by the addition of dog food, peak emergence occurs after 9–13 days, and peak oviposition after 12–16 days.

References Cited

BIEVER, K. D. 1965. A rearing technique for the colonization of chironomid midges. Ann. Entomol. Soc. Amer. 58:135–136.

BRENNAN, J. M., and HARWOOD, R. F. 1953. A preliminary report on the laboratory colonization of the mosquito, *Culex tarsalis* Coquillett. Mosq. News 13:153–157.

HILSENHOFF, W. L. 1966. The biology of *Chironomus plumosus* (Diptera:Chironomidae) in Lake Winnebago, Wisconsin. Ann. Entomol. Soc. Amer. 59:465–473.

SYRJAMAKI, J. 1965. Laboratory studies on the swarming behaviour of *Chironomus strenkzkei* Fittkau in litt. (Dipt., Chironomidae). Ann. Zoologici Fennici 2:145–152.

BIONOMICS OF *CULEX SALINARIUS* COQUILLETT. II. HOST ACCEPTANCE AND FEEDING BY ADULT FEMALES OF *C. SALINARIUS* AND OTHER MOSQUITO SPECIES [1]

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Our continued interest in the bionomics of *Culex salinarius* Coq. (Murphey and Darsie, 1962) led to the investigation of its host-feeding activities on the Bombay Hook National Fish and Wildlife Refuge, Delaware, during the summers of 1958 and 1959. Such information could lead to a better definition of its possible role as a mosquito vector of disease agents. Although *C. salinarius* is not yet a proven vector, it has been associated with several diseases. Davis (1940) was unable to demonstrate laboratory transmission of Eastern encephalitis (EE) by *C. salinarius*. Later, Burbutis and Jobbins (1957), reported a natural infection of EE virus in eight blood-engorged females. However, they suggested that this mosquito plays a minor part in EE epidemiology because Chamberlain *et al.* (1954) had demonstrated *C. salinarius* to be refractory to infection with the virus in the laboratory.

Chamberlain (1958) pointed out that as the infection rate of associated bird-hosts was high at the time the collections were made by Burbutis and Jobbins (1957), the detected virus was most likely in recently ingested blood rather than established in the mosquito tissues. In contrast to these findings, Chamberlain *et al.* (1954) stated that sylvan (enzootic) transmission of St. Louis encephalitis virus to wild birds and fowl is possibly accomplished by *C. salinarius* because he found it to be an excellent vector in the laboratory. Laboratory tests by Newton *et al.* (1945) and Eyles and Most (1947) have demonstrated transmission by *C. salinarius* of the human filarial worm, *Wuchereria bancrofti* (Cobbold). Also, Huff (1927) demonstrated in the laboratory that this species is a possible vector of bird malaria parasites. Transmission of *Plasmodium relictum* (Grassi and Feletti) and *P. cathemerium* (Hartmann) to the English Sparrow, *Passer domesticus* (L.) and *Plasmodium gallinaceum* Brumpt to chickens was successfully accomplished in his studies.

Prior to the present work, detailed studies on host feeding by *C. salinarius* had not been conducted. However, subsequent results obtained by Hayes (1961) from animal baited-trap investigations in-

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dicated that females of *C. salinarius* fed equally well on both mammals and birds and recent serological work by Crans (1964) substantiated these results. Hayes also observed limited feeding on reptiles and amphibians. Previous field observations in Delaware indicated that although females of this species seldom fed upon humans during the daylight hours, they readily attacked man during twilight and darkness. (Murphey and Darsie, 1962).

The primary aim of this study was to investigate the relative host attractiveness of some common vertebrates potentially available to *C. salinarius.* Data on other mosquito species also were recorded when available and are presented herein.

