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DROSOPHILIDAE OF THE GALÁPAGOS ISLANDS, WITH DESCRIPTIONS OF TWO NEW SPECIES

Hampton L. Carson,[1] Francisca C. Val,[2] and Marshall R. Wheeler[3]

Abstract. A 1977 collection of Drosophilidae from 3 major islands of the Galápagos yielded 774 specimens. Of 10 species not recorded previously, 2 are new and are here described. One of these appears to be characteristic of the arid zone in Isla Santa Cruz but cannot be considered endemic until comparable continental habitats are studied. Of the 15 species found, 7 are cosmopolitan and 6 are well-known Neotropical species, suggesting an affinity to Ecuador. We conclude that the drosophilid fauna of the Galápagos is depauperate and consider earlier suggestions that a rich fauna exists to be erroneous.

In the last 25 years, faunal surveys of the world Drosophilidae have produced many surprises. The number of described species has become very large, just over 2500 (Wheeler 1981). Although about 12 species are virtually worldwide, each realm has its own distinctive fauna. Some intriguing oddities occur, such as the parasites of spittle insects, of spiders, of *Simulium* larvae, of frog eggs and of land crabs (see Ashburner 1981 for review).

Perhaps the greatest geographical surprise is the exuberance of the endemic fauna of Hawaii. More than 25% of the world count of species of Drosophilidae are endemic to these rather small oceanic islands. The species in Hawaii range from minute *Scaptomyza* (body length 1.6 mm) to giant *Drosophila* with a wing spread of about 22 mm. This extraordinary situation appears to be unique in Oceania and, indeed, in the rest of the world (Hardy & Kaneshiro 1981).

Although a number of general entomological surveys of the Galápagos Islands have been made (e.g., Linsley & Usinger 1966), very few Drosophilidae have been recorded; in fact Wheeler (1961) listed only 4 described and 1 undescribed species. Most general entomological collections tend to overlook small insects like Drosophilidae and it usually takes a specialist to locate them. Accordingly, the senior author visited the

1. Department of Genetics, University of Hawaii, Honolulu, Hawaii 96822, USA.
2. Museu de Zoologia de Universidade de São Paulo, Caixa Postal 7172, São Paulo, Brasil.
3. Department of Zoology, University of Texas, Austin, Texas 78712, USA.

Galápagos for 2 weeks in May of 1977 with the specific purpose of investigating the fauna of Drosophilidae. Collecting methods that have proven successful in the tropics of both hemispheres and in Hawaii were used. The results suggest that the Galápagos has a rather depauperate drosophilid fauna. Although we record here 15 species of the family, most are widespread members of the Neotropical fauna. Of 2 new species found, 1 occurs in substantial numbers in the cactus forests of lowland Isla Santa Cruz. The circumstances surrounding its discovery are intriguing and more study is highly desirable. The other, a species of *Scaptomyza,* was found at high altitude on 2 islands.

METHODS

Collections were made from 3 islands (see Table 1) between May 11 and May 23, 1977. Eight and a half days were spent in the field; the remaining 4½ days were taken up in interisland travel. Baits made from bananas or papayas fermented with baker's yeast were placed in naturally vegetated areas from sea level to ca. 1200 m. Emphasis was placed on the mesic upland, ostensibly the best *Drosophila* habitat. Where possible, bait was placed on the bottom of 7.5 liter plastic buckets. These buckets were covered with a plywood lid that was left ajar to admit the flies. Collections were made by sweeping over the mouth of these lures while agitating the latter with the foot. In areas to which access was difficult, bait was exposed in plastic bags or in paper cups or placed directly on the ground. The collector also sought out and swept with the net any fermenting substrate, including refuse cans, fruit storage areas, compost heaps, orchards with fallen fruits or flowers, and deliquescing mushrooms. After capture, the flies were placed on an agar-sugar field medium (Spieth 1966) and transported to the laboratory where identifications were carried out under a high-powered stereomicroscope. A number of specimens were live-cultured on instant *Drosophila* medium and were taken to mainland Ecuador for distribution to La Universidad Catolica, Quito, and by mail to New Haven, Connecticut.

