Analysis of the list of zoonoses show that some of them are necessarily of rural areas without sanitary services, as in the case of the African O'nyong-Nyong Fever, sylvan yellow fever, plague, sylvan leishmaniasis and neo-rickettsiasis; but others like rickettsial pox occur in highly developed urban centers, and are therefore susceptible to prompt and accurate diagnosis, effective treatment and control.

SUMMARY. The group of zoonoses transmitted by arthropods constitutes a convenient group for study, not only epidemiologically but also a group in which it is advisable to test several means of control. Investigations on zoonoses must include man and other vertebrates and arthropod vectors. Measures to interrupt transmission must take into account these factors. The most spectacular advances in the epidemiology of zoonoses are to be expected in those caused by viruses.

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ASSESSMENT OF THE EFFECT OF THE INSECTICIDE BAYER 37344 ON THE BEHAVIOR OF *A. GAMBIAE*

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INTRODUCTION. The assessment of the toxicity of new insecticides, to mosquitoes entering houses, is made in experimental huts by techniques that have been evolved over nearly twenty years since Muirhead-Thomson designed the experimental hut to assess the egress of recently fed *A. gambiae* and *A. melas* from houses in West Africa (Muirhead-Thomson, 1947). The emphasis has shifted progressively from techniques primarily designed to study behavior (Muirhead-Thomson, 1947), through a compromise of techniques (Davidson, 1953) to techniques specifically designed to assess mortality with greater accuracy (Burnett, 1957; Rapley, 1961; Smith and Hocking, 1962; and Smith and Webley, 1963). With the final elimination of the hand-catch (Burnett, 1957), combined with a routine 24-hour retention period for mosquitoes entering the window trap, the basic technique of Muirhead-Thomson, for studying excito-repellent effects of an insecticide, has disappeared in the sacrifice of "behavior" for "toxicity."

In recent years, attempts to eradicate mosquito-borne diseases have been frustrated in several areas by the effects of a residual insecticide on the vectors' behavior (Muirhead-Thomson, 1960; W.H.O., 1960). In other areas the effects of the insecticide on the vectors' habits, while easily detectable, have been of no epidemiological significance because of simultaneously high toxicity that was somewhat delayed (Smith, 1962).

There is thus justification, in a program of testing and developing new insecticidal compounds, for assessing effects on behavior as well as residual toxicity. The problem has been, however, how to assess "behavior" simultaneously with "toxicity," without interfering with the accurate techniques that have been developed over many years. This problem has been recently overcome by (1) substituting a "resting count" for the original "hand-catch," (2) combining counts of fed and gravid mosquitoes into one group —the "feeding section," (3) developing an index of repellency. Further details

TABLE 1.—Total number of *A. gambiae* caught in experimental huts in three months.

	Huts with grass roofs treated						Control		
	Hut No. 5			Hut No. 8			Hut No. 1		
	U	F	G	U	F	G	U	F	G
W.T.—Alive	9	1	7	43	2	22	135	59	122
W.T.—Dead	4	0	0	8	0	1	28	3	27
Floor—Dead	4	44	0	16	80	0	0	0	0
Resting	2	2	0	0	2	0	36	276	183
	Huts with mud-lined roofs treated						Control		
	Hut No. 16			Hut No. 17			Hut No. 19		
W.T.—Alive	69	23	121	202	62	435	268	55	248
W.T.—Dead	20	6	11	44	0	24	68	6	18
Floor—Dead	2	8	1	7	38	5	0	0	0
Resting	6	121	63	23	421	179	26	325	282

are given elsewhere (Smith, 1963). These techniques were employed in the recent assessment of Bayer 37344. A previous paper (Smith and Hocking) describes the toxicity of the insecticide, and the present paper examines the results with reference to the effects of the insecticide on the behavior of *A. gambiae*.

RESULTS. The basic results are the total catches of *A. gambiae* in each experimental hut during the three-month period of study, and are shown in Table 1. From these data various indices of egress have been derived and are shown in Table 2.

Overall mortalities of control proportions, and a repellency index of unity and 1.1. show that the huts with mud-lined roofs were not toxic and had no more than the slightest repellent effect on the behavior of naturally entering mosquitoes during the three-month period as a whole.

With the toxic grass-roofed huts, however, the results show that there was a substantially greater proportion of surviving mosquitoes in the window trap. For example, in hut Number 8, 97 percent of survivors entered the window trap compared with 39 percent for the control

TABLE 2.—Average overall mortalities, and indices of egress of *A. gambiae* from experimental huts.

Hut number	Overall mortality	Repellency index	Per cent of dead mosquitoes indoors	Percent of survivors in W.T.	Percent of feeding section of survivors in W.T.
Grass roofs					
5	75	0.7	92	81	80
8	61	1.0	91	97	92
1	16	1.0	0	39	28
Mud roofs					
16	18	1.1	23	53	44
17	14	1.0	50	53	45
19	15	1.0	0	47	33

hut. Table 1 shows that this difference was partly due to inhibition of feeding, and greater survival of unfed mosquitoes than the feeding section, a fact previously observed with other insecticides (Smith, 1963). Consideration of the feeding section alone also shows that 92 percent of the survivors entered the window trap compared with 28 percent for the control hut. The repellency index of 1.0, however, shows that on average the rate of egress from the treated hut was the same as the control hut because, at an overall mortality of 61 percent, the rate of kill within the hut balanced the increased rate of egress of survivors from the hut. Similarly in hut number 5, at an overall mortality of 75 percent, the rate of kill within the hut was greater than the rate of egress of survivors, thereby leading to a repellency index of 0.7. Thus from a practical point of view the insecticide, although strictly speaking repellent, may be described as effectively non-repellent because its rapid toxicity acts as a counterweight to movement outdoors.

DISCUSSION. The results have shown that Bayer 37344 is a rapidly toxic insecticide with repellent properties of no practical significance. The value of the insecticide is, however, limited by its low residual toxicity three months after application.

It would seem that the repellency index gives a better practical asessment of repellency than when egress is expressed as the proportion of survivors in the window trap (Smith and Hocking, 1963). It is now clear that it is not enough merely to describe an insecticide as repellent, unless the rate of kill is taken into account, and the repellency index does this by offsetting the rate of egress by the rate of kill. What may be termed effective repellency only occurs when the repellency index exceeds unity at low overall mortalities.

It seems likely from general observations of mosquitoes during susceptibility tests, and in bioassay tests, that excitorepellency is probably a property of many insecticides and also occurs under field conditions, but is offset by rapid toxicity. The only practical significance of this dual action is perhaps that less reliance should be placed in the pyrethrum spray-catch, as a method for assessing mosquito mortalities in houses, than has been practiced in the past.

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