INCIDENCE OF *AGAMOMERMIS CULICIS* (NEMATODA: MERMITHIDAE) IN *AEDES SOLLICITANS* IN LOUISIANA IN 1967

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Smith (1904) first observed the mermithid nematode *Agamomermis culicis* Stiles parasitizing *Aedes sollicitans* (Walker) in New Jersey in 1902 and 1903. The parasite was not reported again until 1965 in southwestern Louisiana when Petersen *et al.* (1967) studied the biology and life cycle of *Agamomermis culicis* and included observations on the incidence of the nematode parasite in *Aedes sollicitans* in Louisiana. The present paper reports a continuation of that study.

When nematode parasitism of *Aedes sollicitans* was surveyed in Calcasieu and Cameron Parishes, Louisiana during 1967, parasitism was found to be widespread throughout the coastal marshes. Of the 6094 adult female *Aedes sollicitans* taken in 159 collections from 29 areas, 1026 contained one or more juvenile *Agamomermis culicis* (Table 1.). Parasitism ranged from 0 to 96 percent in individual biting populations of *Aedes sollicitans*, and infected *Aedes sollicitans* were taken in all except two collections. (These two negative areas were sampled only once, and only a small number of adults were obtained.) Some parasitism was found every month in which collections were taken except January, though the levels of infection were less than one percent during February, November, and December. Collections made during the summer months had levels of infection of less than 10 percent except in April and July when the levels were 48 and 46 percent, respectively.

In another survey made in 12 areas from October 1966 to December 1967, 96 collections of larvae of *Aedes sollicitans* were taken and brought to the laboratory where they were reared to adults and checked for parasitism. The results are given in Table 2. Thirty-three collections

[1] In cooperation with McNeese State College, Lake Charles, Louisiana.

TABLE 1.—Survey of adult female populations of *Aedes sollicitans* in southwestern Louisiana for parasitism by *Agamomermis culicus* during 1967.

Month	No. of areas sampled	Total no. of collections	No. of positive collections	No. of adults examined	Percentage of adults parasitized	Highest percentage parasitism
January	2	2	0	49	0	..
February	4	5	1	131	0.8	1
March	0	0	..	0	..	..
April	12	20	15	531	47.8	96
May	9	14	4	497	3.0	22
June	5	12	4	474	7.8	42
July	15	22	20	965	46.0	94
August	16	31	20	1345	9.9	80
September	9	22	13	846	9.3	50
October	8	16	9	690	8.0	46
November	7	11	2	423	0.9	6
December	4	4	1	143	0.7	1
Totals or average	29	159	89	6094	16.8	

TABLE 2.—Survey for nematode parasitism of *Aedes sollicitans* collected as larvae and reared to adults from October 1966 through December 1967 in southwestern Louisiana.

Month	Total no. of collections	No. of positive collections	Total no. of adults examined	Number parasitized	Percentage parasitism
October 1966	11	5	234	64	27
November	4	1	115	1	0.9
December	5	0	124	0	0
January 1967	3	0	107	0	0
February	7	1	151	1	0.7
March	5	0	206	0	0
April	9	5	236	122	52
May	13	2	435	8	1.8
June	8	6	361	19	5.8
July	5	3	177	10	5.6
August	13	8	393	70	18
September	5	1	250	10	4.0
October	4	0	198	0	0
November	3	0	98	0	0
December	1	1	50	27	54
Totals or average	96	33	3135	332	10.6

contained parasitized mosquitoes, and 11 percent of the 3135 reared adults were parasitized with *Agamomermis culicis;* in individual collections, parasitism ranged from 0 to 100 percent. Collections with the heaviest infections (some in excess of 90 percent) were taken in mid-April. Individual adults in these collections were commonly infested with 10 or more nematodes, and some harbored as many as 42. Only one positive collection of larvae was obtained after mid-September, 1967. It was collected at Cameron on December 21; 44 percent of 25 males and 48 percent of 25 females were parasitized with 1–4 nematodes. An unseasonably warm 9-day period (mean of 63° F.) that occurred just before the collection undoubtedly accounted for the high rate of infection so late in the year.

In addition, a comparison was made of nematode parasitism in adult female

TABLE 3.—Percentage of monthly collections of adult female *Aedes sollicitans* parasitized by *Agamomermis culicis* from six areas in southwestern Louisiana.