Types are deposited in the Museu de Zoologia de Universidade de São Paulo, São Paulo, Brasil (MZUSP) and in the United States National Museum of Natural History (NMNH), the Smithsonian Institution, Washington, D.C., USA.

DESCRIPTIONS OF NEW SPECIES

1. **Drosophila xerophila** Val, **new species** Fig. 1A–I

External characters of imagines ♂,♀. Arista ochre at base, dark brown to black toward apex and branches, with 2–4 dorsal and 3 ventral branches in addition to apical fork (poorly defined in some specimens). Antennae and frons ochre, ocellar triangle slightly darker. Postverticals 2× length of middle orbital. Posterior reclinate orbital, slightly longer than proclinate, and about 2.2× length of middle orbital. Distance between proclinate and posterior reclinate orbital about same as between the latter and inner vertical. Middle orbital closer to the proclinate. Face, proboscis, and palpi yellow. Carina trapezoidal, prominent, frontally flat, lower portion broader. One strong oral. Eyes with short yellow pilosity. *Mesonotum* ochraceous to yellow, darker than pleurae, legs light yellow. Acrosticals in 6–8 regular rows. Prescutellars absent.

TABLE 1. Drosophilidae of the Galápagos Islands (for details, see text).

SPECIES	SANTA CRUZ*		ISABELA*			BALTRA	SANTIAGO	FLOREANA	ISLAND UNSPECIFIED
	LOWLAND	UPLAND	SANTO TOMAS	VÓLCAN SIERRA NEGRA	SAN CRISTÓBAL*				
Drosophila (*Drosophila*)									
cardinoides Dobzhansky & Pavan	1	33	6		21				
immigrans Sturtevant							(Z)†	(Z)†	(W)‡
hydei Sturtevant	1	7 (AT)§	3						
metzii Sturtevant		23	3	1					
repleta Wollaston	23								
xerophila, n. sp.	302	1							
Drosophila (*Sophophora*)									
ananassae Doleschall	6								
melanogaster Meigen	88								
nebulosa Sturtevant	2	2	10		29				
simulans Sturtevant	3	26	15	5	23 (W‡Z)†	(Z)†			
willistoni spp.		2	10	1	37 (W‡Z)†	(Z)†			
quechua Ayala									
Drosophila (*Scaptodrosophila*)									
latifasciaeformis Duda		3							
Drosophila (*Hirtodrosophila*)									
pictiventris Duda		58	20						
Gitona brasiliensis Lima		(W)‡							
Scaptomyza (*Parascaptomyza*)									
santacruzi, n. sp.		3		6					
Totals	426	158	67	13	110				
Grand total = 774	584		80		110				

* For specific locality, see text.
† Z = Recorded by Zúñiga (1974).
‡ W = Recorded by Wheeler (1961).
§ AT = Arcos-Teran, L. (pers. commun.) also reports this species from Isla Santa Cruz.

