ENTOMOLOGICAL STUDIES DURING THE 1971 YELLOW FEVER EPIDEMIC OF LUANDA, ANGOLA

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ABSTRACT. Entomological studies carried out in the course of the 1971 yellow fever epidemic of Luanda, revealed that *Aedes aegypti* had recently invaded the city from the inland through enormous quantities of infested rubber tires. A progressive vector population was established in the suburban belt, where an indoor adult *aegypti* density of 5.2 females/Man/hour and a mean Breteau index [2] of about 40 were registered. All the three known forms of *aegypti* were found in the city.

INTRODUCTION. Since the 1860–1872 classic epidemic which occurred in Luanda and other coastal cities, no further yellow fever clinical cases had been recorded from Angola (Correia, 1923; Mora, 1933). In more recent years, however, serological tests show that the Y.F. virus continued to be active at least in the northern half of the territory (Beewkes *et al.*, 1943; Cambournac, 1954), where suitable wild reservoirs are also prevalent (Cambournac *et al.*, 1962; Machado, 1969).

Regarding the potential vectors, most of the Y.F. transmitting *Stegomyia* mosquitoes were known to have extensive distribution areas in Angola. *Aedes aegypti* (L.), in particular, is present virtually all over the country, with the main exception of the southwestern desert biome. It is to be noted, however, that although the risks of introduction of this vector anywhere in Angola were obvious, *aegypti* had not been found in Luanda during more recent decades, even though a total of 18 mosquito taxa was recorded from the city by different authors (Colaço, 1952; Gândara, 1956; Ribeiro, 1966).

The Y.F. epidemic in Luanda, a city of about 400,000 inhabitants, started early in 1971, first suspected cases being registered during January, in the middle of the hot rainy season.

ENTOMOLOGICAL SURVEY. Entomological studies were started March 15. A general mosquito survey, both for larvae and adults, was carried out throughout the city, in the main ecological areas involved, the suburban belt and the "green" areas (gardens and cemeteries), as well as the urban center.

Daily indoor densities of adult mosquitoes were investigated in the zones of heavier infestation along the suburban belt by three couples of experienced collectors working with aspirator tube (WHO), from 07.00 to 09.00 hours. About fifty houses were daily visited by collectors in the course of this 2-hour catching period. During house collection, not only females landing on man (the other collector or any of the residents), but also any resting mosquitoes, were caught.

As a result of the survey, 12 mosquito species were identified, 11 of which were much more abundant, at least, in the suburban belt than in the other main ecological areas. *Eretmapodites chrysogaster* Graham was only found in the green areas. Three of the species (*Anopheles gambiae* Giles, *Culex duttoni* Theobald and *E. chrysogaster* Graham) were recorded on the basis of only a few larvae. The remainding nine taxa (Table 1) were recorded as adults; larvae of some of them were not found. As is shown in Table 1, *C. p. quinquefasciatus* was the dominant taxon, accounting for 84 percent of the 5,597 adult mosquitoes caught in houses along the suburban belt. *A. aegypti* comprised 15.3 percent, with an indoor adult density of 5.2 females/man/hour. These taxa together accounted for 99.3 percent of all specimens, the other

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[2] The number of positive larval breeding places per 100 houses.

TABLE 1.—Relative frequencies of species in house-caught adult mosquitoes.

Species	Females		Males		Totals	
	No.	%	No.	%	No.	%
C. p. quinquefasciatus Say	3,420	84.8	1,280	82.0	4,700	84
A. aegypti (L.)	579	14.4	280	17.9	859	15.3
M. uniformis (Theo.)	20	....	0	....	20	....
		0.7		0		0.5
M. africana (Theo.)	7	....	0	....	7	....
A. durbanensis (Theo.)	5	....	1	....	6	....
A. metallicus (Edw.)	2	....	0	....	2	....
A. scatophagoides (Theo.)	1	0.1	0	0.1	1	0.2
C. poicilipes (Theo.)	0	....	1	....	1	....
C. tigripes Gr. & Charm.	1	....	0	....	1	....
Totals	4,035	100.0	1,562	100.0	5,597	100.0

seven species representing a minute percentage of all catches. Similarly, almost all (99.7 percent) of the 2,300 larvae collected throughout the city belonged to one or the other of these two taxa. Larval indices for *aegypti*, however, were found to vary greatly in the suburan belt, though a mean Breteau index of about 40 and a mean indoor container index of about 18 were estimated.