Month	Collection sites					
	Cameron	Sabine	Haymark	Hackberry	Grand Lake	Rutherford Beach
January	0	..	..	..	0	..
February	0	..	1.3	..	0	..
March	..	..	..	..	..	..
April	96	82	33	86	48	76
May	4.2	0	12	2.0	0	..
June	0	14	8.2	..	..	..
July	68	34	31	36	31	87
August	14	20	1.8	2.0	44	2.6
September	2.0	4.3	0.8	4.0	6.5	21
October	0	31	2.0	0	12	11
November	0	6.0	0	0	..	1.3
December	..	..	0	0	..	2.9
Average	15.3	20.5	8.1	17.2	27.1	24.9

Aedes sollicitans in six widely separated sites that encompassed an area of more than 25 miles along the margins of Calcasieu Lake and the Gulf of Mexico (sites 1–6, Fig. 1). The results are summarized in Table 3. Nematode parasitism in the adult females fluctuated similarly during the survey, even though the areas were widely separated. The highest incidence of parasitism in five of the six areas occurred during April; in the sixth (Rutherford Beach), the level of parasitism in April was slightly lower than the highest level (in July) for that area. In four of the areas the levels of parasitism in July were the second highest observed during the year.

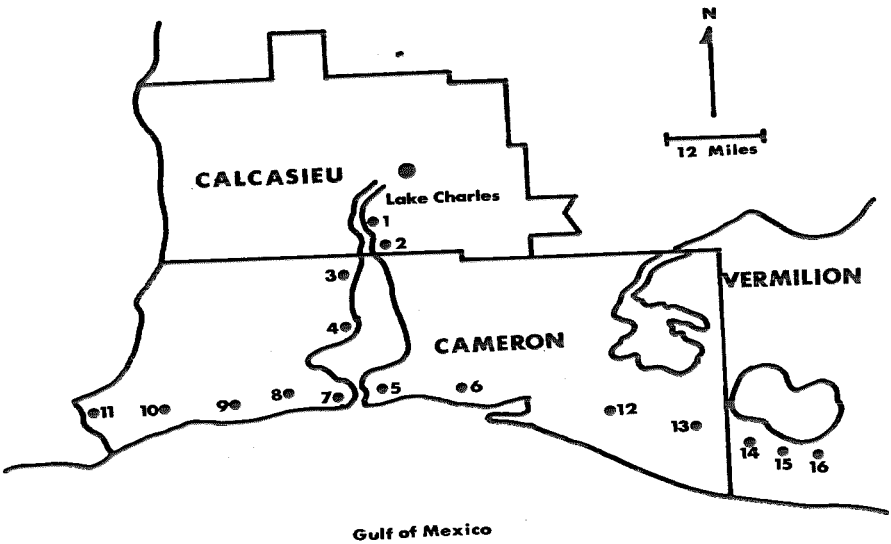

Fig. 1.—Collection sites during survey: 1—Haymark, 2—Grand Lake, 3—Hackberry, 4—Sabine, 5—Cameron, 6—Rutherford Beach. Sites 7–11 surveyed July 28; sites 12–16 surveyed August 2, 1967.

The average parasitism by month was compared with the monthly temperature and rainfall from August 1966 through December 1967 (Fig. 2). As expected, parasitism generally increased when precipitation was heavy and decreased when it was light. The principal exceptions were May, August, and December, 1967. The low rate during December can be explained by the low temperatures (the nematode eggs apparently did not hatch). The low incidence of *Agamomermis culicis* during May and August appeared to be related to the time that it takes for this parasite to complete its life cycle. The heavy rains and warm temperatures in April produced the first substantial broods of *Aedes sollicitans* of the year and a very high incidence of nematode parasitism (48 percent). April had been preceded by a comparatively dry March and light breeding of *Aedes sollicitans*. In May, heavy rains again produced substantial broods of *Aedes sollicitans*, but parasitism dropped to less than 3 percent.