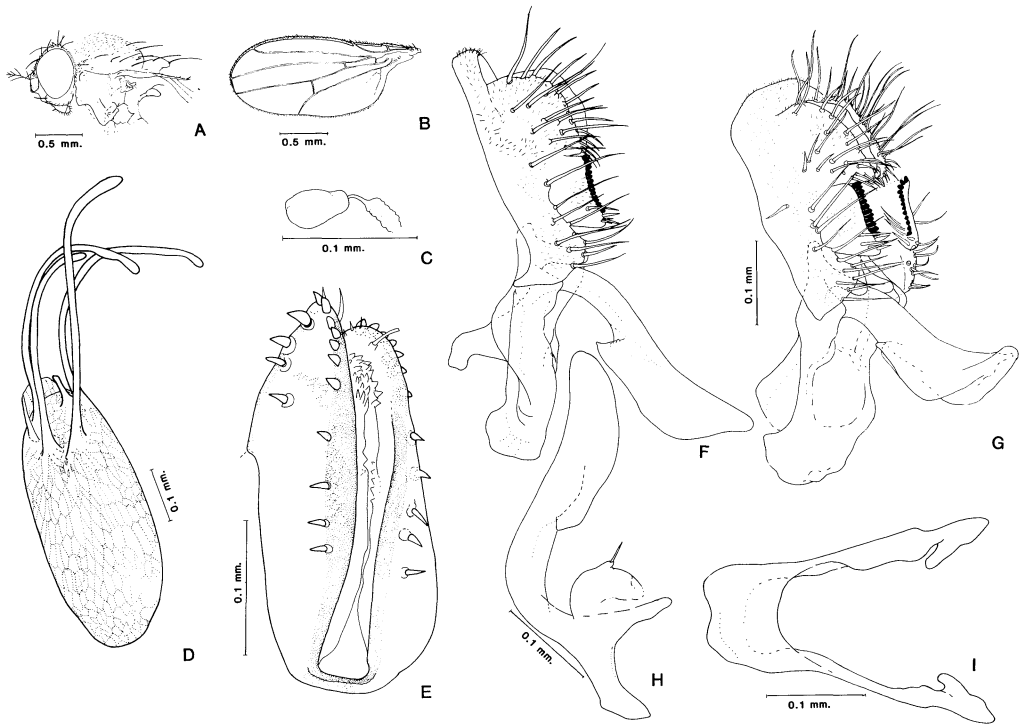

FIG. 1. *Drosophila xerophila:* **A,** holotype ♂, head and thorax, side view; **B,** wing; **C,** spermatheca from paratype; **D,** egg; **E,** ovipositor; **F, G,** general views of ♂ genitalia from paratypes; **H,** aedeagus; **I,** hypandrium.

Anterior scutellars parallel or slightly convergent. Sterno-index ca. 0.70–0.76 (10 specimens). Apical spur present on middle tibia and preapicals on all tibiae. Wings brownish, in some specimens darker on anterior ½ of wing. Costal index 2.62–3.16 (10 specimens). *Abdomen* yellow in ♂ and variable in ♀, usually light brown to brown, with darker posterior margins of tergites (sometimes also darker in anterolateral areas of tergites) when viewed laterally.

Total body length in dried specimens about 2.0–2.5 mm.

♂ *genitalia* (Fig. 1F–I). Anal plate fused. Forceps with 12–13 primary teeth in an almost straight row. Hypandrium trapezoidal, about as long as genital arch, with fingerlike processes subterminal to articulation with epandrium (arch).

♀ *internal characters.* Spermathecae approximately cylindrical, poorly sclerotized, duct penetrating only base of chitinized capsule (Fig. 1C). Ventral receptacle extensively coiled (kinky).

Eggs. With 4 filaments (Fig. 1D).

Type data. Holotype ♂, allotype ♀, 5♂,5♀ paratypes, GALÁPAGOS IS: Isla Santa Cruz, Puerto Ayora, Estacion Charles Darwin, 10 m, 10.V.1977, ex banana and papaya baits placed nr pens of the tortoise *Geochelone elephantopus* and the land iguana *Conolophus subcristatus* (Carson). 1♀ paratype, Isla Santa Cruz: craters above Los Gemelos, 600 m, 16.V.1977 (Carson). For further details, see below. Holotype and allotype in MZUSP, paratypes in NMNH.

