disturbed *Cx. quinquefasciatus* larvae tended to forage away from the surface for longer periods of time between air breathing bouts than did the larvae of *Cx. nigripalpus*, *Cx. salinarius* and *Cx. restuans*.

The main characters for separating the first-instar larvae of the four species of *Culex (Culex)* are presented in the following key:

1. Fourth abdominal segment unpigmented .... *nigripalpus*
Pigmented 2
2(1). Clear crescent anterior to egg breaker *restuans*
no crescent 3
3(2). Upper and lower caudal setae of anal segment separated by 30°–45°; larva returns to surface in 20 sec. or less after disturbance . *salinarius*
Upper and lower caudal setae not unseparated; larva returns to surface 1 min. or longer after disturbance .... *quinquefasciatus*

References Cited

Bohart, R. M. 1954. Identification of first stage larvae of California *Aedes* (Diptera, Culicidae). Ann. Entomol. Soc. Am. 47:355–366.

Dodge, H. R. 1966. Studies on mosquito larvae II. The first-stage larvae of North American Culicidae and of world Anophelinae. Can. Entomol. 98:337–393.

Price, R. D. 1960. Identification of first-instar aedine mosquito larvae of Minnesota (Diptera: Culicidae). Can. Entomol. 92:544–560.

INCREASED ADULT SIZE CORRELATED WITH PARITY IN *AEDES TRISERIATUS*[1]

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Parous rates frequently have been utilized to analyze the age structure of mosquito populations. A population with a large proportion of parous females is aging, and potentially contains more individuals that have had an opportunity to become infected with a transmittable pathogen. Detinova (1962, 1968) and Ungureanu (1974) have reviewed the significance of parous rates to the epidemiology of mosquito-borne disease.

The observed parity rate in a population is known to be influenced by the method of collecting, periodicity of blood-feeding, duration of the gonotrophic cycle, and weather (Service 1976), but the relationship between female size and parity has not been investigated. Container-breeding mosquitoes vary markedly in size; variation in larval diet can produce adults that vary 7× in dry weight[3]. Size variation is of epidemiological significance because longevity of adult female *Aedes triseriatus* (Say) in the laboratory increases with size[3]. Consequently, large females may be disproportionally dangerous as vectors. The object of this study was to determine if the percentage of parous females in *Ae. triseriatus* varied with the size of adult females.

MATERIALS AND METHODS

On September 4, 8, 11 and 24 of 1981, *Ae. triseriatus* females were collected at Western Iron and Metal Co., South Bend (St. Joseph Co.), Indiana. Thousands of tires, many of which contained *Ae. triseriatus* larvae, are stored in the salvage yard (Beier et al. 1983). The mosquitoes were collected with a mechanical aspirator (Nasci 1981) from low understory vegetation (primarily Virginia creeper, *Parthenocissus* sp.; stinging nettle, *Urtica* sp.; spicebush, *Lindera* sp.; and poison ivy, *Rhus radicans*) in a tree line along the western edge of the salvage yard. Total time expended collecting was approximately 6.5 hours.

In the laboratory, the mosquitoes were anesthetized with ether and females of *Ae. triseriatus* were frozen at −70°C. Wing length was used as a measure of body size because this character is significantly correlated with dry weight ($n=178$, $r=0.94$, $P<0.01$)[3]. Females were thawed and the length of one wing from the base of the costa to the tip of the wing margin excluding the apical scales was measured with an ocular micrometer. The observed range of the wing lengths (2.74–4.48 mm) was evenly divided among 3 size-classes: small (2.71–3.30 mm); medium (3.31–3.90 mm); and large (3.91–4.50 mm). Skewness and kurtosis of the entire wing-length distribution of the pooled samples were calculated by the method of Sokal and Rohlf (1969) and the distribution was tested for departure from normality by Chi square goodness of fit (Snedecor and Cochran 1967).

To determine the gonotrophic state of the mosquitoes, each female was washed with a 1% soap solution to wet the cuticle and the ovaries were dissected in several drops of deionized water. Females were classified as nulliparous or parous based on differences in the tracheal system of the ovaries (Detinova 1962). Nulliparous females with ovarioles at stage S-1 (Chrostophers' stages as in Detinova 1962) were designated as non-gonoactive. Gonoactive females were: 1) nulliparous females with ovarioles at stage S-2; 2) blooded or gravid females at stage S-3, 4 or 5; and 3) parous females. Gravid and parous females were pooled into a gravid or parous gonotrophic state because both had completed part of at least 1 gonotrophic cycle. The percentages of the gravid or parous females of the size classes were compared with a test for equality of percentages (Sokal and Rohlf 1969). Non-gonoactive females were assumed to be newly emerged, thus would have had less time to seek hosts than gonoactive nullipars. The pooling of non-gonoactive and gonoactive females could have altered the relative proportion of nullipars in each size class, which would have distorted the results of statistical analysis. However, the non-

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[3] McCombs, S. D. 1980. Effect of differential nutrition of larvae on adult fitness of *Aedes triseriatus*. M.S. thesis. University of Notre Dame, IN. 123 pp.

gonoactive females could not simply be ignored because they are potentially vectors. Consequently, the percentages of each size class gravid or parous were statistically compared both with and without the non-gonoactive females.