MATERIALS AND METHODS. Various field investigations of "host preference" feeding have employed captured host animals placed in mosquito traps which were compared with respect to their relative host attractiveness. Hayes (1961) employed animal baited traps which rotated on an automatic revolving mechanism. Other workers, Dow *et al.* (1957), Edgar and Herndon (1957), Flemings (1958), and Blackmore and Dow (1959), utilized cages arranged in linear, fixed positions.

The specific arrangement and design of the bait traps in the present study was derived from the method of Blackmore and Dow (1958). Each trap was a 24-inch wood-framed cube covered with 18 x 14 mesh screen wire and having baffles on two sides which left a 2-inch opening for mosquito access across each side. A 6-inch overhang of screen wire placed outside the entrance opening lessened the opportunity for escape of trapped mosquitoes. Host animals were placed inside a smaller cage, 14 x 14 x 16 inches, made of 1-inch mesh hardware cloth. Modification of the inner cage, however, was required when testing raccoons, *Procyon lotor maritimus* N. & G., because these animals were able to reach through the one-inch mesh wire and tear the screening of the outer trap. Therefore, with raccoon tests the inner cage was covered with one-fourth inch mesh hardware cloth. Four bait-trap cages were employed for each test. These were arranged in a straight line and placed approximately 2 feet apart. Three contained potential host vertebrates and one was an unbaited control. Tests were initiated just before sunset in the evening and terminated approximately two hours after sunrise the following day. After completion of this exposure period, the cages were covered with polyethylene plastic sheeting and their interiors sprayed with pyrethrum mist to facilitate the collection of trapped mosquitoes.

Potential mammalian hosts, with the exception of the guinea pig, were captured on the Bombay Hook Refuge in various standard field traps. Bird hosts, other than chickens, were collected with mist nets, hand collecting nets and baited traps. Reptiles were taken by hand. No individual host animal was tested more than once even though its species was tested several times. Seven bird, eight mammal and four reptile species were used (Tables 1, 2, 3).

In this study, the evaluation of host attractiveness was based upon two primary factors: (1) The number of female mosquitoes attracted to the host; and (2) the subsequent rate of engorgement (percent) determined approximately 12 hours after the test began. By multiplying these two factors (average number attracted to the host *times* percent engorgement) and *dividing* by 100, an "index of attraction" was computed. These indices were employed to evaluate relative attractiveness for each host species. An index of 0–2 was considered a rating of poor attractiveness; from 3 to 7 fair attractiveness; and 8 or more would represent good attractiveness (Table 4).

RESULTS. A total of 17 tests was conducted in which 19 species of vertebrates were exposed. The number of times a vertebrate species was used varied from one to ten. Fourteen different species of mosquitoes totalling 6,803 individuals were collected during the investigation. Their kind and number are as follows: *Cu-*

TABLE 1.—Numbers of mosquitoes collected and engorged in avian-baited traps Bombay Hook, Delaware, 1958 and 1959.

Mosquito Species	Host Species[1]						
	Mallard[2] 1	Canada Goose[3] 2	Common Egret 1	Barn Owl 1	Redwinged Blackbird 6	Turkey Vulture[4] 1	Chicken 10
C. salinarius	19/15*	41/39*	36/34*	17/16*	150/126*	18/18*	412/366
A. sollicitans	14/12	36/33	15/14*	20/16*	171/149	16/15*	209/190
A. cantator	14/9	22/9	13/12*	6/6*	87/80*	18/16*	179/151
A. vexans	9/7*	17/13*	10/10*	8/6*	77/61*	7/6*	118/98
C. pipiens	7/6	54/38	7/6*	12/12*	79/74	12/12*	292/246
An. quadrimaculatus	17/2	14/11	7/6	2/2*	35/28*	4/4*	83/63
M. perturbans	17/12*	20/19	8/7*	13/8*	60/53	17/15*	121/109
An. crucians (complex)	1/1*	13/9*	10/7*	1/1*	38/31*	3/3*	98/74
C. restuans	6/1	14/11	12/9*	3/2*	40/31	4/2*	106/89
An. punctipennis	4/2*	1	2	3/1*	6/3*	6	26/15
C. territans	1	...	...	...	...	...	...
An. barberi	...	...	...	...	4/2	...	17/14
P. confinnis	1	1	7/7*	...	18/12*	2	11/10
An. walkeri	...	1/1*	1/1*	...	5/4*	...	2/2

[1] Number under each host name indicates the number of trials performed.
[2] *Anas platyrhynchos* L.
[3] *Branta canadensis* (L.)
[4] *Cathartes aura* (L.); other scientific names in text.
* New feeding records.