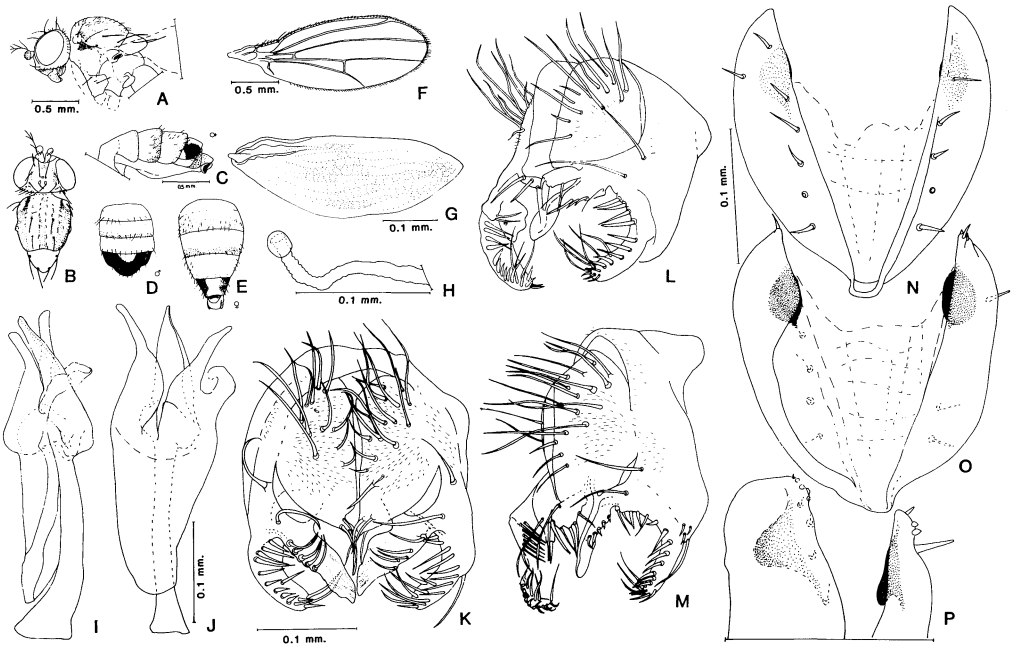

FIG. 2. *Scaptomyza santacruzi:* **A,** holotype ♂, head and thorax, side view; **B,** dorsal view; **C,** lateral and **E,** dorsal view of abdomen of ♀ paratype from Volcán Sierra Negra; **D,** dorsal view of abdomen of ♂ paratype from Los Gemelos; **F,** wing of holotype; **G,** egg and **H,** spermatheca of paratype from Volcán Sierra Negra; **I,** side view and **J,** frontal view of hypandrium and aedeagus of holotype; **K, L,** genital arch of holotype; **M,** semilateral view of epandrium, forceps and cerci from a paratype ♂, Volcán Sierra Negra; **N,** ventral, **O,** dorsal, and **P,** lateral views of ovipositor of paratype ♀ from Volcán Sierra Negra.

Relationships. This small, dull yellowish fly superficially resembles some members of the *willistoni* group of the subgenus *Sophophora,* especially *D. mangabeirai* Malogolowkin, a widespread neotropical parthenogenetic species. Some of the more obvious differences: 4-filamented eggs (vs. 2 in *mangabeirai*), 1 stout oral bristle (vs. 2), 3rd costal section with black bristles on basal ½ or less (vs. ⅔), costal wing index 2.6–3.2 (vs. 2.1), spermatheca weakly sclerotized (vs. heavily sclerotized), and the wholly different ♂ genitalia. The 4-filamented eggs and 1 oral bristle suggest an affinity with the subgenus *Drosophila,* but it cannot be assigned to any subgenus until further information is available (internal anatomy, chromosomes, etc.).

2. **Scaptomyza (Parascaptomyza) santacruzi** Val, **new species** Fig. 2A–P

External characters of imagines ♂,♀. Male face entirely white pollinose, ♀ face white with brownish carina. Antennae light brown; arista brown to black with 3 dorsal and 1 ventral branch, in addition to distal fork. Frons golden yellow between orbitals, gray stripe under orbitals, small gray or brownish spot in middle anterior region (in some specimens this spot is connected to the dark brown ocellar triangle); anterolateral areas and margins of eyes whitish.