THE LOCAL VECTOR POPULATION. The morphological analysis of 29 strains of the local *aegypti* population revealed that all the three known forms of the species were present in Luanda, their relative frequencies being shown in Fig. 1. As can be seen, *queenslandensis* was not only the most common of them (65 percent of the strains) but was the only form recorded from domestic (indoor) habitats, while the type form was dominant in peridomestic habitats, followed by *queenslandensis* and *formosus*. On the other hand, the finding of a few *formosus* strains in Luanda, though these always occurred in peridomestic habitat, shows that there is not a strict correspondence between dark strains and sylvatic habitat, as was indicated by McClelland (1971).

As to the kinds of larval biotopes used by the local *aegypti* population, Fig. 2 shows the relative frequencies of most common types in domestic and peridomestic habitats (40 and 70 actual breeding-

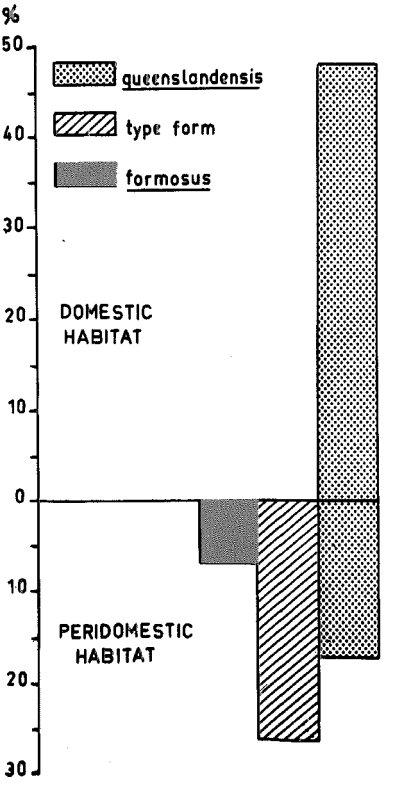

FIG. 1.—Relative frequencies of the different forms of *A. aegypti* in domestic and peridomestic habitats.

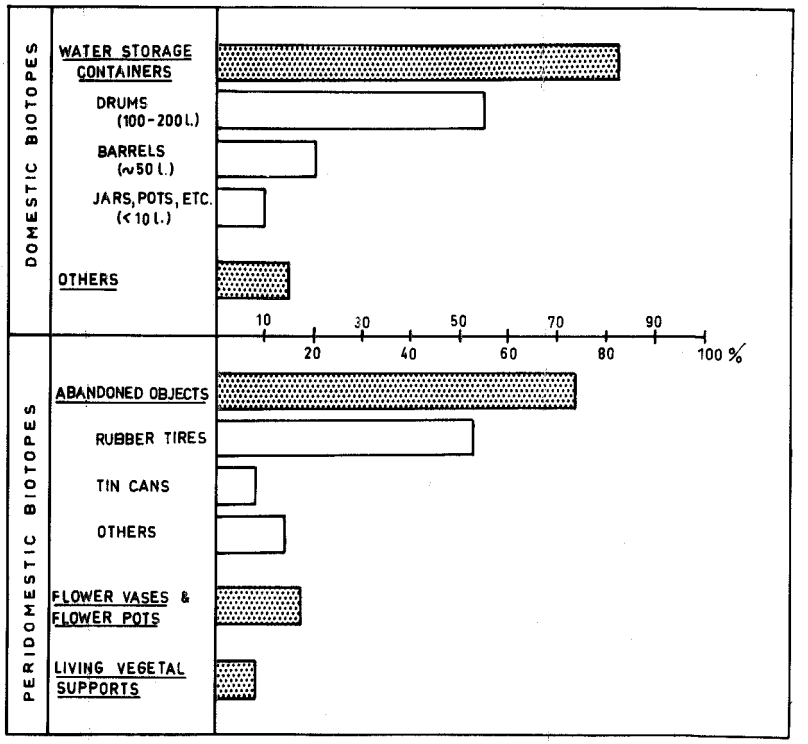

FIG. 2.—Percentage distribution of the most common types of larval biotopes of *A. aegypti*.

places studied, respectively). Water-storage containers (mainly the bigger ones) accounted for 85 percent of the indoor *aegypti* larval breeding, the remaining 15 percent being mainly ornamental vases. In peridomestic habitat, abandoned objects, mainly with rainwater, represented about 75 percent of the outdoor *aegypti* breeding-places. Of these, automobile tires were the most important type, accounting for more than 50 percent of all peridomestic *aegypti* larval biotopes, which agree with the findings of other entomologists working in Africa (Wkly. epidem. Rec., 1969). As to the other types of peridomestic biotopes, it seems worth noting that ornamental vases may constitute important though localized *aegypti* breeding sites, as was also true in some suburban cemeteries in Luanda.

