effectiveness of a control programme involving both Abate and Malathion. Bull. W.H.O. 38: 439–445.
Moore, J. B. and Breeland, S. G. 1967. Field evaluation of two mosquito larvicides, Abate and Dursban, against *Anopheles quadrimaculatus* and associated *Culex* species. Mosq. News 27: 105–111.
Mulla, M. S. 1966. Toxicity of new organic insecticides to mosquito fish and some other aquatic organisms. Mosq. News 26:87–91.
Muller, R. 1970. Laboratory experiments on the control of *Cyclops* transmitting guinea worm. Bull. W.H.O. 42:563–567.
Ruber, E. and Baskar, J. 1968. Sensitivities of selected microcrustacea to eight mosquito toxicants. Proc. N.J. Mosq. Exterm. Assoc. 55: 99–103.
Schober, H. 1967. A study of the use of Abate in mosquito control in Suffolk County, Long Island, N.Y., in 1965. Mosq. News 27:100–105.
Silveira, S. M. 1971. The Northern San Joaquin Region. Proc. Pap. Annu. Conf. Calif. Mosq. Control Assoc. 39:11–12.
Standfast, H. A., Kay, B. H. and Steen, M. A. 1970. Entomology, Mosquito Control. Annu. Rep. Queensl. Inst. med. Res. 25:10.
Tawfik, M. S. and Gooding, R. H. 1970. Dursban and Abate clay granules for larval mosquito control in Alberta. Mosq. News 30: 461–464.
Vannote, R. L. 1971. Current mosquito control problems in New Jersey. Proc. Pap. Annu. Conf. Calif. Mosq. Control Assoc. 39:41–42.
von Windeguth, D. L. and Patterson, R. S. 1966. The effects of two organic phosphate insecticides on segments of the aquatic biota. Mosq. News 26:377–380.
von Windeguth, D. L., Eliason, D. A. and Schoof, H. F. 1971. The efficacy of carbaryl, propoxur, Abate and methoxychlor as larvicides against field infestations of *Aedes aegypti*. Mosq. News 31:91–95.
W.H.O. 1963. Insecticide resistance and vector control. W.H.O Tech. Rep. Ser. No. 265.

SUGAR FEEDING BY FLORIDA MOSQUITOES

W. L. BIDLINGMAYER AND D. G. HEM[1]

Florida Medical Entomology Laboratory, Florida Division of Health, Vero Beach, Florida 32960

Sugar is utilized by mosquitoes directly for flight energy (Hocking 1953, Nayar and Van Handel 1971) and excess amounts are converted into glycogen and fat (Van Handel 1965). Sugar is widely distributed, and mosquitoes have been recorded feeding upon flowers, extrafloral nectaries, honey-dew, and fruit juices (Smith 1904, Howard *et al.* 1912, Nielsen and Greve 1950, Hocking 1953, Haeger 1955, Nielsen and Nielsen 1958, Downes 1958, and Laarman 1968). Usually these reports are based on visual observations and only in a few cases has the presence of sugar in the mosquitoes been confirmed.

METHODS. The method used to detect sugar was based on the reaction of anthrone on fructose (Van Handel 1972). Fructose, free or as the fructose component of sucrose, is found in all plant sugars and the proportion of all fructose in a variety of Florida fruit juices and nectars ranged from 40 percent to 60 percent (Van Handel *et al.* 1972). As unfed or blood-fed mosquitoes do not contain this sugar, the presence of fructose clearly demonstrates the acquisition of a sugar meal.

Field collections were made by a suction trap (Bidlingmayer 1964), and a portable power aspirator, in a red maple (*Acer rubrum*) swamp about 10 miles west of Vero Beach. The latter method consisted of a sheet aluminum tube 13.5 inches in diameter with the distal (intake) end cut obliquely, so that the length of the tube along the long and short sides was 46 inches and 39 inches, respectively. A cloth mesh bag, the margin folded over

[1] Supported by National Institutes of Health Grant No. AI-06587.

the lip of the intake and held in place by an elastic band, was fitted within the tube. A 12-inch fan at the discharge end was operated by a 12-volt motorcycle battery and the battery was carried either in a back pack or by a battery carrier in one hand. Collections were made by passing the intake end of the aspirator a few inches above the surface of the ground while the operator walked along the 1200 ft. of boardwalk that traversed the swamp. Aspirator and suction trap collections were made twice weekly, May through November, and up to 20 specimens of all species from each aspirator collection, and up to 10 specimens of certain species (see Table 1) from each suction trap collection, were tested for fructose.

