THE GENUS *DROSOPHILA* (DIPTERA) IN EASTERN QUEENSLAND

II. SEASONAL CHANGES IN A NATURAL POPULATION 1952-1953

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Summary

The quantitative variations of 16 species of *Drosophila* attracted to banana bait at a single station over a period of 15 months have been assessed. There are two "abundant" winter species; other species fall into "common" and "rare" categories and flourish in either the autumn or spring. Peaks in the numbers of each species correspond either to the period of greatest rainfall, or the period of rising temperatures. Results have been compared with a similar survey at Aldrich Farm, Texas, U.S.A. (Patterson 1943).

D. novopaca, nom. nov. and *D. novamaculosa*, nom. nov. are proposed to replace the homonyms *D. opaca* Mather and *D. maculosa* Mather. *D. levis* Mather is synonymized with *D. bryani* Mall.

I. INTRODUCTION

In order to provide a background for experimental work on the genus *Drosophila* from south-eastern Queensland the following survey was undertaken. The initial aim was to determine the associations and relative numbers of species, which, in a given area, are attracted to banana bait,† and the extent to which these may vary through the year. The experiment has been based on similar work carried out at Aldrich Farm, Texas, U.S.A. (Patterson 1943).

Species collected in the present survey are those recently reviewed (Mather 1955). However, Dr. A. H. Sturtevant (personal communication) has indicated that the specific names *D. opaca* (Mather 1955, p. 558) and *D. maculosa* (Mather 1955, p. 560) are preoccupied by species originally described in the genus *Drosophila*. These species are now known as *Diathoneura opaca* (Williston) (Sturtevant 1942, p. 27) and *Leucophenga maculosa* (Coquillet) (Sturtevant 1921, p. 60). The names *D. novopaca*, nom. nov. and *D. novamaculosa*, nom. nov. are therefore erected to replace the homonyms *D. opaca* Mather and *D. maculosa* Mather respectively.

D. levis Mather (Mather 1955) has been found to be morphologically identical with specimens from a culture of *D. bryani* Mall. (Malloch 1934) from the Marshall Islands collected and identified by M. R. Wheeler, University of Texas. Upon re-examination of all published descriptions of both species it is now apparent that *D. levis* Mather is synonymous with *D. bryani* Mall.; and that this species is a member of the *levis* species group as previously defined (Mather 1955).

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† The standard method for collection of *Drosophila* (Patterson 1943).

II. Collection

(a) *Site*

The University Farm, Moggill, Brisbane, was selected for the following reasons: (1) variety of vegetation which should support a varied *Drosophila* fauna in a semi-natural state (see Appendix I) ; (2) convenient distance from the University (12 miles) ; and (3) being private property, it is not subjected to excessive disturbance.

The area sampled lies at the bottom of a gully running roughly north-east—south-west and flanked by slopes carrying open eucalypt forest and a considerable number of species of trees and shrubs (see Appendix I). Through the gully runs a small stream discharging into the Brisbane River.

(b) *Methods*

Cans of fermenting banana were set up and collections made therefrom at regular intervals (usually of 1 week) by sweeping over them with a hand net. Particular care was taken to collect the maximum number of flies at the bait at each collection. The cans measured 8 in. high by 7 in. diameter and were provided with a hinged lid to protect the bait from rain and desiccation. Staking to the ground was necessary to prevent the cans being upset (by horses and cows). The baits consisted of 2 lb of whole banana mashed up with a small quantity of baker's yeast. With this bait, the insects collected in the net were almost exclusively *Drosophila* spp.

Four baits were utilized, in similar shady situations, arranged in a rough rectangle approximately 100 × 200 yd. The cans were left continuously in the field for 15 months but the baits were changed weekly, immediately after collection, and the old bait removed from the farm to avoid artificial upsetting of the population.

All collections were made in the late afternoon because in Brazil (Pavan, Dobzhansky, and Burla 1950) and in the present series of investigations there is a diurnal fluctuation in the number of *Drosophila* species attracted to the baits with a peak in the late afternoon.

(c) *Treatment of Data*

As the number of collections in each month was increased from November 1952, the year October 1952-September 1953 has been chosen to estimate relative abundance of species and population fluctuation (Table 1). The females of *Drosophila melanogaster, D. simulans, D. serrata, D. takahashii,* and *D. dispar* have been treated as a complex, as they are difficult to distinguish. Similarly females of *D. repleta* and *D. versicolor* were not distinguished.