The establishment of a significant *aegypti* population in Luanda was evidently accomplished through a process of competitive displacement between the invader Y.F. vector and its prevalent ecological homologue *C. p. quinquefasciatus* (De Bach, 1966). On the other hand, as was shown to occur in experimental conditions by Peters *et al.* (1969), it was to be expected that the rapidly-developing *Stegomyia* mosquito would have some advantage over its culicine competitor. In order to define the status of this competition at the time of the survey, 54 random sampled actual larval biotopes of *aegypti* and/or *quinquefasciatus* (with or without other associated species) were examined along the suburban belt of the city. As is shown in Fig. 3, *A. aegypti* was, on the whole, not only the most common species

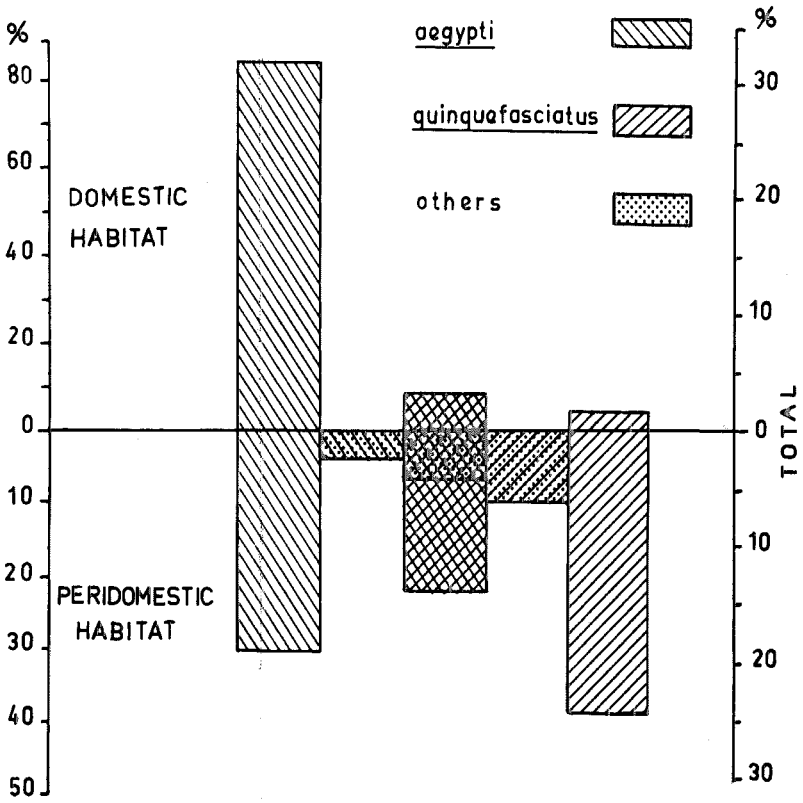

FIG. 3.—Relative frequencies of larval biotopes of *A. aegypti* and/or *C. p. quinquefasiatus* in domestic and peridomestic habitats.

(68.5 percent of all the observations) but it was also particularly successful in indoor habitats (more than 95 percent). *C. p. quinquefasciatus,* however, was also present in 15 percent of the domestic biotopes and, in peridomestic habitats, it continued to be the dominant species, being recorded from 68 percent of all the actual breeding-places. Both species were actually competing in more than 20 percent of these outdoor biotopes, while 32 percent were positive for *aegypti* and not for *quinquefasciatus.* The presence of larvae of other associated species was a rare event, occurring only in peridomestic habitat.

CONCLUSIONS. Based on our knowledge of the entomological situation in Luanda prior to the epidemic, it was established that *A. aegypti* was introduced in the city from the inland in 1970 by enormous quantities of old rubber tires, probably infested with the type form and, possibly, with *formosus.* During the 1970–71 rainy season (October–May), the local *aegypti* population was increased by competitive displacement of the prevalent *C. p. quinquefasciatus* both in outdoor and indoor habitats, though the advantages of *A. aegypti* in competing for domestic biotopes seemed to be even greater with the form *queenslandensis.* At the time of the survey, this process was still virtually confined to the peripheral belt of slum houses

without water facilities. The increasing contacts, both in number and intensity, between Luanda and the farthest inland areas, on one side, and the typical ecology of the growing and overpopulated peripheral belt of the city, on the other, seem to have played a decisive role in the massive introduction and rapid development of the local vector population.