TABLE 2.—Numbers of mosquitoes collected and engorged in mammal-baited traps Bombay Hook, Delaware, 1958 and 1959.

Mosquito Species	Host Species[1]							
	Wood-chuck 8	Musk-rat[2] 2	Rac-coon 4	Opos-sum 3	Red Fox 1	Meadow Vole[3] 1	River Otter 1	Guinea Pig 2
C. salinarius	296/269*	69/58*	107/88*	71/65*	24/19*	30/26*	28/24*	58/50
A. sollicitans	360/322	65/59	115/105	97/88*	14/12*	29/26*	21/19*	74/66
A. cantator	205/167	38/33	75/68	62/56	17/16*	13/12*	9/7*	74/67
A. vexans	168/141	48/42	84/75	59/50	13/9*	19/17*	10/7*	26/21
C. pipiens	62/21	12/4*	21/17	12/6*	2/0	2/1*	3/1*	20/9
An. quadrimaculatus	134/109	41/34	47/41	42/35	15/13*	21/17*	4/2*	31/25
M. perturbans	85/68*	28/25*	67/62*	12/9*	6/6*	5/4*	...	12/10
An. crucians (complex)	76/63*	27/23*	56/47*	32/30*	5/2*	19/16*	9/7*	41/34
C. restuans	6/4*	1/1*	2/2*	1/1*	...	...	...	...
An. punctipennis	38/26*	2/2*	12/5*	12/9*	1/1*	2/2*	1/1*	14/10
C. territans	...	...	...	...	...	...	...	...
An. barberi	16/10*	3/2*	10/7*	7/5*	...	4/3*	...	8/5*
P. confinnis	7/6*	1/1*	4/4	10/8	...	...	...	1/1
An. walkeri	17/8*	...	...	3/2*	...	...	...	...

[1] Number under each host name indicates the number of trials performed.
[2] *Ondatra zibethicus zibethicus* (L.).
[3] *Microtus pennsylvanicus pennsylvanicus* (Ord); other scientific names appear in text.
* New feeding records.

TABLE 3.—Numbers of mosquitoes collected and engorged in reptile-baited traps, Bombay Hook, Delaware, 1958 and 1959.

Mosquito Species	Host Species[1]			
	Kingsnake	N. Watersnake[2]	Snapping Turtle[3]	E. Box Turtle[4]
C. territans	14/12*	34/28*	26/21*	30/26
An. quadrimaculatus	2/0	2/2*	4/2*	3/3*
A. sollicitans	10/4*	4/0	8/4*	3/0
M. perturbans	4/2*	8/4	2/0	...
C. pipiens	2/0	4/0	5/0	8/0
C. salinarius	...	8/0	3/0	4/0

[1] Two trials were performed for each host species.
[2] *Natrix sipedon sipedon* (L.).
[3] *Chelydra serpentina serpentina* (L.).
[4] *Terrapene carolina carolina* (L.).
* New feeding records.

