POPULATION DYNAMICS OF FRUITFLIES IN BRITISH COLUMBIA

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ABSTRACT

Fluctuations in the populations of three species of the genus *Drosophila* were studied for fourteen months at an isolated fruitdump in the Southern Okanagan Valley of British Columbia. The fruitdump was considered to provide ideal conditions for overwintering since it contained vast quantities of food and generated abundant heat. However, only *D. hydei* overwintered, whereas *D. pseudoobscura* and *D. melanogaster* did not. *D. hydei* seemed to occupy the most desirable location on the fruitdump, to the exclusion of the other species. None of the three species oversummered at the dump. The question of maintenance of *D. pseudoobscura* and *D. melanogaster* populations is discussed.

For over a decade, we have been developing genetic insect control systems using *Drosophila melanogaster* Meigen as a model system. The methods involve population replacement using chromosomal rearrangements, such as compound autosomes and compound-free arm combinations, together with conditional mutations, such as temperature-sensitive lethal mutations (Fitz-Earle and Holm, 1981). The techniques are dependent for their success upon there being sufficient time to establish a population of insects, once they have been released at a strategic stage (e.g. when the population numbers are at their lowest).

Before testing the model system outside of laboratory conditions, we considered that it was necessary to locate a suitable field site where a large population of *D. melanogaster* occurred naturally. Such a population was required as a source of native fruitflies to demonstrate that no mating barrier existed between them and laboratory stocks and in which we could generate rearrangements suitable for field releases. Moreover, as a pre-condition for successful field trials, we thought we should investigate aspects of the ecology of the native fruitflies. We were concerned about such questions as: the best time of the year to make releases into the wild of our genetically engineered insects and the ability of such flies to survive the prevailing local climatic conditions once released. In other words, we were concerned with the population dynamics of native *D. melanogaster* over an extended period.

Little is know of the population ecology of members of the genus *Drosophila* in British Columbia. The Spencer Entomological Museum of the University of British Columbia contains few specimens in its collections. The earliest recorded field observations would appear to be those of Patterson and Wagner (1943), who showed that *Drosophila pseudoobscura* had been found in South-western and South-central B.C., and *D. athabasca* in Eastern B.C. *D. melanogaster* and *D. hydei* were omitted from their maps since these species were considered to be cosmopolitan. Prior to 1943, species of *Drosophila* were found during the winter months in Vancouver. Leech (1931) captured *D. funebris* breeding on a mixture of rotten potatoes and carrots in a corner of a basement and during the period November 8, 1939 to March 28, 1940, Foster (1943) collected *D. inversa* and one other species of *Drosophila*. The locations of *D. pseudoobscura, D. athabasca* and *D. persimilis* within B.C. were reported by Dobzhansky and Epling (1944). *D. pseudoobscura* was restricted to South-central B.C. in a broad arc encompassing Yale, Lytton, Kamloops, Shuswap lake, Nakusp and Kaslo, and to the south of those points. *D. persimilis* was found in much cooler and moister areas from Pavilion north to Quesnel in central B.C. and at Cowichan Lake and Campbell River on Vancouver Island. To the North and East of a line connecting Quesnel and Kaslo (i.e. the Rocky Mountain trench and the Rocky Mountains themselves) the only species found was *D. athabasca,* which occurred also in areas where *D. persimilis* was collected, but in lower numbers. No *D. athabasca* was found in the *D. pseudoobscura* region. Dobzhansky and Epling (1944) did not collect *D. melanogaster* or *D. hydei.* Not one of the above papers referred to the population numbers of *Drosophila* species in B.C., or elsewhere.

In areas outside of B.C., it has been shown widely that the incidence of *D. melanogaster* and other *Drosophila* species increases significantly during the ripening periods of fruits such as tomatoes (e.g. Wave, 1962). The numbers are low in late summer but they increase dramatically in the fall.

We were intrigued by two questions that do not seem to be adequately covered in the literature. If *Drosophila* overwinter, or oversummer, how is this achieved, especially in regions where extremely low winter (or high summer) temperatures are common, such as Southern B.C.? If *Drosophila* do not overwinter (or oversummer) in such regions, are they reintroduced each spring or fall, and if so, how?

