A CULICINE MOSQUITO SURVEY OF THE KRUGER NATIONAL PARK*

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Resumé: The results of a Culicine mosquito survey of the Kruger National Park are discussed and presented in three tables. Possible vectors of Yellow fever encountered were: *Aëdes (Stegomyia) aegypti L., A. (S.) metallicus* Edw., *A. (S.) vittatus* Big., and *A. (Diceromyia) furcifer* Edw. Of further interest is what appears to be the first record of the genus *Orthopodomyia* in Africa south of the Sahara.

1. *Object of the Survey:*

Information is being compiled on the distribution and density of Culicine mosquitoes on the South African sub-continent by the Plague Research Laboratory, in collaboration with the Council for Scientific and Industrial Research, and the South African Institute for Medical Research. The mosquito survey of the Kruger National Park was carried out as part of a larger field expedition planned also to determine the rodent species, their fleas and other ectoparasites in the area, and was carried out from the 12th to the 30th April 1953.

Although the object of the survey was to determine the species of Culicine mosquitoes present in the Park, some Anophelines were caught with the methods used and therefore are also listed.

2. *Description of the Area Surveyed:*

The Kruger National Park is a narrow rectangular-shaped strip of country which lies on the Eastern borders of the Transvaal (Long. 31° to 32° E. and Lat. 22° to 25° 30′ S). In size it is about 40 miles wide and 220 miles long, with flanks throughout its eastern boundary onto the Lebombo Hills and onto the Portuguese Province of Mocambique.

The whole Park with the exception of the prominence known as Pretorius Kop is a low-lying rolling plain with altitude varying from 500′ in the south to 1500′ in the north. Six rivers traverse the area. Five of these, Luvuvhu, Crocodile, Letaba and Olifants are large permanent streams, while the Shingwidzi becomes dry periodically.

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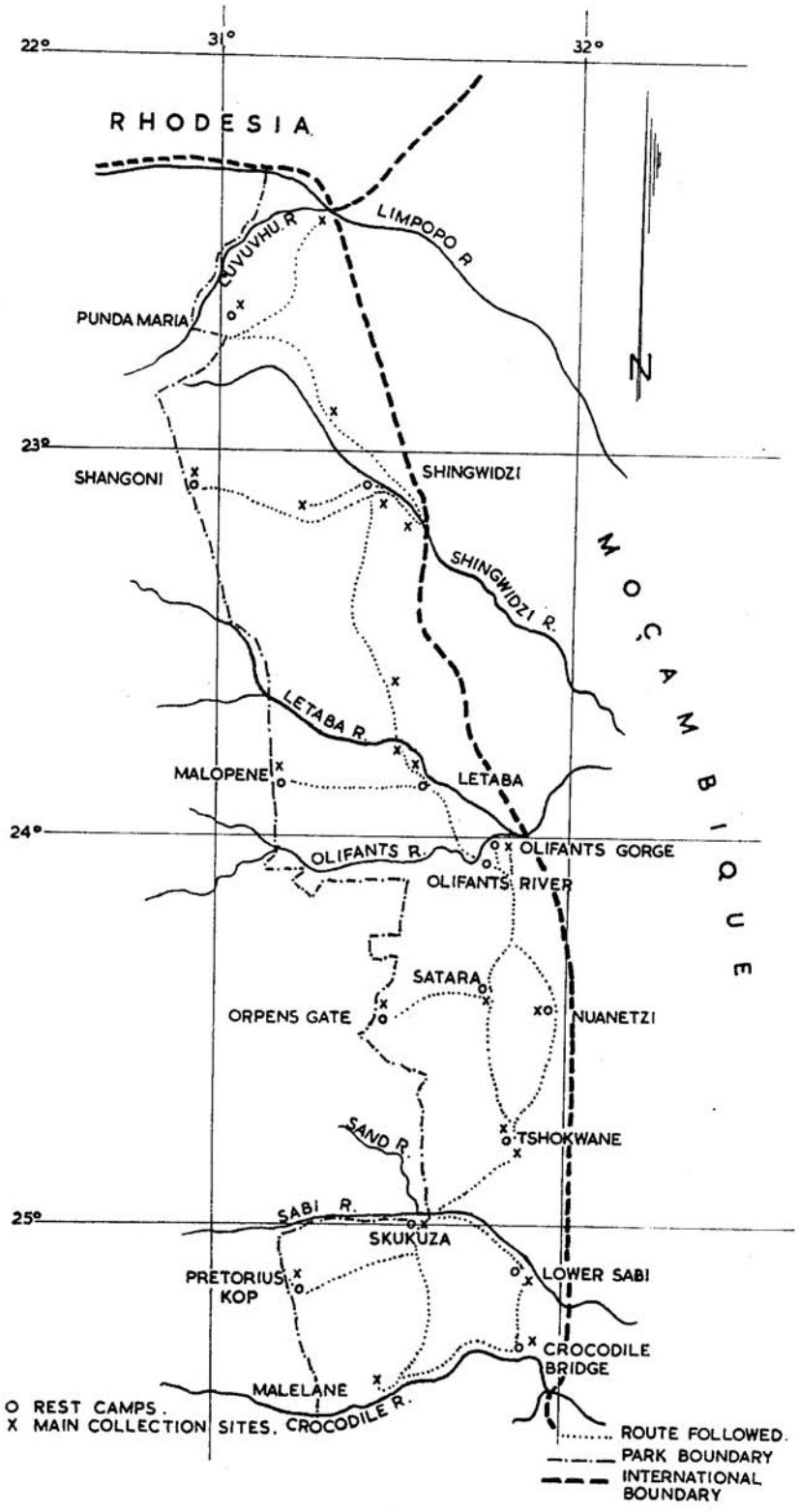
FIGURE 1.


