.

2) Takamatsu, Kagawa Prefecture (34°40'N, 134°E). Collections were made at two places, Mt. Shiun and Ritsurin, where the environments were pine forests and human habitations, respectively. At Mt. Shiun flies were

[1] Received for publication October 25, 1979. Contribution No. 2194 from the Inst. Low Temp. Sci.

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collected from eight fruit traps ("milk can" baited with fermented banana) in the evening for three days, December 31, 1977, January 1 and 6, 1978. At Ritsurin many drosophilid flies were found gathering on a heap of decayed fruits of mandarin orange. They were collected with an insect net in the evening on December 30, 1977, January 1 and 7, 1978.

3) Ashizuri and Tosashimizu, Kôchi Prefecture (32°70'N, 133°E). Flies were collected on decayed fruits of mandarin orange in the daytime on January 4, 1978.

On collection, samples were put into small glass vials containing fixative, Kahle's solution, and about 24 hrs. later transferred into 70% alcohol. All females were disected and examined for their ovarian conditions: Stage I) undeveloped, II) developing, III) mature and IV) postmature (22).

Table 1. Winter drosophilid flies and female ovarian conditions at Kariya. Italic numerals: numbers of individuals collected by sweeping, roman: by fruit traps

Ovarian stage	Female I	Female II	Female III	Female IV	Male	Total
Microdrosophila urashimae	*1*	—	*1*	—	*1*	*3*
Mi. matsudairai	—	—	*1*	—	—	*1*
Scaptomyza graminum	—	—	*2*	—	*2*	*4*
Drosophila curviceps	—	—	1	—	1	2
D. immigrans	2	*1*, 1	2	—	9	*1*, 14
D. simulans	—	—	1	—	—	1
D. lutescens	*6*, 1	—	*1*	*3*	*8*, 1	*18*, 2
D. actissima	—	*1*	—	*1*	*1*	*3*
Sc. elmoi	*44*	*1*	—	*11*	*43*	*99*
Sc. pallida	*25*	—	—	*2*	*29*	*56*
D. suzukii	*9*	—	—	*1*	*4*, 1	*14*, 1
D. triauraria	*2*	—	—	—	*1*	*3*
D. nigromaculata	*2*	—	—	—	*1*	*3*
D. annulipes	*1*	—	—	—	*1*	*2*
Mi. maculata	*1*	—	—	—	*1*	*2*
Microdrosophila sp.	*1*	—	—	—	—	*1*
D. bizonata	*1*	—	—	—	—	*1*
D. rufa	*1*	—	—	—	—	*1*
D. auraria	—	—	—	*1*	*1*	*2*
Mi. purpurata	—	—	—	*1*	—	*1*
Liodrosophila aerea	—	—	—	*1*	—	*1*
D. hydei	—	—	—	*1*	—	*1*
D. oshimai	—	—	—	—	*1*	*1*
D. melanogaster	—	—	—	—	*1*	*1*
Total	*94*, 3	*3*, 1	*5*, 4	*22*	*95*, 12	*219*, 20

Results

The results are separately presented for each locality in Tables 1, 2 and 3. At Kariya a total of 239 drosophilid flies was obtained. Of them 219 specimens of 22 species belonging to four genera were brought from sweeping collections, but the other 20 specimens of 5 species of genus *Drosophila* from fruit traps. As three species were obtained by both collections, in total 24 drosophilid species were recorded in this winter collection. At Takamatsu a total sample consisted of 234 specimens of 11 species belonging to three genera, and at southern Kôchi that of 58 specimens, 4 species of genus *Drosophila*.

Taking female ovarian condition as an indicator of reproductive activity, the following species, one or more females of which had mature and/or

Table 2. Winter drosophilid flies and female ovarian conditions at Takamatsu

Ovarian stage	Female I	Female II	Female III	Male	Total
Drosophila immigrans	5	7	3	33	48
D. lutescens	43	12	3	82	140
D. hydei	—	—	1	1	2
D. melanogaster	—	2	—	1	3
Liodrosophila aerea	—	1	—	1	2
D. suzukii	9	—	—	12	21
D. pulchrella	3	—	—	1	4
D. bizonata	2	—	—	7	9
D. rufa	2	—	—	1	3
D. nigromaculata	—	—	—	1	1
Scaptomyza pallida	—	—	—	1	1
Total	64	22	7	141	234

Table 3. Winter drosophilid flies and female ovarian conditions at Ashizuri and Tosashimizu

Ovarian stage	Female I	Female II	Female III	Male	Total
Drosophila busckii	—	—	5	1	6
D. lutescens	—	—	4	1	5
D. immigrans	2	11	16	17	46
D. melanogaster	—	1	—	—	1
Total	2	12	25	19	58

developing ovaries, are regarded to be reproducing in winter in southern part of Japan: *Microdrosophila urashimae*, *Mi. matsudairai*, *Scaptomyza graminum*, *Liodrosophila aerea*, *Drosophila curviceps*, *D. acutissima*, *D. lutescens*, *D. immigrans*, *D. simulans*, *D. melanogaster*, *D. busckii* and *D. hydei*. The ovarian conditions of the other species, except *D. oshimai* whose females were not collected, are similar to those of wild species in prehibernating and hibernating phases in Hokkaido (6, 20, 21), being undeveloped and/or postmature. It is, however, inconclusive for small samples in most species, except for two species, *Sc. pallida* and *D. suzukii*, which were collected in moderate numbers of individuals. *Sc. elmoi* is supposed to belong to the latter reproductively inactive group, because of a large accumulation of females with undeveloped ovaries in contrast to only one with developing ones.