Warren P. Spencer (1950) in a chapter in the Biology of Drosophila, states that *D. melanogaster* overwinters indoors and that "colonies of these flies may be found breeding in some fruit and vegetable cellars . . ." He continues: "Here (Wooster, Ohio), year-round collections may be made . . ." With the widespread use of canning and freezing of fruits and vegetables in the home, refrigerated storage warehouses for produce, and scrupulous quarantine tech-

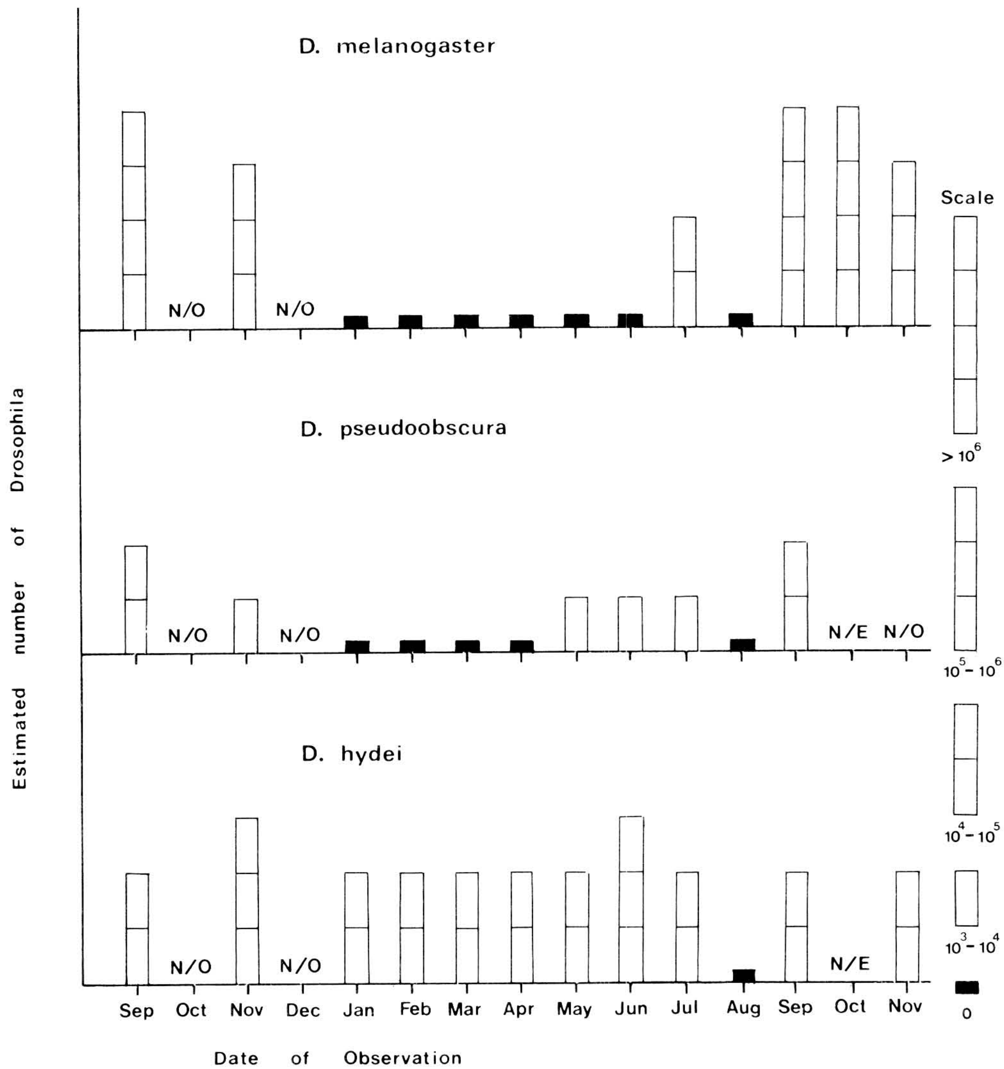

Fig. 1. Comparison of estimated numbers of three species of fruitflies on the surface of a fruit dump over a fourteen-month period. N/O = no observation made. N/E = not estimated.

