Mosquitoes occurring in the axils of *Pandanus rabaiensis* Rendle on the Kenya coast

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ABSTRACT

The water-holding axils of Pandanus rabaiensis *Rendle support the preimaginal stages of mosquitoes in Kombeni Forest on the Kenya coast. Nine mosquito species were identified from three collections made between April and June, 1977. These included: (1) the most abundant species,* Aedes haworthi, *which was not found in treehole samples from the same forest; (2)* Anopheles (Cellia) rabaiensis *White, the first anopheline discovered inhabiting phytotelmata in the Afrotropical Region; (3)* Toxorhynchites brevipalpis, *its first East African record from plant axils.*

The paper cites thirteen literature references to mosquitoes inhabiting Pandanus *axils in the Afrotropical Region. Most mosquito species found in* Pandanus *are not specific for that habitat.*

KEY WORDS : Culicidae - Larvae - Pupae - Habitat

RÉSUMÉ

Dans la forêt de Kombeni sur la côte kényane, les aisselles en eau de Pandanus rabaiensis *Rendle contiennent des stades préimaginaux de moustiques. 9 espèces ont été identifiées lors des 3 récoltes faites entre avril et juin 1977. Parmi celles-ci on note la présence de :*

- Aedes haworthi, *espèce la plus abondante, qui n'avait pas été trouvé dans les trous d'arbres de cette forêt,*
- Anopheles (Cellia) rabaiensis *White, premier anophèle découvert dans les phytotelmes en Région Ethiopienne,*
- Toxorhynchites brevipalis *trouvé pour la première fois en Afrique Orientale dans les aisselles de plantes.*

Cette note cite treize références de moustiques hébergés par les aisselles de Pandanus *en Région Ethiopienne. La plupart des espèces de moustiques de* Pandanus *ne sont pas spécifiques de cet habitat.*

MOTS-CLÉS : Culicidae - Larves - Nymphes - Gîtes.

1. INTRODUCTION

Pandanus is a genus, currently including some 600 described species (Stone, 1975), of dioecious monocots native to the Old World tropics. Trees of this genus are noted for their stilt-like aerial roots and spiral arrangement of large, sword-shaped leaves. The leaf axils of these so-called screw pines are known to hold water and create habitats for preimaginal mosquitoes. The mosquito fauna of *Pandanus* may be partly endemic and specialized for inhabitancy of the plant. Three genera: *Aedes, Culex* and *Uranotaenia* contain island species with the epithets *pandani* and/or *neopandani* in recognition of their favored larval habitat (Knight and Stone, 1977).

The genus *Pandanus* is commonly divided into two geographic centres of evolutionary activity, the Afro-Madagascar-Mascarene-Seychelles region and the Indomalaysian-Australian-Pacific region (Martelli, 1933; Stone, 1975). The foregoing considers only records of *Pandanus*-mosquito associations from the Afrotropical Region (*sensu* Crosskey and White, 1977). Dalziel (1920) reported the occurrence of *Uranotaenia* and *Aedes* larvae in *Pandanus veitchii* Hort., a Polynesian ornamental introduced into Nigeria. Peters (1955) described two new species of *Culex (Culiciomyia)* from an unidentified *Pandanus* in Liberia and further indicated that two *Uranotaenia* species occupied this same larval habitat (Peters, 1956). Ingram and DeMeillon identified two species of *Aedes* from an undetermined *Pandanus* in S. Africa, and ten species

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representing five mosquito genera were reported from the axils of a *Pandanus* sp. in Irangi, Zaire by Lambrecht and Zaghi (1960). The type specimens of *Uranotaenia pandani* were collected from screw pine axils in the Seychelles (Theobald, 1912), on which islands this species was later observed in other container habitats (Lambrecht, 1971). Brunhes (1969) described *Culex (Culiciomyia) pandani* from specimens collected from *Pandanus* sp. axils in Madagascar, where it was found in association with members of the genera *Uranotaenia, Ficalbia,* and *Toxorhynchites.*

Haddow (1948) discovered five mosquito species occuring in the axils of *Pandanus chiliocarpus* Stapf., a native screw pine which grows on swampy forest edges in Bwamba, Uganda. The most abundant species present were *Uranotania ornata* Theobald and an unidentified member of that genus, later described as *Uranotaenia yovani* (Van Someren, 1951); Peters (1956) recorded these same two species from *Pandanus* sp. axils in Kpain, Liberia. In the only other record of note from East Africa, *Culex (Culiciomyia) gilliesi* was described from the axils of an undetermined *Pandanus* growing in the botanic gardens at Amani, Tanzania (Hamon & Van Someren, 1961).