III. Results

(a) *Species Collected*

The species collected, which have recently been reviewed (Mather 1955) are listed, together with mean monthly temperatures and rainfalls,

in Table 1. The climatic data have been supplied by the Queensland Meteorological Bureau, and are for Brisbane, 7 miles north-east from Moggill. Taxonomically, three subgenera are represented, the prevalence of the subgenus *Pholadoris* being of interest.

On the basis of abundance of males for the year October 1952-September 1953, the species may be classified as follows:

"Abundant": *D. simulans* (63%), *D. serrata* (21%)

"Common": *D. takahashii* (4%), *D. lativittata* (4%), *D. immigrans* (2%), *D. hydei* (2%), *D. versicolor* (1%), *D. melanogaster* (1%), *D. enigma* (1%), *D. repleta* (1%)

"Rare": *D. cancellata* (0.1%), *D. novamaculosa* (0.05%), *D. novopaca* (0.025%), *D. dispar* (0.025%), *D. busckii* (0.025%), *D. bryani* (0%).*

The percentages of abundant and common species varied little at each bait at any one time. Rare species, however, were not always present at each of the four baits simultaneously. Species taken represent all species which have previously been recorded from the Brisbane area.

(*b*) *Population Fluctuation*

With the 10 more common species, sufficient individuals were caught to calculate monthly frequencies over a complete year (Oct. 1952-Sept. 1953) (see Table 2).

As the number of collections made per month varied, it was necessary with each species to divide the total for the month by the number of collections made in that month, and to use these derived figures for the calculation of monthly frequencies.

The species segregate into five groups representing the time of their maximum numbers:

(i) Spring species: *D. hydei, D. repleta,* and *D. versicolor*

(ii) Autumn species: *D. simulans*

(iii) Spring and autumn species: *D. serrata*

(iv) Winter species: *D. enigma, D. takahashii, D. immigrans,* and *D. lativittata*

(v) Species present in all seasons: *D. melanogaster.*

D. lativittata and *D. enigma* have not been taken in northern Queensland (Mather 1955). As these species flourish at Moggill Farm only during the colder months, it may be assumed that they are temperate rather than tropical species.

With the seven rarer species, it will be noted that *D. novopaca* was collected in summer, *D. bryani* in autumn and winter, *D. dispar* in winter,

* *D. bryani* females only were taken (see Table 1).

TABLE 1

COLLECTION RECORDS FOR MOGGILL FARM

Subgenus	Species	1952 July ♂	July ♀	Aug. ♂	Aug. ♀	Sept. ♂	Sept. ♀	Oct. ♂	Oct. ♀	Nov. ♂	Nov. ♀	Dec. ♂	Dec. ♀
Pholadoris	*D. cancellata*						2			4	5		
	D. enigma		1	1	1	3	4			1	1		
	D. lativittata	3		20	22	1	14	1		8	7		
	D. novopaca												
	D. novamaculosa									2	5	2	
	D. bryani												
Sophophora	*D. busckii*	4		7	1	2	4						
	D. melanogaster	2		3		2		1		13		5	
	D. simulans	77		225		157		33		87		16	
	D. serrata		47	13	148	2	130	7	14	58	81	19	30
	D. takahashii	1		6									
	D. dispar												
Drosophila	*D. hydei*					1	3	1	2	43	39	8	3
	D. repleta					1		1		41			
	D. versicolor								2	24	21	11	1
	D. immigrans	1				9	11	1	5	1			
Totals		136		447		346		68		441		95	
Number of collections		2		2		2		2		6		5	
Average number/collection		68		223		173		34		73		19	
Mean temperature (°F)		58.7		60.6		65.1		69.7		73.3		76.0	
Rainfall (in.)		1.07		1.80		0.92		3.78		2.34		2.74	
Mean normal temperature (°F)		59.5		62.3		64.6		69.3		75.1		76.4	
Normal rainfall (in.)		2.15		1.83		1.96		2.68		3.70		4.97	

TABLE 1 (*Continued*)