Since *Agamomermis culicis* requires from 5 to 6 weeks to complete its life cycle (Petersen *et al.* 1967), it appears that once temperature and moisture were suitable, essentially all the overwintering nematode eggs hatched. Then parasitism

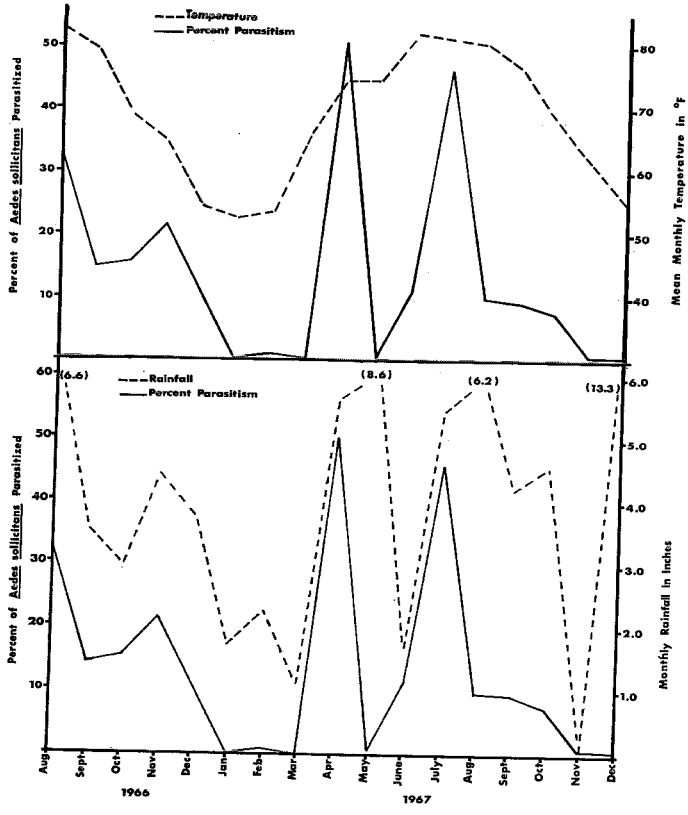

FIG. 2.—Comparisons of the average monthly temperature and rainfall with the percentage parasitism of *Aedes sollicitans* by *Agamamermis culicis* over an 18-month period in southwestern Louisiana.

in May was low despite the satisfactory conditions, because the April broods of the parasite had not yet completed their life cycle. The same general cycle occurred during July when, as noted, the second highest average infections of the year (46 percent) occurred (July, like April, was preceded by a comparatively dry month). The level of infection diminished again in August, as expected, even though conditions were good for mosquito production. Thus, precipitation, temperature, and tides probably have an important role in determining the extent of parasitism by *Agamomermis culicis* in *Aedes sollicitans*.

In the latter part of July, substantial rains in the study area produced broods of *Aedes sollicitans* with high levels of nematode parasitism. During this period a special survey was conducted along the entire 96 miles of coast line from Port Arthur, Texas, to Pecan Island, Louisiana, in an attempt to determine the distribution

and extent of nematode parasitism in adult female *Aedes sollicitans* (see Fig. 1). On July 27, collections made at Cameron and Rutherford Beach had levels of infection of 94 and 86 percent respectively. On July 28, five collections made between Holly Beach (No. 7) and Port Arthur (No. 11) had levels of infection of 62, 82, 48, 78, and 60 percent respectively. In contrast, in five collections made from EM–II (No. 12) to Pecan Island (No. 16) on August 2, the levels of infection were only 6, 6, 22, 21, and 24 percent, respectively. Probably the parasitism in these latter samples would have been higher had the collections been made around July 27 since by August 2, many parasitized mosquitoes may have obtained a blood meal or died as a result of the developing nematodes. However, *Aedes sollicitans* supplied to the authors throughout the year by the mosquito abatement districts around New Orleans indicated that parasitism of *Aedes sollicitans* was low in southeastern Louisiana; only three of the 2286 specimens contained nematodes.

Agamomermis culicis is apparently host specific for *Aedes sollicitans* in nature (Petersen *et al.*, 1967). During the survey *Agamomermis culicis* was observed only in *Aedes sollicitans* and not in *Aedes taeniorhynchus* (Wiedemann), *Aedes vexans* (Meigen), or *Psorophora confinnis* (Lynch-Arribálzaga), even though larvae of these species were occasionally collected at the same time and from the same habitat which produced *Aedes sollicitans* that were 100 percent infected.