lex salinarius—1391, *Aedes sollicitans* (Walker)—1281, *Aedes cantator* (Coquillett)—832, *Aedes vexans* (Meigen)—673, *Culex pipens* L.—616, *Anopheles quadrimaculatus* Say—508, *Mansonia perturbans* (Walker)—485, *Anopheles crucians* (complex)—440, *Culex restuans*—195, *Anopheles punctipennis* (Say)—130, *Culex territans* Walker—105, *Anopheles barberi* Coquillett—69, *Psorophora confinnis* Lynch-Arribalzaga—63, *Anopheles walkeri* Theobald—29. Eighty-three percent of the total were engorged and appeared to have fed to repletion. While no engorged mosquitoes were taken from the unbaited, control traps, unengorged females averaged 1.75 per trap night. Since these low numbers of unengorged mosquitoes in the control traps most likely do not represent attraction, collections of 1 or 2 unengorged females were not included in the data. Further reason for such an elimination is that these figures would not have any meaning in terms of the index of attraction since engorgement was necessary for arriving at an index figure. In addition, 117 possible new feeding records are presented in Tables 1, 2, and 3.

In general, many more mosquitoes were collected from traps holding warm-blooded vertebrates than in the reptilian cages (Tables 1, 3, and 3).

Trap cages of both mammalian and avian hosts collected greater numbers of female *C. salinarius*, *A. cantator*, and *A. sollicitans* than cages containing reptiles. The last species engorged on reptiles, but in very low numbers (Table 3).

Warm-blooded hosts, with the noted exception of red fox, *Vulpes fulva fulva* (Desmarest), all attracted substantial numbers of *C. pipiens* (Table 2) and also were very attractive to female *M. perturbans*. Limited numbers of this latter species also engorged on reptiles. With both of these mosquitoes, more were collected (engorged) from a greater variety of avian cage-traps than with mammalian cage traps (Table 4). In addition, all warm-blooded hosts were fed upon by *A. vexans*. However, substantial numbers were collected from a wider spectrum of mammalian than from avian host cage-traps (Table 4). No collections of this mosquito were made from reptile cage-traps.

The results shown in Tables 1, 2, and 4 indicate that while all of the warm-blooded host cage-traps contained engorged females of both *An. quadrimaculatus* and *An. crucians* (complex), greater numbers of these two species were found associated with caged mammals. Small numbers of *An. quardimaculatus* were collected from three of the four reptile cage-traps (Table 3). Although all of the avian cage-traps contained *C. restuans*, only chicken and common egret, *Casmerodius albus* (L.), attracted substantial numbers; only four of the eight mammalian hosts were fed upon and these to a limited de-

TABLE 4.—Host attractiveness indices for mosquitoes, Bombay Hook, Delaware, 1958 and 1959 [1]

Mosquito Species	Host Species: Avian							Mammalian								Reptilian			
	Mallard	Canada Goose	Common Egret	Barn Owl	R.W. Blackbird	Turkey Vulture	Chicken	Woodchuck	Muskrat	Raccoon	Opossum	Red Fox	Meadow Vole	River Otter	Guinea Pig	Kingsnake	N. Watersnake	Snapping Turtle	E. Box Turtle
C. salinarius	8+	8+	8+	8+	8+	8+	8+	8+	8+	8+	8+	8+	8+	8+	8+	0	0	0	0
A. sollicitans	8+	8+	8+	8+	8+	8+	8+	8+	8+	8+	8+	8+	8+	8+	8+	2	0	2	0
A. cantator	8+	8+	8+	6	8+	8+	8+	8+	8+	8+	8+	8+	8+	7	8+	0	0	0	0
A. vexans	7	7	8+	6	8+	6	8+	8+	8+	8+	8+	8+	8+	7	8+	0	0	0	0
C. pipiens	6	8+	6	8+	8+	8+	8+	1	2	4	2	0	1	1	4	0	0	0	0
An. quadrimaculatus	2	6	6	2	6	4	6	8+	8+	8+	8+	8+	8+	2	8+	0	0	0	0
M. perturbans	8+	8+	7	8	8+	8+	8+	8+	8+	8+	3	6	4	0	5	0	1	1	2
An. crucians (complex)	1	5	6	1	5	3	7	8	8+	8+	8+	2	8+	7	8+	1	2	0	0
C. restuans	1	6	8+	2	5	2	8+	1	1	1	1	0	0	0	0	0	0	0	0
An. punctipennis	2	1	0	1	1	0	2	3	1	1	3	1	2	1	5	0	0	0	0
C. territans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	8+	8+	8+