In another area at the edge of the salt marsh adjacent to the laboratory, additional suction trap collections were taken. Up to 10 specimens of each species were tested daily, but only *Aedes taeniorhynchus* and *Culex nigripalpus* occurred here in large numbers.

Immediately after return to the laboratory, mosquitoes were placed individually in 10 x 75 mm test tubes and wetted with 2–3 drops of chloroform-ethanol (1:1) to remove wax from the cuticle. To each test tube 0.5 ml of the fructose reagent was added, and after about one hour,

TABLE 1.—Numbers of mosquitoes tested and the percentages containing fructose. Specimens taken from collections made in maple swamp between May 1 and November 30, 1972 by a power aspirator during daylight hours and by a suction trap at night.

	Female			Male		
	Number			Number		
Species	tested	w/fructose	%	tested	w/fructose	%
		Power aspirator				
Aedes infirmatus	247	88	36	148	59	40
Culiseta melanura	720	259	36	912	266	29
Psorophora ferox	91	18	20	46	7	..
Psorophora confinnis	68	12	18	7	1	..
Culex nigripalpus	1061	179	17	1013	167	17
Aedes vexans	53	9	17	11	3	..
Culex (Melanoconion)	404	58	14	225	16	7
Aedes atlanticus	317	30	10	208	51	25
Anopheles crucians	300	11	4	292	16	6
Uranotaenia lowii	526	13	3	123	7	6
Uranotaenia sapphirina	650	6	1	279	5	2
Aedes taeniorhynchus	24	21	..	11	7	..
Culex territans	26	7	..	30	11	..
Aedes triseriatus	1	1	..	1	1	..
Wyeomyia mediolbipes	11	4	..	4	2	..
Aedes fulvus pallens	8	1	..	5	3	..
Coquillettidia perturbans	3	2	..	..	..	..
Culex salinarius	4	1	..	..	..	..
Mansonia titillans	3	1	..	..	..	..
		Suction trap*				
Aedes vexans	55	29	53	..	..	..
Culiseta melanura	638	115	18	518	161	31
Anopheles quadrimaculatus	228	35	15	..	..	..
Psorophora confinnis	63	9	14	..	..	..
Culex nigripalpus	669	44	7	..	..	..
Anopheles crucians	453	30	7	..	..	..
Aedes taeniorhynchus	13	10	..	..	..	..

* Not all species captured were tested.

the appearance of a green or blue color in the reagent revealed the presence of fructose.

RESULTS AND DISCUSSION. Fructose was found in 21 species (Table 1 and also *Deinocerites cancer*). Most species appear to feed freely, the percentage of individuals with sugar ranged according to species from 1 percent to over 50 percent. *Culiseta melanura, Aedes infirmatus, Aedes taeniorhynchus* and perhaps *Aedes vexans,* were heavier feeders than *C. nigripalpus,* while *Anopheles crucians,* and both *Uranotaenia* species, had very low rates. Feeding rates for male mosquitoes were similar to those for their respective females.

Table 2 shows that the percentage of mosquitoes with fructose varied during the year. Within each area, the sugar feeding rates of the two species showed similar fluctuations (footnotes a and b), which may reflect availability of sugar. Both *A. taeniorhynchus* and *Cs. melanura* fed more heavily than *C. nigripalpus. C. nigripalpus* captured near the salt marsh showed a higher rate of sugar feeding than those taken in the maple swamp area. This suggests that sugar is more abundant in the vicinity of the salt marsh and that *C. nigripalpus* is less efficient than either *A. taeniorhynchus* or *Cs. melanura* at finding sources. Maple swamps have fewer nectar sources than the adjacent open pinelands, and therefore the high sugar rates for *Cs. melanura* showed that, despite its greater restriction to this type of habitat, this species is highly successful in obtaining sugar supplies.

Visual inspection to detect nectar-fed mosquitoes was unreliable, for mosquitoes that appeared empty were often positive and specimens with abdomens distended by a clear fluid also may lack sugar.

The digestion of sugar proceeds logarithmically and small sugar meals are rapidly converted into glycogen and fat which do not react with the reagent (Van Handel 1965). Large meals may require several days. In field populations, neither the amount nor the time of the meal is known, and therefore a weak response to the reagent (light green ring) may indicate either a recent small meal or the remnants of a large meal taken several days earlier. Negative tests do not demonstrate that the specimens have never fed on nectar, and the probability of an individual mosquito obtaining sugar is greater than shown here.