The mosquito fauna of the Kenya coast has, by tropical standards, been relatively well studied (Lumsden, 1955; Teesdale, 1959; Van Someren, *et al.,* 1955, 1958; Wiseman, *et al.,* 1939). Nonetheless, there are no records of mosquito collections from *Pandanus rabaiensis* Rendle, an endemic species common along creek edges near Mombasa (Dale & Greenway, 1961). Like most *Pandanus* native to the African continent, *P. rabaiensis* is placed in the subgenus *Vinsonia* (Stone, 1974). During the final months of a study of treehole mosquitoes in a coastal Kenyan forest, I discovered mosquito larvae inhabiting *P. rabaiensis* axils. It is the purpose of the present paper to record the mosquito species encountered and their relative abundance in three collections between April and June 1977.

COLLECTION SITE AND METHODS

Collections were made from *P. rabaiensis* growing on a westward-facing slope of the Kombeni River in Rabai location, 25 km NW of Mombasa (3°55'S, 39°35'E). The plant is relatively common on the lower half of a steep embankment which harbors an isolated strip of *Sterculia-Chlorophora/Memyclon* lowland rain forest (Moomaw, 1960). The river banks are partially inundated by seasonal floods, but the water level had not recently touched any of the *P. rabaiensis* sampled in this survey. The annual rainfall in Shauri Moyo village, which borders the river, was 1 008 mm in 1975 and 955 mm in 1976. April-June are commonly among the wettest months of the year, but May and June were abnormally dry in 1977 (Table I).

P. rabaiensis exhibits a growth form typical of trees of the genus. A young plant produces spiny leaves 3-4 m long arranged in a pineapple-like whorl close to the ground (Fig. 1). The leaf whorl rises on an erect bole as the plant matures (Fig. 2). At a height of 5-10 m the

TABLE I

Mosquito Collections from *Pandanus rabaiensis* Rendle.

Collection date (1977)	Rainfall (mm) 30 days preceding collect.	Mean fluid (ml) per impoundment (range)	Impoundments with larvae / Impoundments examined with water	Mean no. pre-adults per positive impoundment (range)	*Culex nebulosus* Theobald	*Culex horridus* Edwards	*Aedes calceatus* Edwards	*Aedes heischi* Van Someren	*Aedes aegypti* L.	*Aedes haworthi* Edwards	*Aedes fulgens* Edwards	*Toxorhynchites brevipalpis* Theobald	*Anopheles rabaiensis*	% of total collection identified
29 April	154.5	109.5 (60-200)	8/10	38.5 (1-210)	164		1		3	6	1			57
25 May	38.1	167.0 (55-230)	5/5	10.8 (4-17)		2		1		38	1	2	1	85
28 June	31.7	114.1 (5-350)	20/21	25.0 (2-120)	34					207			12	52
	Totals:	120.1	33/36	26.1	198	2	1	1	3	251	2	2	13	56

Fig. 1. – A young *P. rabaiensis* in Kombeni Forest from which mosquito larval samples were collected by pipetting.