[1] Host attractiveness index=percent engorged mosquitoes *times* number attracted per test, *divided* by 100. "Good" attractiveness (8 or more); "moderate" attractiveness (3 to 7); "poor" attractiveness (0 to 2).

gree. No reptile host was fed upon by *C. restuans.*

Many of the warm-blooded host cage-traps contained limited numbers of engorged *An. punctipennis* (Tables 1 and 2). *Culex territans* was collected engorged only from reptile cage-traps (Table 3).

Each of the three mosquitoes which have yet to be discussed, *An. barberi, P. confinnis,* and *An. walkeri* were represented by less than 100 specimens. *An. barberi* was collected in more different kinds of mammalian cage-traps than in bird cage-traps. Cage-traps containing mammals, such as woodchuck, *Marmota monax monax* (L.), raccoon, opossum, *Didelphis marsupialis virginiana* Kerr, and guinea pig contained this mosquito, and several birds, namely common egret, red-winged blackbird, *Agelaius phoeniceus* (L.), and chicken also were attractive. *An. walkeri* fed upon woodchuck, opossum, red-winged blackbird and chicken.

DISCUSSION. The previously mentioned objective of this investigation was to obtain information which could lead to a better definition of the role of *C. salinarius* as well as certain associated mosquitoes as vectors of virus and other parasitic disease agents of vertebrates. Accordingly, knowledge of the relative attraction of these mosquitoes to various vertebrate hosts which are potential disease reservoirs is of paramount importance.

In this report, the data are presented in terms of a host attractiveness index. This assumes that "numbers attracted" and "numbers engorged" were of relatively equal importance. This was an attempt to develop a tool, the index, which will simplify evaluation of data pertinent to relative host attractiveness or "host preference" studies. Without such a tool, the effects of relative population size and flight activity of a given mosquito, while important by themselves are often misleading with respect to these interrelated effects. Obviously, the *numbers collected* in a live-bait-trap reflects attractiveness but it is also dependent upon population size and flight activity of the mosquito. Conversely, *percent engorgement* appears to be less dependent upon these two factors. Hayes (1961) found evidence which supports such independence. Therefore, by equilibrating *percent engorgement* with *numbers attracted* in the "host attractiveness index," the bias introduced by populations size and flight activity, in theory, is reduced.

In general, the results of this investigation as they appear in Tables 1, 2, and 3 are essentially self-explanatory. They show whether a host is capable of serving as a bloodmeal source for various mosquito species and as such they reflect what may be possible in nature.

C. salinarius.—The results of this study concerning the host feeding habits of *C. salinarius* agree with those of Hayes (1961) with one notable exception. In addition to the findings which suggested non-preferential feeding on both mammals and birds, Hayes observed limited feeding on reptiles. Prior to these investigations, very little was known about relative host attractiveness to this mosquito. More recently, serological identification of bloodmeals of wild caught *C. salinarius* females by Crans (1964) showed almost an equal mammalian to avian feeding pattern. Based on all of these results, this species must be regarded as a general feeder, seeking blood meals from both mammals and birds with little discrimination. The results (Table 4) show that a host attractiveness index of at least 8 was found for all the warm-blooded hosts tested.

Especially important is the disease vector potential (i.e.,—eastern encephalitis) of such a generalized feeding and prevalent pest species.

Probably in nature the availability of hosts plays a very important role. Stratification of the adult females and the potential hosts could dictate the blood source. Present knowledge of the vertical distribution of this species indicates that in addition to ground level activity, *C. salinarius* also is active at higher elevations. MacCreary (1941) found the highest proportion of this species to be collected at the uppermost test elevations of 80 and 103 feet. Furthermore, Blakeslee *et al.* (1959) trapped the largest segment of the total collection at his uppermost test level of 20 feet. This information suggests that arboreal hosts, probably birds, may be characteristic bloodmeal sources.