22°
31°
32°
RHODESIA
LUVUVHU R.
LIMPOPO R.
PUNDA MARIA
N
23°
SHANGONI
SHINGWIDZI
SHINGWIDZI R.
MOÇAMBIQUE
LETABA R.
MALOPENE
LETABA
24°
OLIFANTS R.
OLIFANTS GORGE
OLIFANTS RIVER
SATARA
ORPENS GATE
NUANETZI
SAND R.
TSHOKWANE
25°
SABI R.
SKUKUZA
PRETORIUS KOP
LOWER SABI
CROCODILE BRIDGE
MALELANE
CROCODILE R.
O REST CAMPS.
X MAIN COLLECTION SITES.
ROUTE FOLLOWED.
PARK BOUNDARY
INTERNATIONAL BOUNDARY

The soils have mainly been derived from lavas of the Karoo System (Lebombo Hills) and granites. The lavas have produced the rich loams and clays of the east, while weathering of the granite has produced the coarse red sandy loams of the west.

Bushveld savanna of varying height and density covers the entire area. Codd (1951) defines five regions: (1) the large-leaved deciduous *Combretum terminalia-Sclerocarya* open woodland of the Pretorius Kop area; (2) the mixed *Combretum apiculatum* veld of the western half of the Park northwards to the Olifants River; (3) *Acacia nigrescens-Sclerocarya* parklands of the eastern half of the Park northwards to the Olifants River; (4) a large tract of *Copaifera mopani* woodland, varying widely in height and density stretching from the Olifants River northwards to Punda Maria; and (5) a small area of sandveld vegetation between Punda Maria and the Luvuvhu River boundary.

Our attention was largely confined to the *Acacia nigrescens-Sclerocarya* parkland of the south-east and the Mopani woodland north of the Olifants River, while some work was carried out in each of the other regions.

The climate can be described as hot and dry with summer rainfall. Rainfall is usually in the form of thunderstorms resulting in considerable run-off from the soil surface. Average rainfall from Punda Maria to Satara is between 15″ and 20″ per annum. From Satara to the southern boundary the average rainfall is between 20″ and 25″ per annum. Pretorius Kop receives just over 30″ and Punda Maria with its surrounding hills, between 20″ and 25″ per annum (Union of S.A., 1948).

Temperature varies widely from near freezing-point in winter to over 100°F in summer. Isotherms run more or less parallel to the altitude contours of the Park. Mean temperatures are as follows: January (mid-summer); Maximum: 75° to 80° F in the western two thirds of the Park, and 5° F higher in eastern third. July (mid-winter): Maximum: 60° to 65° F over the whole area. The annual mean is 70-75° F throughout the Park (Union of S.A., 1942).

3. *Results of the Survey:*

Table 1 is a summary of all mosquito species taken during the survey; table 2 shows the localities where specimens were found according to the locus system used by Davis (1948); while table 3 is an analysis of breeding and resting places of specimens caught, according to species. Figure 1 shows the route taken through the Park.

A total of 907 mosquitoes was obtained. The majority, 799, were larvae, while 108 were adults. Four genera comprising 25 species were found consisting of three species of *Anopheles*, one of *Orthopodomyia*, twelve of *Aëdes* and nine of *Culex*.

The *Orthopodomyia* species collected in the Kruger National Park appears

Table 1. Summary of all mosquito species found.