Frons length subequal to width. Postvertical bristles slightly longer than posterior orbital; inner verticals ca. 1.5× posterior orbitals. Posterior orbitals slightly longer than weak middle orbitals. Distance between inner vertical and posterior reclinate orbital ⅔ greater than between posterior orbital and proclinate; middle orbital closer to proclinate. Genae, palpi, and occiput yellow. One strong oral bristle. Eyes with very short light pile. *Acrosticals* in 2 regular rows; 2 humerals. Mesonotum yellow, light brown median stripe between acrosticals, pair of narrow light brown lines along base of dorsocentral bristles, reaching anterior region of mesonotum; pair of dark brown broad stripes alongside humeral callus, lighter towards scutellum and pleura (Fig. 2B). Legs yellow; apical spur on middle tibia, preapicals on all tibiae. Pleura yellow with brown stripe in epipleural region (Fig. 2A). Sternoindex 0.6–0.7 (3 specimens). Wing length 2.0–2.7 (6 specimens); costal index 2.7–3.2 (7 specimens). *Abdomen* yellow with sublateral large dark shining spots on 5th tergite, centrally fused in ♂, not fused in ♀ (weakly marked in 2♀). Tergite 6 black or dark. Posterior margin of anterior tergites variable, usually with dark band in 3rd tergite (Fig. 2C–E).

♀ *internal characters and ovipositor.* Subquadrangular spermathecae weakly sclerotized with very long duct, deeply telescoped. Ovipositor guides strongly sclerotized, concave, with subterminal internal thickening of chitin, forming buttonlike structure (Fig. 2N–P).

♂ *genitalia.* As in Fig. 2I–M. Anal plate partially fused to epandrium, bearing well-developed secondary lobes with spines. Claspers with flat projection on dorsoapical edge.

Eggs. Without filaments (Fig. 2G).

Type data. Holotype ♂, 2♂,1♀ paratypes, GALÁPAGOS IS: Isla Santa Cruz: Los Gemelos, 550 m, 16.V.1977 (Carson); 1♂,2♀ paratypes, Isla Isabela: Volcán Sierra Negra, 850 m, 19.V.1977 (Carson). Holotype in MZUSP, paratypes in NMNH.

Relationships. The male genitalia of this species greatly resemble those of the cosmopolitan *S. pallida* Zetterstedt and the oriental *S. elmoi* Takada; the 3 species are evidently closely related. The abdominal pattern of *S. santacruzi,* both male and female, is distinctive (see Fig. 2) and unlike that of any other known neotropical members of this subgenus (Wheeler & Takada 1966).

COLLECTING RESULTS

General results are recorded in Table 1, which also reviews previous findings. The following information, expanded from field notes (Carson), is given as supplementary data.

Isla Santa Cruz, lowland locality (Table 1). Collecting was concentrated at the Charles Darwin Biological Station near Puerto Ayora and along the trail leading up from Puerto Ayora towards the hamlet of Bellavista. The fruit room at the station restaurant yielded most of the listed *D. melanogaster, D. repleta, D. hydei* and *D. ananassae.* Baits were placed in a natural forested area that had been converted to a shaded set of rockbound pens for the retention of tortoises and land iguanas. The rest of the species listed in Table 1 came from this area. Phyllodes of *Opuntia* cactus were being used as the principal source of food for the tortoises; some drosophilid specimens were swept from this slightly decaying substrate.

With the exception of a single specimen captured in the craters area (*Miconia* zone, 550 m; see Table 1) the new species *D. xerophila* was found exclusively in the lowland

area below 10 m elevation. Most specimens were found near the tortoise pens, although an association with tortoises, iguanas, or *Opuntia* may have been fortuitous.