A. sollicitans.—All of the warm-blooded hosts tested showed a good host attractiveness index for *A. sollicitans* (Table 4) and thereby demonstrated a possible broad spectrum of feeding on both mammals and birds. In addition, the host attractiveness indices (Table 4) suggest that limited feeding upon reptiles may occur. Although reportedly mammalian hosts are preferred when available (Jobbins, *et al.*, 1961, Thompson *et al.* 1963), this mosquito apparently is capable of feeding on a wide variety of birds as well.

A. cantator.—Birds and mammals were fed upon with little exhibited difference in preference by *A. cantator.* Only one bird, barn owl, *Tyta alba* (Scopoli) and one mammal, river otter, *Lutra canadensis lataxina* F. Cuvier, elicited indices of less than 8 and these were associated with "moderate" attractiveness, indicating that both birds and mammals are fed upon with little discrimination.

A. vexans.—All warm-blooded hosts were fed upon by *A. vexans.* The relative host attractiveness indices indicate that a greater proportion of mammals (7 out of 8) were fed upon than birds (3 out of 7). However, there was no indication that reptiles were utilized. According to Horsfall (1955), blood is apparently taken from whatever hosts are available.

C. pipiens.—On the basis of the host attractiveness indices, rural *C. pipiens* is primarily a bird feeder although limited feeding occurred on most of the test mammals. Preliminary serological investigations with New Jersey specimens of *C. pipiens* have yet to demonstrate any mammalian feeding; however, urban collections of this mosquito had not been examined (Crans, 1964). Hayes (1961) reported that the results of his studies showed that birds were preferred over mammals.

An. quadrimaculatus.—The data concerning *An. quadrimaculatus* indicated that they feed predominantly on mammalian hosts. All mammals except river otter produced a "good" host attractiveness index whereas none of the avian hosts gave higher than "moderate" values. These findings are substantiated by the results of the serological investigations by Crans (1964). In addition there was some indication of limited feeding on reptilian hosts which has not been reported previously.

M. perturbans.—Avian hosts were fed upon by *M. perturbans* to a greater extent than mammals. All but one avian host, common egret, produced a "good" attractiveness index. These results indicate a slight preference for birds over mammals. The present published evidence concerning the host preferences of this mosquito is not conclusive. Hayes' (1961) work does not show preference between these two classes of hosts. Conversely, the investigation by Crans (1964) indicated that *M. perturbans* is predominantly a mammalian feeder. However, host preference studies with this species of mosquito in Canada (Downe, 1962) indicated that it was a generalized feeder, capable of accepting most warm-blooded animals as a bloodmeal source, but that it also showed a predilection for avian bloods if they were available.

An. crucians (complex).—The mosquitoes listed as *Anopheles crucians* (complex) were most likely *Anopheles bradleyi* King as the study site bordered a tidal marsh heavily populated with larvae of this species. Our results indicate that there is a greater preference for mammals over birds for this species (Table 4). Six of eight mammals received "good" host attractiveness indices whereas none of the birds elicited such a high index. As far as it is known, there is little other information concerning the hosts of this mosquito.

C. restuans.—Mammals were either not attractive hosts or, at best, exhibited only "poor" attractiveness to *C. restuans*, whereas some birds tested showed from "moderate" to "good" host attractiveness for this mosquito (Table 4). These data indicate that while both classes of vertebrates can be fed upon, birds may be preferred. Hayes (1961) collected small numbers of engorged specimens from mammals, birds and reptiles but found little indication of preference. The results of other work suggests that *C. restuans* prefers to take blood from birds (Howard, 1916; Owen, 1937; and McLintock, 1944).