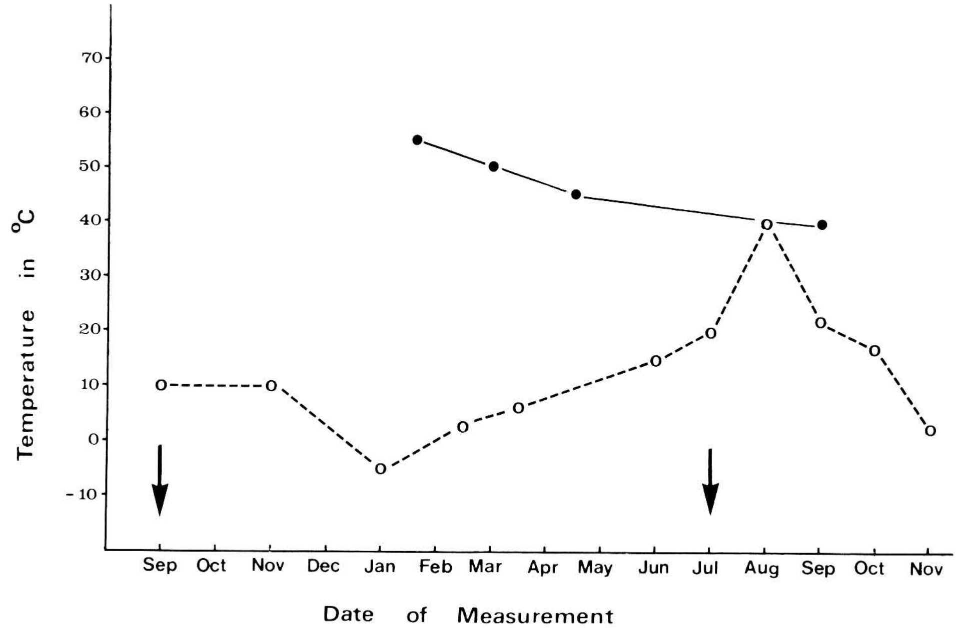

Fig. 2. The ambient temperatures (o---o), the temperatures beneath the surface of the apex of the fruit dump (• — •) and major fruit dumpings (shown by heavy arrows) over a fourteen-month period.

niques in such industries as wineries, in these times it seemed to us that the traditional, artificial, man-made environments, once considered capable of supporting a *D. melanogaster* population over the winter, would be reduced severely. Moreover, the harsh winter conditions of inland regions must prevent overwintering in the natural environment unless exceptional conditions were provided.

It was suggested to us that a probable site for harbouring and over-wintering the insects might be the vast reservoir of food and heat provided by a decaying pile of fruit. To this end, we determined to locate a fruit dump, make our collections for the genetic studies and monitor the dump over a calendar year to obtain ecological information. The genetic experiments, using laboratory and field cages, have been reported elsewhere (Fitz-Earle, Holm and Suzuki, 1975; Fitz-Earle and Holm, 1981). This paper describes useful new information on the spatial relationships among three *Drosophila* species and their relative abundance over the period of fourteen months at a location in B.C.

The fruit dump chosen for our studies consisted of the accumulated dumpings of culled fruits such as cherries, apricots, peaches, apples and pears that were unsuitable for marketing or processing. The dump was located at Summerland, which is in the arid Ponderosa Pine - Bunchgrass biogeoclimatic zone of southern B.C. At the beginning of the study the dump comprised about 350 tonnes of fruit, was about 6 m high and 15 m in diameter. The rotting fruit generated heat, so that on cold days condensing water vapour was clearly seen coming from the summit. Estimated numbers over time of *D. melanogaster*, *D. hydei*, and *D. pseudoobscura* are given in Fig. 1. The ambient temperatures, the temperatures at the hottest site measured in the fruit pile (25 cm. beneath the surface of the apex of the pile) and the approximate times of major fruit dumpings are shown in Fig. 2.