ACKNOWLEDGMENTS. We wish to thank the Public Health Service authorities in Luanda and the Director of the Public Health Institute for their kind co-operation. We are greatly endebted to the Entomology staff of the Institute, headed by Mr. R. Antunes Capela, and to Dr. Helena C. Ramos of this School for their invaluable assistance during field and taxonomic work.

References Cited

Beewkes, H., Mahaffy, A. F., Burke, A. W. & Paul, J. H. 1934. Yellow fever protection test surveys in the French Cameroons, French Equatorial Africa, the Belgian Congo, and Angola. Trans. R. Soc. Trop. Med. Hyg. 28(3):233–258.

Cambournac, F. J. C. 1954. L'infection amarile dans l'Angola et dans les Iles de São Tomé et Principe. Bull. Wld. Hlth. Org. 11(3):504–507.

Cambournac, F. J. C., Pinto, M. R. & Janz, J. 1962. Nota sobre a existência de reservatórios de vírus de febre amarela no região do sul e sudeste de Angola. An. Inst. Med. Trop. 19(¼):15–19.

Colaço, A. T. F. 1952. Contribuição para o conhecimento dos *Culicidae* de Angola (Luanda, Sambo e Nova Lisboa). An. Inst. Med. Trop. 9(2):511–516.

Correia, A. C. G. S. 1923. O problema da febre amarela em Angola e os seus climas marítimos. Rev. Med. Ang. 4(3):247–308.

De Bach, P. 1966. The competitive displacement and coexistence principles. Ann. Rev. Entomol. 11:183–212.

Gândara, A. F. 1956. Subsídio para o estudo dos "Culicidae" (Diptera) de Angola. An. Inst. Med. Trop. 13(3):387–418.

Machado, A. B. 1969. Mamíferos de Angola ainda não citados ou pouco conhecidos. Publ. Cult. Comp. Diam. Ang. 46:93–231.

McClelland, G. A. H. 1971. Variation in scale pattern of the abdominal tergum of *Aedes aegypti* (L.) Worldwide survey of populations with particular reference to East Africa. WHO document VCB/71.271.

Mora, A. D. 1933. La fièvre jaune dans l'Angola. Conférence du Cap. Annexe 3. Bull. Trim. Org. Hyg. 2(1):56–59.

Peters, T. M., Chevosse, B. I. & Callahan, R. A. 1969. Interactions between larvae of *Aedes aegypti* (L.) and *Culex pipiens* L. in mixed experimental populations. Mosq. News 29(3): 435–438.

Ribeiro, H. 1966. Research on the mosquito of Angola. I-A culicine survey in Luanda. An. Inst. Med. Trop. 23(½):157–161.

Weekly epidemiological record, WHO. 1969. 44(47):633–644.

NOTICE

MOSQUITO SYSTEMATICS

This year will see the completion of the fifth year of publication of the privately-published journal, *Mosquito Systematics* (known as *Mosquito Systematics Newsletter* through its first 3 volumes). By action of the Board of Directors of the American Mosquito Control Association at its 1972 and 1973 national meetings, fiscal responsibility for this journal is to be transferred from Kenneth L. Knight to the Association at the beginning of 1974.

With more than 300 pages scheduled to appear in 1973 this journal is devoted to the publication of original materials dealing with any phase of mosquito systematics, including geographical distribution, phylogeny and the fossil record.

The journal is published quarterly on the 15th of March, June, September and December. The subscription rate is $7.00 per year with single copies selling for $2.00 per copy. Membership in the AMCA is not a prerequisite for subscribing to *Mosquito Systematics,* nor is it available gratis to Association members.

Communications relating to editorial matters and manuscripts submitted for publication should be addressed to Kenneth L. Knight, Editor, *Mosquito Systematics,* Department of Entomology, North Carolina State University, Raleigh, N. C. 27607. Communications relating to subscriptions and to sale of back issues should be addressed to the Executive Director, AMCA, P. O. Box 278, Selma, California 93662.