An. punctipennis.—No host tested showed "good" attractiveness for *An. punctipennis*. However, there is a slight indication that mammals may be preferred because three mammals did elicit a "moderate" attractiveness index. These findings are supported by those of Crans (1964) which indicate preference for mammalian over avian blood for all anopheline species examined. Other than these observations, little is known concerning the preferred hosts of this mosquito.

C. territans.—Our data concerning *C. territans* indicated a "good" host attractiveness index for all reptiles except kingsnake, *Lampropeltis getulus getulus* (L.), which elicited a "moderate" index. No warm-blooded hosts were fed upon. These results are in accord with the findings of a considerable number of workers (Shannon, 1915; Dyar, 1928; and Matheson, 1944) who reported that the females are not known to feed on warm-blooded hosts, but do feed on reptiles and amphibians. However, of special importance, is the finding by Crans (1964) that some feedings occurred on warm-blooded hosts (i.e. one rodent, one raccoon and two birds).

SUMMARY. The employment of the host attractiveness index system allows for means of making more simple the comparisons of data on relative preference feeding between classes of vertebrate hosts for the major mosquito species in any given area by reducing the possible misleading effects incurred when the data on *numbers collected* and *percent engorgement* are considered separately, a situation often encountered in published results of this kind of investigation. The use of Table 4 in the previous discussion of results has demonstrated the ease of such comparisons. More general use of this index offers some promise that the investigations of host feeding preferences of mosquitoes by other workers may be evaluated more easily through the use of such a tool.

References

BLACKMORE, J. S., and DOW, R. P. 1958. Differential feeding of *Culex tarsalis* on nestling and adult birds. Mosq. News 18(1):15–17.

BLAKESLEE, T. E., THEODORE, E., AXTELL, R., and JOHNSTON, L. 1959. *Aedes vexans* and *Culex salinarius* light trap collections at five locations. Mosq. News 19(4):283.

BURBUTIS, P. P., and JOBBINS, D. M. 1957. *Culiseta melanura* Coq. and Eastern equine encephalomyelitis in New Jersey. Proc. 44th Mtg. N. J. Mosq. Exterm. Assoc. 68–78.

CHAMBERLAIN, R. W. 1958. Vector relationships of the arthropod borne encephalitides in North America in: Animal disease and human health. Ann. N. Y. Acad. Sci. 70(3):312–319.

———, SIKES, R. K., NELSON, D. B., and SUDIA, W. D. 1954. Studies on the North American arthropod-borne encephalitides. Amer. Jour. Hyg. 60(3):278–285.

CRANS, W. J. 1964. Continued host preference studies with New Jersey mosquitoes, 1963. Proc. 51st. Ann. Mtg. N. J. Mosq. Exterm. Assoc. 50–58.

DAVIS, W. A. 1940. A study of birds and mosquitoes as hosts for the virus of EEE. Amer. Jour. Hyg. 32:45–59.

DOW, R. P. 1959. A method of testing insect traps and attractants, and its application to studies of *Hippelates pusio* and *Culex tarsalis*. Jour. Econ. Entomol. 52:496–503.

———, REEVES, W. C., and BELLAMY, R. E. 1957. Field tests of avian host preference of *Culex tarsalis* Coq. Amer. Jour. Trop. Med. and Hyg. 6(2):294–303.

DOWNE, A. E. R. 1962. Some aspects of host selection by *Mansonia perturbans* (Walk.) (Diptera:Culicidae). Canad. Jour. Zool. 40:725–732.

DYAR, H. G. 1928. The mosquitoes of the Americas. 616 pp. Pub. 387, Carnegie Institution of Washington.

EDGAR, S. A., and HERNDON, J. F. 1957. A rotary insect-preference trap. Mosq. News 17(1):14–17.

EYLES, D. E., and MOST, H. 1947. Infectivity of Pacific Island *Wuchereria bancrofti* to mosquitoes of the United States. Amer. Jour. Trop. Med. 27(2):211–220.