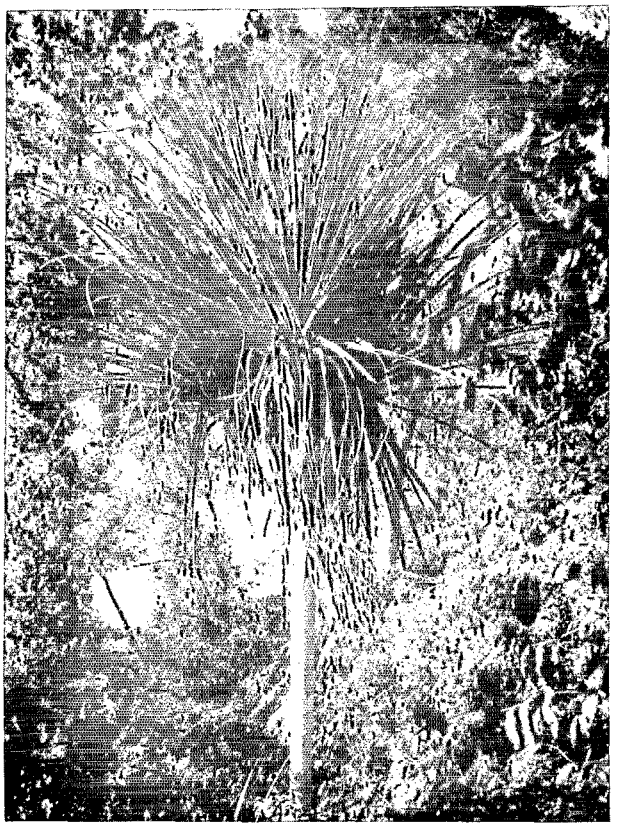

Fig. 2. – A maturing specimen of *P. rabaiensis* whose central leaf whorl is 6-8 m above ground.

trunk may bifurcate one or more times, producing an elevated "garden" of separate leaf clusters.

All collections were made from immature plants whose axils were within reach of persons standing on the forest floor (Fig. 1). Water catchments suitable for maintaining mosquito larvae and pupae are formed by single axils or the axillary overlap of two or more leaves. Phytotelmata (*sensu* Varga, 1928) not confluent with neighboring catchments on the same plant are herein referred to as impoundments, a term used to describe isolated water catchments in bromeliads (Benzing, *et al.*, 1972). Impoundments were drained to the limits that a 0.5 cm O.D. pipette tip could extract all fluid. On the day of collection the amount of water in single impoundments was measured and the number of larvae and pupae counted. Larvae and pupae were reared in the laboratory to adulthood for specific determinations. In spite of relatively high mortality during rearing (Table I), there were no signs that preimaginal deaths were biased towards particular species.

RESULTS AND DISCUSSION

A total of 845 larvae and pupae was collected from 33 of the 36 axillary impoundments which held water and were sampled in April, May, and June, 1977. The sampled impoundments held a mean of 120.1 ml of water and 26.1 preimaginal mosquitoes per positive sample (Table I). The former is more than ten times the mean water volume recorded by Haddow (1948) from single *P. chiliocarpus* axils. However, mosquito densities in both studies were approximately equal, amounting to one larva per 5 ml of collected fluid.

Specific determinations were made of 474 individuals reared to adulthood (Table I). *Culex (Culiciomyia) nebulosus* Theobald and *Aedes (Aedimorphus) haworthi* Edwards accounted for approximately 95 % of all identifications. The former species is known to occupy a broad range of preimaginal habitats (Hopkins, 1952), and Haddow (1948) recorded it from *P. chiliocarpus*. Members of the subge-

nus *Culiciomyia* apparently account for a large proportion of the mosquitoes occupying *Pandanus* axils in the Afrotropical Region.

The abundance of *A. haworthi* in *P. rabaiensis* impoundments was surprising as this species had not previously been collected from plant axils on the Kenya coast where, as elsewhere, it is commonly regarded as a treehole mosquito (Van Someren, *et al.*, 1955; Hopkins, 1952). However, it was not among 15 species identified from 1142 individuals obtained in 135 treehole samples in Kombeni Forest between April, 1975 and May, 1977. It has been taken, albeit infrequently, from bamboo pot traps in the same forest and its outliers (Lounibos, in press). The axils of *P. rabaiensis* may be the locally-preferred larval habitat of this species. Lambrecht and Zaghi (1960) reported the closely-related *Aedes simulans* Newstead & Carter occupying *Pandanus* axils in the Irangi rain forest.

Among the seven species which accounted for the remaining 5 % of identifications, *Anopheles rabaiensis* White was recently described as the first *Anopheles* larva found above ground level in the Afrotropical Region (White, in press).