Species.	Larvae	Adults	Totals
Anopheles coustani	4	—	4
Anopheles rufipes	2	4	6
Anopheles squamosus	7	1	8
Orthopodomyia sp.	48	1	49
Aëdes fulgens	155	30	185
Aëdes aegypti	66	20	86
Aëdes metallicus	92	11	103
Aëdes calceatus	21	18	39
Aëdes unilineatus	44	5	49
Aëdes vittatus	5	—	5
Aëdes marshalli	220	10	230
Aëdes haworthi	2	—	2
Aëdes dentatus	—	1	1
Aëdes ochraceus	12	1	13
Aëdes lineatopennis	—	1	1
Aëdes furcifer	69	—	69
Culex tigripes	1	—	1
Culex horridus	—	2	2
Culex nebulosus	2	—	2
Culex ethiopicus	—	1	1
Culex annulioris group	3	—	3
Culex theileri	5	—	5
Culex univittatus	2	2	4
Culex simpsoni	18	—	18
Culex decens	21	—	21
Totals	799	108	907

to be quite distinct from any other described species of this genus and is therefore considered to be endemic as it has not been recorded from any other region. This is, therefore, the first record of this mosquito genus from the African mainland.

Edwards (1941) writes that: "*Orthopodomyia* is a genus of few species, but widely distributed in Europe, Asia and America. It has not been found on the African mainland, but a single species occurs in Mauritius; this is quite distinct from all those at present known from the Oriental region, though evidently related to them".

Edwards (loc. cit.) notes that by many zoologists the Malagassy Region or subregion (Madagascar, Mascerennes, Seychelles and adajcent islands) is regarded as distinct from the Ethiopian region. He points out that: "The mosquitoes of Madagascar and adjacent islands are still very imperfectly known and important discoveries may yet be made regarding them, but almost all evidence at present available indicates that they are essentially similar to those of the African mainland". He only lists O. *arboricollis* d'Emmerez de Charmoy from the Ethiopian region, i.e. from Mauritius only.

Our first record of *Orthopodomyia* from the mainland is of interest as Edwards also writes: "Of the total 41 species of mosquitoes at present known from the whole of the Malagassy subregion, no fewer than 29 occurs also in Africa, while one more *(Aëdes albopictus)* is a common Oriental species; all these may be presumed to have been recently introduced to the islands. Of the remaining eleven species which are regarded as endemic to the subregion, the majority show clear affinities with African forms, several differing only very slightly. Only one species *(Orthopodomyia arboricollis)* is clearly more related to Indian than to African forms, and there are no endemic genera or subgenera. For these reasons there appears no justification for treating Madagascar as forming a region separate from the Ethiopian when considering the zoogeography of mosquitoes."

It therefore appears that our record of an endemic *Orthopodomyia* species on the African mainland lends further support to Edwards' conclusion.

Further species of interest encountered were: *Aëdes aegypti, Aëdes metallicus, Aëdes vittatus* and *Aëdes furcifer* because of their role as Yellow fever vectors elsewhere in Africa (Strode *et al*, 1951).

In the Kruger National Park the more common breeding places such as are found about domestic premises and those resulting from agricultural pursuits are almost entirely absent. Human habitations are concentrated in compact groups spaced many miles apart and are limited to well-constructed holiday and a few native labour camps. Seepage areas from earthen dams constructed to water game, as well as muddy trampled areas at watering-places did not yield any specimens. Tree-holes which can hold water for

sufficient lengths of time have the greatest breeding potential (Steyn *et al*, 1955). Breeding-places are discussed below in the order of their importance.

TREE-HOLES.

On the survey route a stop was made approximately every five miles to search for breeding. Most trees in an area approximately 100 yards square were examined on either side of the road at each stop. Approximately 55 stops were made on the survey, and the number of trees examined each time was estimated at about 100, depending on the density of the bush at each stopping point. Thirty-four stops yielded specimens.

As the rainfall in the Eastern Transvaal is higher and more regular than in the North-western Transvaal, the breeding potential of tree-holes in the Park is higher than that of tree-holes in the Upper Limpopo River Valley which was surveyed by us some time ago (Steyn Loc. cit.).

There are also a larger number of mature trees in the Park on account of the protection afforded from human damage, even though an area in the north was completely burnt out with a resultant destruction of trees in all stages of growth. Because of these two factors more trees were found with holes suitable for mosquito breeding (about 15% as compared with 10% for the upper Limpopo River Valley) and the number found with actual breeding proceeding was also higher (about 1% as compared with under 1% for the Limpopo Valley).