Subgenus	Species	1953 Jan. ♂	Jan. ♀	Feb. ♂	Feb. ♀	Mar. ♂	Mar. ♀	Apr. ♂	Apr. ♀	May ♂	May ♀	June ♂	June ♀	July ♂	July ♀	Aug. ♂	Aug. ♀	Sept. ♂	Sept. ♀
Pholadoris	*D. cancellata*							1	1										
	D. enigma							3	1	3	8	13	13	2	7		2		
	D. lativittata		2		3	19	13	8	7		4	2	2	29	22	50	31	29	22
	D. novopaca			1	1														
	D. novamaculosa								1										
	D. bryani								1		1								
Sophophora	*D. busckii*															1			
	D. melanogaster	2		2		7		3		1		1						3	
	D. simulans	19		148		641		551		328		491		69		40		40	
	D. serrata	26	18	117	94	182	506	147	301	39	240	16	407	23	81	28	41	146	109
	D. takahashii			1		8		20		25		51		34		10		4	
	D. dispar													1					
Drosophila	*D. hydei*	5	5			1		2	3	2	1	1							
	D. repleta				3														2
	D. versicolor	8		1		1										1		3	
	D. immigrans					6	14	6	4	15	8	39	47	8	5	9		6	11
Totals		85		371		1398		1040		675		1083		281		213		375	
Number of collections		4		3		5		3		2		4		4		4		4	
Average number/collection		21		124		279		347		337		271		70		53		94	
Mean temperature (°F)		77.1		76.5		74.3		70.1		64.6		60.2		58.7		60.6		68.1	
Rainfall (in.)		5.98		14.41		5.44		1.87		0.93		0.12		0.05		3.66		0.56	
Mean normal temperature (°F)		74.4		74.9		73.3		72.1		64.9		60.3		59.5		62.3		64.6	
Normal rainfall (in.)		6.36		6.35		5.75		3.62		3.69		2.65		2.15		1.83		1.96	

TABLE 2

PERCENTAGE POPULATION FLUCTUATION OF SELECTED SPECIES

Species	1952			1953								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
D. enigma		2.0					8.1	33.5	40.0	13.7	3.0	
D. lativittata	0.8	3.8	0.6	0.8	1.5	10.0	8.0	3.1	1.5	20.0	31.0	20.0
*D. melanogaster**	5.7	25.0	11.5	5.7	7.7	16.0	11.5	5.7	2.9			8.6
*D. simulans**	2.3	2.0	0.4	0.7	6.8	17.6	25.5	22.8	16.9	2.4	1.4	1.4
*D. serrata**	1.6	4.4	1.8	3.0	17.7	16.5	22.3	8.9	1.8	2.6	3.2	16.6
*D. takahashii**					0.7	3.5	14.3	27.3	27.9	18.6	5.5	2.2
D. hydei	5.4	57.0	9.3	11.0		0.8	7.1	8.4	1.1			
*D. repleta**	6.8	93.0										
*D. versicolor**		41.0	22.7	20.6	3.1	2.6					2.6	7.7
D. immigrans	5.6	0.4				7.5	6.2	21.6	40.0	6.1	4.2	8.0

* Calculated on males only.

D. busckii in winter and spring, and *D. cancellata* and *D. novamaculosa* in spring and autumn. However, as only small numbers of these species were taken at any time, they may have been missed in other seasons.

(*c*) *Sex Ratio*

A very marked discrepancy between the sexes is apparent (Table 3); 63 per cent. of the total specimens caught were males, and with one exception (*D. immigrans*), this occurs in every species where adequate numbers were collected. Whether this is due to a real preponderance of males or whether there is a differential attraction to, or tendency for males to remain at, the baits, is uncertain.

TABLE 3

DROSOPHILA SPECIES: SEX RATIO

Species	Males and Females	Males	Females	Males (%)	Females (%)
D. cancellata	13	5	8		
D. enigma	64	26	38		
D. lativittata	321	172	149	54	46
D. novopaca	2	1	1		
D. novamaculosa	8	2	6		
D. bryani	2	0	2		
D. busckii	19	14	5		
D. melanogaster		45			
D. simulans		2922			
D. serrata	6198	823	2247	64	36
D. takahashii		160			
D. dispar		1			
D. hydei	120	64	56	53	47
D. repleta		43			
D. versicolor	121	49	29	76	24
D. immigrans	206	101	105	49	51
Totals	7074	4428	2654	63	37

IV. DISCUSSION

To what extent the population fluctuations, as indicated by the banana-bait method, reflect the actual population fluctuations of the species is at the present time unknown, since, although banana has been shown to be the best bait for attracting a maximum number of species and in large quantities, the proportion of species attracted with different baits does actually vary (Spencer 1950). However, the results are considered as true for that portion of the population which is attracted to this bait.