Discussion

In northern temperate regions drosophilid flies cease any outdoor activities during long severe winter, e. g., for about five months, November to April, in Hokkaido. Recently it has been revealed that wild species overwinter in diapausing state, which is induced by autumn photoperiodic and thermal conditions, in several northern countries, northern Japan (6, 14, 20, 21), Finland (8, 9, 10, 11, 12, 13), England (1) and U. S. S. R. (4). On the other hand, several authors reported winter activities of some species in southern Japan with mild winter coditions (5, 15, 16, 17, 18). Reviewing such previous reports, the species collected in a good number in winter and/or showing a winter peak of collected individual number are listed below. The species whose ovarian development was confirmed in the present study are arranged left, and domestics are marked with *.

Microdrosophila matsudairai
Mi. urashimae (18)
Liodrosophila aerea (15)
Scaptomyza graminum
**Drosophila busckii*
D. lutescens (15[2], 17[2])
**D. melanogaster*
**D. simulans*
**D. hydei* (15)
D. acutissima (15, 17[3])
**D. immigrans* (15)
D. curviceps (15, 16[4], 17[4])
Leucophenga concilia (15)
L. subpollinosa (15)
L. orientalis (15[1])
Microdrosophila fuscata (15)
Mi. cristata (15)
Mi. pleurolineata (15)
Mi. pseudopleurolineata (15)
Dettopsomyia argentifrons (18)
Paramycodrosophila sp. (15)
Mycodrosophila erecta (15)
My. planipalpis (15)
Drosophila fascipennis (15)
D. bifasciata (17)
D. suzukii (15)

1) Cited as *L. magnipalpis*. 2) Cited as *D. lutea*. 3) Cited as *D.* sp. *grandis*-like II.
4) Cited as *D.* sp. *immigrans*-gr. I.

D. pulchrella (15)
D. unipectinata (15, 17[5])
D. oshimai (5, 15[6])
D. bizonata (17)
D. sternopleuralis (15)
D. grandis (17)
D. annulipes (15)

As shown with asterisks, five domestic species are included in the list. All of them were confirmed to develop their ovaries in winter. Watabe (21) reported the absence of photoperiodism for ovarian development in *D. melanogaster* and *D. immigrans*. The origins of these domestics are considered to be tropical regions (2, 3, 7, 19), and they are distributed all over the world by modern artificial transportations. As described by Watabe (21), such domestics without diapausing mechanism can not overwinter in outdoor conditions in northern temperate regions. But in southern Japan they are suggested to be able to survive and further to breed outdoors in and around human habitations in winter.

In contrast to the domestics some wild species must enter the hibernal diapause also in southern temperate regions, as suggested in *Sc. pallida* and *Sc. elmoi*, though their photoperiodism is still not experimentally confirmed. Up to the present, the photoperiodism for reproductive diapause has been detected in southern temperate populations of only two wild species, four local populations at Urawa, Chiba, Takamatsu and Matsuyama for *D. auraria* and Takamatsu population for *D. rufa*, by Kimura (pers. comm.). Although *D. bifasciata* is included in the above list, it is known that this species hibernates in reproductive diapause controlled by photoperiod in northern temperate regions, Hokkaido (21) and Finland (8, 11). It is dubious that this northern palaearctic species continues to breed without hibernal diapause during winter in southern temperate regions.

The ovarian conditions observed in the present study indicate winter reproductive inactivity of *D. suzukii* and may or may not suggest its reproductive diapause. But the absence of photoperiodism was experimentally confirmed in its Sapporo population by Watabe (pers. comm.). Therefore, its winter reproductive conditions must be attributed to developmental arrest caused by unfavourable temperature lower than the threshold. This species and *D. lutescens* exhibit similar bionomical trends intermediate between those of domestics and wild species in Hokkaido (Watabe, pers. comm. and cf. 21). *D. lutescens* showed a increasing tendency of ovarian development from north to south (Tables 1, 2 and 3), i. e., only one female with mature ovaries of a total of eleven females at Kariya, while all four females mature at southern Kôchi. For this species, too, the absence of photoperiodism was confirmed in both southern and northern populations, Kagoshima, Takamatsu

5) Cited as *D.* sp. *unipectinata*-like. 6) Cited as *D.* (*Sophophora*) sp.

and Sapporo (Kimura, pers. comm.). The winter ovarian development of this species must be controlled by thermal conditions, as well as in *D. suzukii*, though its developmental lower threshold seems different from that of the latter.

As the last group there are some wild species in which winter ovarian development was observed. *D. oshimai* adapted strictly to flowers of particular plants, *Camellia* trees especially *C. sasanqua*, blooming in winter (5) may belong to this group, though its winter reproduction has not yet been confirmed in nature. These species characterize the mild winter conditions in southern temperate regions and their distributions are supposed to be restricted to narrow climatic zone. Unfortunately, their particular bionomics and related physiology are not studied at all.

Even a very preliminary investigation on reproductive conditions of winter drosophilid flies brought much bionomical information. Several different strategies were suggested for the adaptation to temperate climates. Further, the geographical distribution of each species must be correlated to its bionomics and physiology.

Acknowledgment

I wish to express my sincere thanks to Prof. Shôichi F. Sakagami for his reading of the manuscript. Cordial thanks are also due to Dr. Masahito T. Kimura who allowed free use of unpublished data and gave me information on the physiology of diapause of some species, and to Mr. Hide-aki Watabe for his valuable suggestions.

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