As *D. xerophila* was the only species that seemed at all unusual and was quite numerous, the following procedure was used to see if this species could be found far from the tortoise pens and out in the open, natural, arid zone away from chopped *Opuntia* and any human habitation or refuse. On Isla Santa Cruz near the town of Puerto Ayora, the arid zone is about 2.5 km wide, rising to only about 10 m above sea level. Inland, it is bordered by a vertical wall about 15 m high. The vegetation is an extremely dry scrub, including 2 cacti, *Opuntia echios* and a columnar species of *Jasminocereus. Cryptocarpus pyriformis, Bursera, Maytenus,* and *Croton* are also present. Temperatures in this zone during the day are extremely high and collecting of *Drosophila* from baits is not possible.

At about 900 h on May 23, 1977, 2 buckets of well-fermented banana were carried inland to a point on the Bellavista trail approximately 0.7 km past the last house N of Puerto Ayora. They were placed in a depression in the lava in open cactus scrub and covered with lids. Collecting attempts were begun at 1700 h and were continued at 10-min intervals until dusk. It was nearly dark before the first fly was captured at 1755 h. Flies then came actively to the bait for the ensuing 15 min, stopping abruptly at 1810 h. The collection consisted of 38♀ and 17♂ of *D. xerophila* and 1♀ and 1♂ of *D. simulans.* Collections of flies from one of these baits was somewhat hampered by a mockingbird (*Nesomimus melanotis*), which repeatedly visited the can and appeared to be feeding on the flies. In our field experience, no such strictly limited flying time has been observed when collecting *Drosophila* in any other situation, with the possible exception of the drosophilids of the Sonoran desert in the southwestern United States.

From these observations, it may be suggested that *D. xerophila* is a native element of the arid zone of Isla Santa Cruz. Further studies of the ecology of this fly and attempts to collect it on other islands as well as comparable areas on the west coast of South America should yield interesting data.

Isla Santa Cruz, upland locality (Table 1). The flies listed were captured at 4 localities in the mesic upland on May 16, 1977. These were in orchards around Bellavista (194 m), Santa Rosa (425 m), in the National Park (Los Gemelos), near the park's boundary with agricultural land (550 m), and at the area near the craters (Maternidad, in the *Miconia* zone, 600 m). The area near Los Gemelos in the National Park harbors a dense forest of large *Scalesia* (sunflower) trees, with an understory of *Psychotria, Chiococca alba,* and *Tournefortia. D. xerophila* was the only species caught at Maternidad; the best collecting was on baits that had been laid in the *Scalesia* forest the night before. These yielded 7 of the 10 species recorded from the highlands, including all of the *D. pictiventris, D. metzii,* and *S. santacruzi.* The *D. latifasciaeformis* and 6 *D. cardinoides* were collected at Santa Rosa, whereas 1 *D. willistoni* and 2 *D. nebulosa* were obtained at Bellavista. Although fruits were scarce, the orchards at Santa Rosa contained banana, plantain, coffee, avocado, orange, papaya and guava trees.

Isla Isabela, Santo Tomás locality (Table 1). Collections were made on May 18 near

the hamlet of Santo Tomás at 335 m among guava and coffee trees planted in a partially cleared forest including *Zanthoxylum* and *Urera*. At both this locality and at Los Gemelos on Santa Cruz, *D. pictiventris* was collected from fungus.

Isla Isabela, Volcán Sierra Negra locality (Table 1). The 13 flies listed were taken on May 19 in 2 deep cracks or pits lined with large tree ferns that had escaped the depredations of the ubiquitous cattle. One of these pits was at about 850 m elevation and the other at 1000 m. The latter was about 30 m below the summit of Volcán Sierra Negra. Except for these pits, the slopes were covered with pasture and thickets of guava.

Isla San Cristóbal. Collections on this island were made near the village of Progreso, using baits and sweeping in orchards and in occasional naturally vegetated fern gullies. The road to Freshwater Bay was followed from about 240 m elevation to approximately 580 m in the *Miconia* zone. Only 4 species were collected. Most specimens were obtained by sweeping over fallen oranges and guavas. Banana, mango, and coffee trees were also present. The Progreso area appeared to be the best site for collections of *D. willistoni*. Cultures were sent to Professor Jeffrey R. Powell of Yale University and were studied by Ms Marta Rico. Based on tests of mating behavior, hybridization, and allozymes, 6 lines derived from isofemales were identified as *D. willistoni* subspecies *quechua* (see Ehrman & Powell 1982). Although they were not tested, the specimens from Isla Santa Cruz and Isla Isabela were assumed to be the same subspecies as the flies from Isla San Cristóbal.