RESULTS AND DISCUSSION

There were 571 females collected from the tire yard. Wing measurements ranged from 2.74–4.48 mm ($\bar{x}=3.54$ mm, $SD=0.41$). The total distribution of wing lengths was skewed to the right, platykurtotic, and not normally distributed (Chi square goodness of fit, $P<0.001$). Mosquitoes of these three size classes consisted of 31% small ($\bar{x}=3.07$ mm, $SD=0.16$), 48% medium ($\bar{x}=3.58$ mm, $SD=0.17$), and 21% large ($\bar{x}=4.13$ mm, $SD=0.16$) (Table 1). Among the 511 mosquitoes which were gonoactive 26% (133) were small, 50% (257) were medium, 24% (121) were large. Only 11% (60/571) of the females were non-gonoactive; the majority of these were in the small size category.

Of the gonoactive females, 35% of the small, 42% of the medium, and 64% of the large were gravid or parous females (Table 1). In the large size class, a significantly higher percentage of the gonoactive females were gravid or parous than either of the other two size classes (test for equality of percentages, $P<0.001$ for each). The small and medium classes did not differ significantly in the percentage of gravid or parous females ($P>0.10$). When non-gonoactive and gonoactive females were pooled, 26% of the small, 39% of the medium, and 63% of the large females were gravid or parous (Table 1). The percentage of gravid or parous females of each size class was significantly different from the other 2 classes ($P<0.001$ for each comparison).

McCombs[3] investigated the relationship between larval nutrition and fitness of adults of *Ae. triseriatus.* She found that an optimal larval diet increased both the size (as measured by wing length) and laboratory survival of adults. Adult females of *Ae. triseriatus* collected in the field are often smaller than those reared in the laboratory[3], presumably because of intense competition for limited nutrients in tree holes (Fish and Carpenter 1982). Discarded tires are another habitat invaded by *Ae. triseriatus.* The considerable variation in the amount of organic material in individual tires (Beier et al. 1983) probably produces substantial size variation in the females emerging from tires. If large females have a higher survival rate than small females in the field, or are more successful in bloodfeeding, the large females should have a greater probability of being gravid or parous. Thus the hypothetical relationship between female size and parous rate should apply to both kinds of females, those emerging from tree holes and those from tires.

Significantly more large gonoactive females were gravid or parous than those in the 2 smaller size classes which suggests that fitness increases with size. Inclusion of the non-gonoactive females in the statistical analysis supports the hypothesis because the percentage gravid or parous females of all size classes differ significantly. Interestingly, 68% (41/60) of the non-gonoactive females belonged to the smallest size class. Perhaps ovaries of larger females developed more quickly because they had adequate energy reserves at emergence.

Even though large females may have had a higher survival rate than the smaller females, they were only 22% of the total sample. However, females must survive a considerable period before they become infective because the extrinsic incubation period of La Crosse virus in *Ae. triseriatus* is about 18–20 days at 20° C (P. R. Grimstad, personal communication). Consequently, the relatively small proportion of large females may be of the highest medical significance, because they would have the highest probability of surviving to become epidemiologically dangerous.

References Cited

Beier, J. C., M. Travis, C. Patricoski and J. Kranzfelder. 1983. Habitat segregation among larval mosquitoes (Diptera: Culicidae) in tire yards in Indiana, USA. J. Med. Entomol. 20:76–80.

Detinova, T. S. 1962. Age-grouping in Diptera of medical importance with special reference to some vectors of malaria. WHO Monogr. Ser. 47:216 pp.

Detinova, T. S. 1968. Age structure of insect popula-

Table 1. Wing length and percentage gravid or parous of *Aedes triseriatus* collected in a tire yard, September 1981.

Wing length	Small (2.71–3.30 mm)	Medium (3.31–3.90 mm)	Large (3.91–4.50 mm)	Total
Non-gonoactive nulliparous (stage S-1)	41	18	1	60
Gonoactive nulliparous (stage S-2)	87	150	44	281
Gonoactive gravid or parous	46	107	77	230
Total (%)	174(31)	275(48)	122(21)	571
% Gravid or parous	26*	39*	63*	40
% Gonoactive females** gravid or parous	35[a]	42[a]	64[b]	45

* $P < 0.001$ for each comparison of total females.