The degree of host specificity was studied further by placing equal numbers of first instar larvae of various mosquito species in a common container and exposing them to preparasitic juveniles of *Agamomermis culicis*. The exposed larvae were reared to adults, killed, separated by species, and examined for nematodes. The results are summarized in Table 4. Only *Aedes taeniorhynchus, Culex pipiens quinquefasciatus* Say, *Aedes aegypti* (L.), and *Aedes sollicitans* developed infections. Even though some parasitism was observed in *Aedes taeniorhynchus* and *C. p. quinquefasciatus*, both appeared resistant to the nematode. Two infected *Aedes taeniorhynchus* were obtained in a single test in which 100 percent of the *Aedes*

TABLE 4.—Summary of laboratory attempts to infect mosquito species with *Agamomermis culicis*.

No. of tests	Species	No. of adults checked	Number infected	Average no. nematodes/ infected individual	Percentage parasitism
6	*A. taeniorhynchus*	374	3	2.7	0.8
	A. sollicitans	170	159	10.0	94
1	*C. p. quinquefasciatus*	209	3	1.3	1.4
	A. sollicitans	5	5	4.8	100
1	*A. aegypti*	110	7	1.4	6.4
	A. sollicitans	11	10	7.3	91
1	*P. confinnis*	17	0	....	0
	A. vexans	4	0	....	0
	A. aegypti	64	9	2.1	14
	A. sollicitans	22	22	10.9	100
1	*P. confinnis*	15	0	....	0
	A. vexans	27	0	....	0
	A. sticticus (Meigen)	2	0	....	0
	A. triseriatus (Say)	20	0	....	0
	A. taeniorhynchus	12	0	....	0
	P. ferox (Humboldt)	16	0	....	0
	A. sollicitans	21	21	10.9	100

sollicitans were infected with an average of 61.2 parasites per individual, and one showed host resistance. Only one other *Aedes taeniorhynchus* was infected. *Aedes aegypti* was the least resistant of the species, however, it was considerably more resistant than *Aedes sollicitans*. It appears that when *Agamomermis culicis* gains entrance to a host and resistance occurs, it occurs in the larval state; the method of resistance is not known.

Since mortality was high in *Aedes sollicitans* parasitized by *Agamomermis culicis*, the parasite significantly reduced some populations of *Aedes sollicitans* in southwestern Louisiana. Therefore, the nematode is sometimes an effective biological control agent for *Aedes sollicitans* and it might be well worth the effort to disseminate it into new areas.

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COMPARATIVE TOXICITY OF DURSBAN® AND ITS DIMETHYL ANALOG (OMS 1155) TO INSECTICIDE-SUSCEPTIBLE AND RESISTANT *CULEX* AND *ANOPHELES* MOSQUITOES [1]

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The introduction of Dursban® (*O-O*-diethyl *O*-3,5,6-trichloro-2-pyridyl phosphorothioate) as a wide spectrum insecticide (Gray 1965, Kenaga *et al.* 1965) has aroused considerable interest in this and other pyridyl phosphate compounds (Rigterink and Kenaga 1966). Of particular importance is the high order of toxicity of Dursban to mosquito larvae and adults. Our data indicate that against larvae of *Culex pipiens fatigans* Wied., Dursban toxicity exceeds that of malathion by a factor of 37, DDT by 12, fenitrothion by 10, and fenthion by 3 (Georghiou *et al.* 1966); it also exceeds that of Abate® (*O,O*-dimethyl phosphorothioate *O,O*-diester with 4,4′-thiodiphenyl) by a factor of 2 against larvae of *Aedes taeniorhynchus* (Wied.) (Gahan *et al.* 1966). In field tests Dursban was found effective against a variety of mosquito species (Lewis *et al.* 1966, Ludwig and McNeil 1966), and at recommended dosages, it was reported to be safe to fish (Ferguson *et al.* 1966) shrimp and crabs (Ludwig *et al.* 1967).

The mammalian toxicity of Dursban (LD_{50} oral, rats, 135 mg/kg) is somewhat higher than that of other new larvicides such as fenthion (215–245 mg/kg), fenitrothion (250–670 mg/kg), and Abate (1766 mg/kg). Among other pyridyl phosphates, the dimethyl analog of Dursban, OMS 1155 (*O,O*-dimethyl *O*-3,5,6-trichloro-2-pyridyl phosphorothioate) (Rigterink and Kenaga 1966) exhibits remarkably low mammalian toxicity (>1600

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