Of the 10 abundant and common species taken, four (*D. enigma, D. takahashii, D. immigrans, D. lativittata*) increased during winter, and two species, *D. simulans* and *D. serrata,* increased during the autumn.

These species all contributed to the major peak of the total *Drosophila* population which was reached in April. In August 1952 and September 1953 increasing numbers of the spring species, *D. hydei, D. repleta, D. versicolor,* and *D. serrata,* created, with the declining *D. simulans,* another peak in the population. The spring species then continued to increase, although they never reached very great numbers, to create the small November population peak.

Consideration of climatic data (Table 1) shows that the winter-autumn species peak follows the peak in the annual rainfall; and it is possible that these species flourish with the lush vegetation produced by this high rainfall coupled with the moderate temperatures. The spring

TABLE 4
FRUITS WITH WHICH DROSOPHILA SPECIES MAY BE ASSOCIATED

Fruiting Season	Species	Origin
All seasons	*Cassytha pubescens* R.Br.	Indigenous
Summer	*Elaeocarpus obovatus*	Indigenous
Summer	*Paspalum dilatatum**	Brazil
Summer and autumn	*Cudrania javanensis*	Indigenous
Summer and autumn	*Eustrephus latifolius*	Indigenous
Summer and autumn	*Passiflora suberosa*	Brazil
Summer and autumn	*Passiflora alba*	Brazil
Summer–winter	*Cryptocarya triplinervis*	Indigenous
Autumn	*Baccharis halimifolia*	America
Autumn–spring	*Ageratum conyzoides*	America
Spring and summer	*Lantana camara*	Tropical America

* Produces a sugary honey dew when attacked by the fungus *Claviceps.*

species flourish with the rising temperature of that period. Although during 1952-1953 there was an unusually high rainfall in February, this is always the period of maximum rainfall; and although variations in the environment may occur from year to year affecting the *Drosophila* population to a greater or lesser extent, the general pattern of the succession described here is probably characteristic.

The majority of fruit-bearing plants in the area with which the *Drosophila* species may be associated (Table 4) fruit mainly in the summer and autumn; and although no positive information is available on the relationship of their fruit to the *Drosophila* species, it is significant that rotting fruits are abundant when the major peak of the *Drosophila* population does occur.

The only comparable survey to the present study is that conducted at Aldrich Farm, Austin, Texas, U.S.A. during July 1939-June 1940 (Patterson 1943), and it is of interest to compare the two (Table 5). It is possible that if the collection at Moggill had been as intensive as at Aldrich, additional species would have been collected, but at most these would have been rare, and, in fact, new records for the area.

At Moggill the subgenera *Pholadoris, Sophophora,* and *Drosophila* are represented, whereas at Aldrich the subgenera *Hirtodrosophila, Sophophora,* and *Drosophila* are present.

At Aldrich, *D. simulans* and *D. melanogaster,* of the *melanogaster* species group, are the abundant species, and reach their peak in autumn, following the maximum summer rains, thus accounting for the major peak of the whole *Drosophila* population for the year. At Moggill, where the maximum rainfall is also during the summer months, *D. simulans* and *D. serrata* (also of the *melanogaster* species group) behave in a similar fashion as described above. At Aldrich, as at Moggill, there are also species with their peak numbers in the spring, causing the minor spring peak in total numbers of the genus. There are also species which are more evenly distributed over the whole year.

TABLE 5
COMPARISON OF CONDITIONS AT MOGGILL AND ALDRICH FARMS

Observation	Moggill Farm	Aldrich Farm
Latitude	27.5°S.	31°N.
Distance from coast	17 miles	150 miles
Rainfall	41.40 in.	33.46 in.
Mean monthly temperature range	58.7-77.1°F	40.6-85.1°F
Specimens collected	7072	79,404
Species collected	16	25
Abundant species	2	2
Common species	7	10
Rare species	7	16

Six species, viz. *D. busckii, D. melanogaster, D. simulans, D. repleta, D. hydei,* and *D. immigrans* are common to both Moggill and Aldrich and it is of interest to compare the seasonal fluctuations of these species at the two localities. *D. busckii* is essentially a spring species at Aldrich and likewise at Moggill it is a late winter–early spring species. Due to *D. simulans* and *D. melanogaster* being treated as a complex at Aldrich, detailed comparisons cannot be made with these species, but from the data available, it is evident that whereas *D. melanogaster* is quite prevalent at Aldrich it is not so at Moggill. The closely related *D. hydei* and *D. repleta* are spring species both at Moggill and Aldrich. Finally, whereas *D. immigrans* does not show regular seasonal fluctuation at Aldrich, it is largely a late autumn–early winter species at Moggill.