From the data, it is immediately apparent that *D. melanogaster* was in considerable abundance during the fall, but died out during the winter. *D. pseudoobscura* was in lower numbers throughout the same period, persisted longer, and yet it, too, died out eventually. By contrast, *D. hydei*, although never found in high numbers, persisted throughout the winter and into the spring. That *D. hydei* was able to overwinter in the fruit pile, and that *D. melanogaster* and *D. pseudoobscura* were unable to overwinter there, was unequivocal. Further study of our observations revealed the *D. hydei* colonized sites that had higher temperatures than those colonized by the other two species. We found that as the ambient temperatures declined, *D. hydei* was located closer to the apex of the fruit pile where the temperatures were well in excess of the ambient temperature (Fig. 2). At the time of greatest disparity there was a 60°C spread between the ambient temperature and that of the hottest site measured.

When all three species were present together in the late fall, there was an obvious concentric distribution with *D. hydei* at the apex of the fruit pile, and *D. pseudoobscura* together with *D. melanogaster* at the base.

On several occasions during the winter after adult *D. melanogaster* and *D. pseudoobscura* had disappeared from the fruit pile, we collected samples of decaying fruit, containing eggs, larvae and pupae of the two species, for examination in the laboratory. All the eggs and larvae were dead. In the *D. pseudoobscura* samples, on one occasion only, a pupa eclosed and three other pupae developed into pharate adults. Of the *D. melanogaster* pupae sampled, none yielded adults.

We also observed that, although all three species were present in July, a month when some fruit was dumped at the site, no flies were found a month later. The ambient temperature in August was approximately 40°C at the dump and all the fruit on the surface became desiccated.

In our opinion the fruit pile studied provided the most ideal environment possible for overwintering of fruitflies; certainly it was far superior to a fruit and vegetable cellar. And yet *D. melanogaster* and *D. pseudoobscura* failed to survive the winter. Our limited investigations do not permit us to state categorically that the two species never overwinter in southern B.C., but, without evidence to the contrary, reluctantly we are forced to consider the possibility that *D. melanogaster* and *D. pseudoobscura* populations may be maintained from year to year by reintroductions. Even the possibility that the two species migrate annually from the climatically more moderate regions to the south, seems to us to be totally untenable. The converse problem of oversummering would seem to be even more complex, yet the fact remains that in August no flies were found at our site and a month later they had returned. Again, the reintroduction alternative to oversummering seems highly unlikely. Nevertheless these various possibilities should be examined.

Thus, currently we are devising experiments, using genetic techniques, to endeavour to distinguish between the overwintering/oversummering and the reintroduction models. In addition, we are reexamining the chromosome replacement system for insect regulation. If such a system is to succeed, the resident population in any given year must provide the founder population for subsequent years. Otherwise, chromosome replacement will not serve as a practicable means of regulating insect numbers or eliminating species undesirable to man.

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REFERENCES

Dobzhansky, Th. and C. Epling, 1944. Contributions to the genetics, taxonomy and ecology of *Drosophila pseudoobscura* and its relatives. Carnegie Inst. Washn. Pubn. 554.

Fitz-Earle, M. and D. G. Holm, 1981. *Drosophila melanogaster* models for the control of insect pests. *In* "The Genetics and Biology of Drosophila" Vol. 3 (J. Thompson and M. Ashburner, eds.) Academic Press, New York and London (in press).

Fitz-Earle, M., D. G. Holm, and D. T. Suzuki, 1975. Population control of caged native fruitflies in the field by compound autosomes and temperature-sensitive mutants. Theor. Appl. Genet. **46:** 25-32.

Foster, Ray E., 1943. Insects active throughout the winter at Vancouver, B.C. Part II: Lists of the Orthoptera, Dermaptera, Homoptera, Hemiptera, Diptera, and Hymenoptera. Proc. Ent. Soc. British Columbia **40:** 32-34.

Leech, Hugh, 1931. *Drosophila funebris* as a host of the fungus Stigmatomyces. Proc. Ent. Soc. British Columbia **28:** 19-20.

Patterson, J. T. and R. P. Wagner, 1943. Geographic distribution of species of the genus Drosophila in the United States and Mexico. U. of Texas Publn. 4313.

Spencer, W. P., 1950. Collection and Laboratory Culture. Ch. 7, pp. 535-590, In "Biology of Drosophila" (M. Demerec, ed.). Hafner, New York, N.Y.

Wave, H. E., 1962. Seasonal distribution of Drosophilid flies in Beltsville, Maryland, tomato fields. J. Econ. Entomol. **55:** 409-411.