SUMMARY. A simple method for detecting sugar in wild caught mosquitoes revealed sugar feeding in females of 21 species. Feeding rates were high in *Aedes taeniorhynchus* (up to 65%) and *Culiseta melanura* (up to 39%) and low in *Anopheles crucians* (4%), *Uranotaenia lowii*

TABLE 2.—Numbers of female mosquitoes examined by months and percentages with fructose taken in suction traps: A—adjacent to a salt marsh, B—within a maple swamp.

		1972										1973		
Species		Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Trap A[1]														
Aedes taeniorhynchus	No.	83	130	191	192	173	216	154	201	85	106	16	23	11
	%	52	54	64	38	55	44	65	60	35	59	25	9	9
Culex nigripalpus	No.	70	80	152	202	184	191	207	210	180	143	176	136	65
	%	14	15	23	16	24	12	14	20	4	11	4	4	8
Trap B[2]														
Culiseta melanura	No.	..	180	177	90	70	90	80	80	50	..	..	..	..
	%	..	39	24	21	21	14	16	15	0	..	..	..	..
Culex nigripalpus	No.	..	180	179	90	70	90	80	80	80	..	..	..	..
	%	..	19	12	9	4	6	4	1	4	..	..	..	..

[1] Correlation of monthly sugar feeding rates between species: r=.74 (P=<.01).
[2] Correlation of monthly sugar feeding rates between species: r=.80 (P=<.01).

(3%) and *Uranotaenia sapphirina* (1%). These are minimum rates as sugar expended in flight or converted into glycogen and fat cannot be determined. Monthly changes in feeding rates presumably reflect availability of sugar. Suction trap collections adjacent to a salt marsh showed higher feeding rates than in a fresh water maple swamp. Both sexes exhibited similar feeding rates.

ACKNOWLEDGMENTS. We wish to express our appreciation to Elaine Cody, Barbara Franklin and John Rodman for performing the laboratory work. Thanks are also due to Dr. M. W. Provost for reviewing the manuscript and to Dr. E. Van Handel for permitting use of his technique for detecting sugar prior to publication.

References

Bidlingmayer, W. L. 1964. The effect of moonlight on the flight activity of mosquitoes. Ecology 45:87–94.

Downes, J. A. 1958. The feeding habits of biting flies and their significance in classification. Ann. Rev. Ent. 3:249–266.

Haeger, J. S. 1955. The non-blood feeding habits of *Aedes taeniorhynchus* (Diptera: Culicidae) on Sanibel Island, Florida. Mosq. News 15:21–26.

Hocking, B. 1953. The intrinsic range and speed of flight of insects. Trans. R. Ent. Soc. Lond. 104:223–345.

Howard, L. O., Dyar, H. G. and Knab, F. 1912. The mosquitoes of North and Central America and the West Indies. Vol. I, 520 pp. Carnegie Inst. Publ. No. 1959, Washington, D.C.

Laarman, J. J. 1968. The intake of sugars by females of wild *Anopheles gambiae* and *Anopheles funestus*. Acta Leidensia 36:137–44.

Nayar, J. K. and E. Van Handel. 1971. The fuel for sustained mosquito flight. J. Insect. Physiol. 17:471–481.

Nielsen, E. T. and Greve, H. 1950. Studies on the swarming habits of mosquitoes and other nematocera. Bull. Ent. Res. 41:227–58.

Nielsen, E. T. and Nielsen, H. T. 1958. Observations on mosquitoes in Iraq. Ent. Medd. (Copenhagen) 28:282–321.

Smith, J. B. 1904. Report of the New Jersey State Agricultural Experiment Station upon the mosquitoes occurring within the State, their habits, life history, etc. 482 pp. MacCrellish and Quigley, Trenton, N. J.

Van Handel, E. 1965. The obese mosquito. J. Physiol. 181:478–86.

Van Handel, E. 1972. The detection of nectar in mosquitoes. Mosq. News 32:458.

Van Handel, E., Haeger, J. S. and Hansen, C. W. 1972. The sugars of some Florida nectars. Amer. J. Botany 59:1030–2.

THE ANAHEIM MEETING

Among the features of the Anaheim meeting will be panels on labor relations, mosquito distribution and taxonomy, and bio-control. According to Program Chairman Mel Oldham, there will be an all-day session designed especially for trustees and commissioners.