** Percentages of gonoactive females with different letters are significantly different.

[a] $P > 0.10$.

[b] $P < 0.01$ for each comparison.

tions of medical importance. Annu. Rev. Entomol. 13:427–450.

Fish, D. and S. R. Carpenter. 1982. Leaf litter and larval mosquito dynamics in tree-hole ecosystems. Ecology 63:283–288.

Nasci, R. S. 1981. A lightweight battery-powered aspirator for collecting resting mosquitoes in the field. Mosq. News 41:808–811.

Service, M. W. 1976. Mosquito ecology. Halsted Press. New York. 583 pp.

Snedecor, G. W. and W. G. Cochran. 1967. Statistical methods. Iowa State University Press. Ames. 593 pp.

Sokal, R. R. and F. J. Rohlf. 1969. Biometry. W. H. Freeman and Co. San Francisco. 776 pp.

Ungureanu, E. M. 1974. Population dynamics and age grading of mosquitoes. Bull. W. H. O. 50:317–321.

ROCK HOLE HABITATS OF A FERAL POPULATION OF *AEDES AEGYPTI* ON THE ISLAND OF ANGUILLA, WEST INDIES

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In the New World, *Aedes aegypti* (Linn.) is associated with a well defined range of immature habitats, principally small to large artificial containers. On Anguilla, West Indies, two distinct populations have been identified; a domestic population with immatures principally in large domestic underground water storage cisterns and old asphalt drums, and a rock hole population. The latter habitat was first cited by Belkin and Heinemann (1976) from a collection made by A. Guerra during August 1966. The rock hole population has since been found to be truly feral and rock holes containing immature *Ae. aegypti* occur at distances up to more than 1 km from the nearest human habitation.

The island of Anguilla lies between 62°58′ and 63°11′W, and 18°10′ and 18°17′N in the northeastern Caribbean and is 25 km long by just over 5 km wide at its widest, with a total land area of about 83 km^2; its long axis is oriented WSW to ENE. Anguilla is composed of limestones on a volcanic base, and is low lying and undulating, reaching up to 65 m on the north coast. The ridge along the north coast dips SSE to the south coast. Throughout the island are a number of depressions from a few tens of meters across to several kilometers, which contain the cultivable soil. Most of the remainder of the island is covered with cactus/thorn scrub, highly modified by erosive goat browsing and with little or no ground cover. The ground in these areas is mostly bare rock slabs or broken rock with sparse soil. The soil cover is eroded, and the limestone is considerably weathered into karst solution holes, varying from a few mm to 1.5 m diam. The rainfall is low and erratic with no clear rainy season in most years, although there is an overall tendency of higher rainfall during September–November (Table 1). Because of the low rainfall, water is often carried into the bush for tethered sheep and goats; a potential method of distributing domestic mosquitoes.

Participants in the Second *Aedes aegypti* Eradication Campaign, begun in 1972 under one of the authors (SM), were aware of the feral mosquito problem. Rock holes immediately adjacent to houses were identified and treated, and eventually an extra sprayman was employed specifically to treat rock holes. The second Campaign was discontinued in 1976, and no control was undertaken until 1981 when the Third Eradication Campaign was started under another of the authors (AGP). A more extensive search of the island was conducted recently, identifying *Ae. aegypti* positive rock holes over a wide area and at considerable distances from houses.

Karst holes over 100 mm in diam, by about 50 mm deep that will hold at least 20 mm of water serve as larval habitats for *Ae. aegypti* (Fig. 1). Holes that will hold water are associated both with continuous rock and with slightly raised limestone slabs, from 2 – 50 m^2, interspersed with broken rock and soil pockets. Coral rock formations of these types occupy at least 17 km^2 of the island with a hole density of 20–100 ha.$^{-1}$ Surveys made during February and September 1982 indicated that between 5 and 75 percent of rock holes containing water also had *Ae. aegypti* (Table 2). The overall percentage of positive rock holes sampled during February and September were 22.8 and 43.2 respectively.

The number of larvae in rock holes is very variable, attaining about 1000 immatures per m^2 of flooded rock hole area. Larvae occur in holes in full or partial shade, and occasionally in full sunlight, also

Table 1. Monthly rainfall at The Valley, Anguilla.[1]

Month	51 year mean[2]	1981–82[3]
January	62 mm	35 mm
February	39	173
March	37	32
April	64	29
May	105	121
June	65	10
July	79	89
August	102	39
September	130	55
October	130	184
November	130	39
December	83	108
Total	1,026	914

[1] Unpublished data from the Department of Agriculture and Fisheries, Government of Anguilla.

[2] Period 1931 to 1981.

[3] Monthly total October 1981 to September 1982.

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