Table 1 also lists all other known records of *Drosophila* from Galápagos, combining the contributions of Arcos-Teran (pers. commun.), Wheeler (1961), and Zúñiga (1974). For most of these records, specific locality information within islands is unknown.

CONCLUSIONS

In May of 1977, 774 specimens of 13 species of Drosophilidae were recorded from the Galápagos. Combined with 2 species recorded by others, the total known fauna consists of 15 species. Seven of these represent species that are virtually cosmopolitan in distribution. Six are widespread and well-known Neotropical elements (*D. cardinoides, D. metzii, D. nebulosa, D. willistoni, D. pictiventris,* and *Gitona brasiliensis*). In view of the settlement of the islands by farming families from Ecuador, this element in the fauna is not unexpected. The 2 remaining species, *D. xerophila* and *S. santacruzi,* may be endemic, but this conclusion must remain tentative until studies of the fauna of comparable continental habitats have been carried out.

With regard to our identification of *D. metzii,* the chalk-white carina and face of the Galápagos males and other general aspects of the external morphology of these flies agree closely with the description of this species (see comments in Pipkin 1967). One of us (FCV) has observed a minor difference in the apex of the aedeagus between the type specimen of *D. metzii* from Cuba and the Galápagos flies. A separate note on this character is being prepared, but we do not consider the difference large enough to justify the erection of a new species. *D. pictiventris* is a very widely distributed

member of the subgenus *Hirtodrosophila*, having been recorded from El Salvador, Mexico, Trinidad, Panama, Costa Rica, Honduras, St. Vincent, St. Lucia, Colombia, Puerto Rico, and Ecuador. Accordingly, its presence on the Galápagos is not surprising.

On the basis of what is now known, we venture the judgment that the Galápagos has an extremely depauperate fauna of Drosophilidae. This conclusion is in accord with the findings of Johnson & Raven (1973), who noted that the pattern of low endemism in the moist uplands is characteristic of the Galápagos and distinguishes it from almost all other high island groups that have been studied in detail. A large endemic fauna of Drosophilidae does not appear to exist either in the uplands or lowlands. Unfortunately, little is known of the fauna of the higher forested craters. For example, there are 5 such craters on Isla Isabela, from 1128 to 1705 m, some of which contain dense forests. Conspicuous by their absence are the cactus-breeding members of the *repleta* group of the genus *Drosophila*. This very large group of species is characteristic of deserts of Texas, Arizona and Mexico, as well as Central and South America (Wasserman 1982).

In view of the small number of drosophilids we have recorded from the Galápagos, it is surprising that a "conventional wisdom" appears to exist in some circles that there is a large undiscovered fauna comparable to that of Hawaii. In our opinion, this view stems from a misinterpretation of remarks made by Dobzhansky (1972) about the significance of certain insular drosophilid faunas, using Hawaii as an example. In conversations with Professor Robert Bowman, Dobzhansky apparently left the impression that the Galápagos might also have a rich drosophilid fauna. The former (Bowman 1972) apparently took Dobzhansky's enthusiasm to mean that there was, indeed, preliminary evidence for the existence of a rich Galápagos fauna. Accordingly, he concluded his transcribed remarks on the subject as follows: "I predict that there will be rich rewards in speciation studies of Galápagos *Drosophila*."

Even if our conclusion about the sparse nature of the drosophilid fauna is borne out in the future, the fascination of doing biological work in this extraordinary place will not be diminished in our eyes. When about to leave the Galápagos, one of us (MRW) wrote in the visitor's book on the ship: "I have walked where Darwin walked; I have seen what Darwin saw; I have had a dream come true."

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