FLEMINGS, M. B. 1958. A field study on the host biting preference of *Culex tritaeniorhynchus* Giles and other mosquito species of Japan. Proc. 45th Mtg. N. J. Mosq. Exterm. Assoc. 89–97.

HAYES, R. O. 1961. Host preferences of *Culiseta melanura* and allied mosquitoes. Mosq. News 21(3): 179–187.

HORSFALL, W. R. 1955. Mosquitoes, their bionomics and relation to disease. 723 pp. New York: The Ronald Press Co.

HOWARD, D. W. 1916. The common mosquitoes of Minnesota. St. Entom. Minn., 16th Ann. Rpt. pp. 73–92.

HUFF, C. G. 1927. Studies on the infectivity of plasmodia of birds for mosquitoes, with special reference to the problem of immunity in the mosquito. Amer. Jour. Hyg. 7:706–734.

JOBBINS, D. M., BURBUTIS, P. P., and CRANS. W. J. 1961. Mosquito blood meal determinations —a cooperative project. Proc. 48th Ann. Mtg. N. J. Mosq. Exterm. Assoc. 211–215.

MACCREARY, D. 1941. Comparative density of mosquitoes at ground level and at an elevation of approximately one hundred feet. Jour. Econ. Entomol. 34(2):174–179.

MATHESON, R. 1944. A handbook of the mosquitoes of North America. 2nd Ed. 312 pp. Ithaca, New York: Comstock Publishing Co.

MCLINTOCK, J. 1944. The mosquitoes of the greater Winnipeg Area. Canad. Entom. 76:89–104.

MURPHEY, F. J., and DARSIE, R. F., JR. 1962. Studies on the bionomics of *Culex salinarius* Coquillett. I, Observations on the crepuscular and nocturnal activities of adult females. Mosq. News (22):162–171.

NEWTON, W. L., WRIGHT, W. H., and PRATT, I. 1945. Experiments to determine potential mosquito vectors of *Wuchereria bancrofti* in the continent U. S. Amer. Jour. Trop. Med. 26(5): 699–706.

OWEN, W. B. 1937. The mosquitoes of Minnesota, with special reference to their biologies. Minn. Agr. Sta. Tech. Bull. 126.

SHANNON, R. C. 1915. Mosquitoes attacking a frog. Proc. Entom. Soc. Wash., 17:99.

THOMPSON, E. D., HAYES, D. E., and LUDLOW, K. W. 1963. Notes on the feeding habits of *Aedes sollicitans* in the Chincoteague-Assateague Island area of Virginia. Mosq. News 23(4):297–298.

SOME FACTORS AFFECTING KILL OF THE STABLE FLY, *STOMOXYS CALCITRANS* (L.), WITH INSECTICIDAL THERMAL AEROSOLS

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Insecticidal thermal aerosols have attained wide use as space treatments for control of adult mosquitoes during the past two decades. The spectacular appearance of "fogs" probably is the basis for the popular acceptance of this method by the public; however, this spectacular aspect of fogging also might be the basic cause of some misuse of the method. Fogging is not different from spraying or dusting with respect to the basic requirements of effective dosage and good coverage for insect control, for the mere visible presence of an insecticidal fog in a target area does not ensure effective insect kill.

Tests of naled (Dibrom) in thermal aerosols against adult stable flies, *Stomoxys calcitrans* (L.) at Panama City, Florida during 1965 revealed some factors relating to dosage, volume, and drift which illustrate basic principles of the aerosol method.

METHODS. Test plots were established in a residential area at Panama City Beach, Florida, approximately one-fourth mile inland from the beach. The area consists of beach sand sparsely covered with low growing vegetation, an occasional tree, and single-story dwellings. Streets are 300 feet apart in one direction and approximately 600 feet in the other.

The test was designed for multiple swaths in a manner similar to that described by Rathburn and Rogers (1959).

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