The absence of this species in previous surveys of the mosquito fauna of the Kenya coast may indicate that this *Anopheles rabaiensis* W. is a *Pandanus* specialist.

The present survey is one of the few Afrotropical studies in which no *Uranotaenia* species were found in *Pandanus* impoundments. The similarity of *Uranotaenia* and *Anopheles* in larval behaviour has been noted (Hopkins, 1952), and *Anopheles rabaiensis* W. reported here as occuring in *P. rabaiensis* may be occupying the larval niche filled by *Uranotaenia* spp. in other parts of Africa.

The collection of two *Toxorhynchites brevipalpis* Theobald from *P. rabaiensis* is believed to be the first East African record of this predatory larva in plant axils. It had previously been reported inhabiting *Strelitzia* and *Dracena* axils in S. Africa (Muspratt, 1951), and was one of the most abundant mosquitoes identified from *Pandanus* axils by Lambrecht and Zaghi (1960) in Zaire. One of the two individuals collected from *P. rabaiensis* impoundments was a pupa, indicating that *T. brevipalpis* may successfully complete development in this habitat. It is noteworthy that this same mosquito was recorded only once from 55 treehole samples made in Kombeni Forest between March and May, 1977 (Lounibos, in press). Moreover, most treeholes examined on the latter two dates of impoundment collections were dry or merely moist. *P. rabaiensis* impoundments may provide important water-retaining reservoirs suitable for generalist container breeders when alternative habitats are dry. In forests on the Seychelles Islands, water catchments in *Pandanus* axils are claimed to be permanent (Scott, 1914).

The remaining five species : *Culex (Neoculex) horridus* Edwards, *Aedes (Stegomyia) calceatus* Edwards, *Aedes (Stegomyia) heischi* Van Someren, *Aedes (Stegomyia) aegypti* L. (ssp. *formosus* Walker) and *Aedes (Finlaya) fulgens* Edwards accounted for less than 2 % of all identifications. Each of these has been recorded from treeholes and bamboo pot traps in Kombeni Forest (Lounibos, in press and unpublished data).

Aedes (Stegomyia) simpsoni Theobald while common in *Musa* axils on the Kenya coast (Teesdale, 1957) and in bamboo pot traps in Rabai location (unpublished data), was not among the nine species determined from *P. rabaiensis*. The absence of *A. simpsoni* in this habitat conforms with the observations of Haddow (1948) in Bwamba, Laarman (1958) in Irangi, and Pajot (1975) in Bangui who did not find this species in *Pandanus*, although it was common in nearby banana axils.

Many of the plant axils supporting mosquitoes in the Afrotropical Region are not native to that zoogeographic zone, e.g. *Musa*, *Colocasia*, and *Ananas*. The specificity of the mosquito inhabitants of *Pandanus* for that larval habitat should be considered from an evolutionary as well as modern viewpoint. Thus, species such as *U. pandani* in the Seychelles might have evolved originally in close association with endemic *Pandanus* spp., but subsequently became habitat-promiscuous as non-native plants with axillary morphology similar to *Pandanus* infiltrated these islands. In Micronesia absolute specificity for *Pandanus* does not occur among members of the *Aedes (Stegomyia) pandani* Stone species group which inhabit the native cultivar *Colocasia* as well as the axils of *Pandanus* spp. (Bohart, 1956).

The importance of *P. rabaiensis* as a larval habitat for moquitoes can only be assessed by surveys which compare the number of axillary impoundments occupied and quantitative estimates of larval densities therein, with alternative habitats in the same area. Consideration should, furthermore, be given to the potentially large number of *P. rabaiensis* impoundments high above ground level (Fig. 2), whose suitability for mosquito inhabitancy has apparently never been investigated for any *Pandanus* species. In view of the discovery of an anopheline mosquito in the impoundments of *P. rabaiensis*, and the known specificity of certain malaria vectors outside the Afrotropical region for plant axils (e.g., Pittendrigh, 1950; Reid, 1968), the potential of *Pandanus* axils as reservoirs for vectors of mosquito-borne diseases should not be ignored.

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