D. versicolor is worthy of special discussion. This species has been assigned to the *mulleri* species group (Mather 1955) and a number of American members of this species group have been shown to breed on the fruit of species of cacti (Patterson 1943). It will be noted (Table 2) that the population peak of *D. versicolor* is in spring, whereas cacti species usually fruit in autumn. Further, no species of cacti were observed within

the collection area although it is possible that isolated specimens may grow within the vicinity of Moggill. It therefore seems possible that *D. versicolor* is not associated with cacti fruits in this area.

Thus the broad general picture at both Moggill and Aldrich is similar, the most outstanding difference at Moggill being the presence of six species belonging to the subgenus *Pholadoris* whereas at Aldrich no members of this subgenus are recorded.

V. Acknowledgments

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Appendix I

Flora of Moggill Farm Collection Area

The area under investigation lies at the bottom of a gully running roughly north-east–south-west and flanked by slopes carrying open eucalypt forest. On the moister eastern aspect this forest comprises *Eucalyptus tereticornis* S. (blue gum) with a number of other species including *Tristania suaveolens* S. (swamp box), *E. tesselaris* F. Muell. (Moreton Bay ash), *Acacia aulacocarpa* A. Cunn., and *A. cunninghamii* Hook. On the drier western exposure *E. hemiphloia* F. Muell. (gum-top box) predominates with an occasional *E. maculata* Hook. (spotted gum). On both slopes there is a ground cover of grasses including *Bothriochloa decipiens* (Hack.) C. E. Hubb (pitted blue grass), *Cymbopogon refractus* (R. Br.) A. Camus (barb-wire grass), *Eragrostis leptostachya* Steud., and herbs

such as *Hydrocotyle* sp., *Oxalis corniculata* L., *Ionidium suffruticosum* Ging., *Glycine tabacina* Benth., and *Cheilanthes tenuifolia* Sw.

The comparatively flat floor of the gully is of very variable width, but often at least 80 ft across. At the junction of the gully flat and flanking slopes, a somewhat denser vegetation may appear in the moister habitat. With the blue gum and box appears *Casuarina glauca* Sieb. (swamp she-oak), while the scrambling *Lantana camara* L. is frequently well developed and a vigorous herbaceous ground cover appears in the protection of the tree cover. Amongst the grasses here are *Paspalum dilatatum* Poir., *Cynodon dactylon* Pers. (blue couch), *Oplismenus compositus* Beauv., and *Echinopogon nutans* C. E. Hubb, the latter two particularly in the more shaded positions. *Ageratum conyzoides* L. (billy goat weed) with its light blue inflorescence is extremely common, and amongst the other numerous herbaceous species are *Verbena officinalis* L., *Rumex* sp., *Commelina cyanea* R. Br., *Lobelia purpurascens* R. Br., and *Cyperus gracilis* R. Br. Herbaceous climbers such as *Passiflora suberosa* var. *minima* Jacq., *P. alba* L. & O., *Eustrephus latifolius* var. *angustifolia* Benth. are also frequently present.

Over the gully flat are a few trees of *Eucalyptus tereticornis* but the most common tree is *Casuarina glauca*. *Baccharis halimifolia* L. (groundsel) forms dense stands in places, particularly near the margins of the flat, and the spiny scrambling shrubs of *Cudrania javanensis* Trec. are scattered here and there. The ground cover is almost entirely of *Paspalum dilatatum* with *Cynodon dactylon* in places and a few herbs such as *Aster subulatus* Michx., *Oxalis corniculata*, and *Ageratum conyzoides*. In places, the flat is cut by a small stream and along its banks are developed some trees of *Callistemon viminalis* (Sol. ex Gaertn.) G. Don. ex Loud., *Melaleuca bracteata* F. Muell., and a few semi-rainforest species such as *Cryptocarya triplinervis* R. Br. and *Elaeocarpus obovatus* G. Don. Over these in many places is a dense layer of the climbing *Passiflora suberosa* var. *minima* and less frequently of *Ipomoea palmata* Forsk.