The species of tree in which breeding was most commonly found was the Marula *(Sclerocarya caffra)* followed by Knoppiesdoorn *(Acacia nigrescens)*. Breeding was also found in Hardekool *(Combretum imberbe)* and in Baobab *(Adansonia digitata)*. Many of these trees are found to have holes which cannot hold water. These holes are often used by tree rodents for nesting purposes.

Holes in Marula trees appear more often in the large trees and are found most frequently where a major branch has been destroyed close to the main stem and when dry, has been either broken off or gutted by fire, leaving a rather large hole round which the bark grows to form a prominent callus. Many of these holes inside the stems can hold about 4 pints of water when full, with the opening varying between a few inches to 6 inches in diameter. The wood all round the tree-hole was always found to be in sound condition. The holes are filled by the run-off from the broad and relatively smooth trunk and the large and shady canopy of the tree ensures a minimum evaporation of the water in the hole.

Holes in the Knoppiesdoorn and in Hardekool on the other hand are usually smaller, less shaded, and often are drained by a fissure either into

the heart of the tree or connecting the hole to an opening in the bark lower down. The bark of these tree trunks is rougher than that of the Marula and smaller quantities of rainwater run-off flow directly into such holes, while the trunks are less shaded by smaller canopies thus making for a higher rate of evaporation.

Of all the trees examined Baobabs had the greatest area of shade, with large areas of scar tissue where the bark forms small hollows, particularly round the base of the tree where prominent root buttresses may also catch up and hold rain-water. Large holes extending into the trunks of Baobabs however, were observed only once.

Usually only one hole per tree is found in Marula, Knoppiesdoorn and Hardekool trees. In Baobabs large numbers of crevices and hollows are seen, many of which are capable of holding water for the requisite length of time to allow successful mosquito breeding.

The tree-hole breeders found were *Orthopodomyia sp., Aëdes fulgens, Aëdes aegypti, Aëdes metallicus, Aëdes calceatus, Aëdes unilineatus, Aëdes marshalli, Aëdes haworthi, Aëdes furcifer, Culex horridus, Culex nebulosus* and *Culex decens.*

POOLS IN RIVER-BEDS.

These pools are formed by the river or streams drying up between the infrequent rains and leaving isolated pools. While they cannot be described as permanent they do give the opportunity for breeding to progress between showers of rain. As they are limited to the beds of the bigger streams they are only of secondary importance from the point of general distribution throughout the area. The pool breeders found were *Anopheles coustani, Anopheles rufipes, Anopheles squamosus, Culex ethiopicus, Culex annulioris* and *Culex simpsoni.*

BORROW-PITS.

Borrow-pits are observed at regular intervals along the main highways in the Park from where gravel is taken for resurfacing the roads. From these manmade breeding-places the following species were obtained: *Anopheles coustani, Anopheles rufipes, Anopheles squamosus, Aëdes ochraceus, Aëdes lineatopennis, Culex tigripes, Culex theileri, Culex univittatus, Culex simpsoni* and *Culex decens.*

CLAY-POTS.

Breeding was found in some instances to be proceeding in clay-pots abandoned next to deserted huts. The species collected were *Aëdes marshalli, Aëdes haworthi* and *Aëdes furcifer.*

Table 2: Localities, loci, and habitats of specimens caught.

Locality.	*Locus.*	*Habitat.*	*Species*
28 m. Pietersburg-L. Trichardt		Marula tree-hole	*Aëdes marshalli*
Pafuri Rangers Hut	2231 Ac	Clay-pots	*Aëdes marshalli* *Aëdes furcifer* *Aëdes haworthi*
2.4 m. Pafuri X roads — Punda Maria	2231 Ac	Marula tree-hole	*Aëdes furcifer* *Aëdes fulgens*
		Snail shells	*Aëdes fulgens*
		Baobab base	*Aëdes aegypti*
Baobab Hill	2231 Ac	Baobab base	*Aëdes aegypti* *Aëdes metallicus*
16.2 m. Pafuri X roads Punda Maria	2231 Ca	Marula tree-hole	*Aëdes aegypti* *Culex nebulosus*
1.2 m. Acornhoek — Rabelais Gate	2431 Ca	Borrow-pit	*Anopheles rufipes* *Anopheles squamosus* *Culex tigripes* *Culex theileri* *Culex univittatus* *Culex simpsoni*
13.7 m. Acornhoek — Rabalais Gate	2431 Cb	Marula tree-hole	*Aëdes marshalli* *Aëdes fulgens* *Aëdes aegypti* *Aëdes calceatus*
1.8 m. Rabalais Gate* — Satara	2431 Ad	Marula tree-hole	*Aëdes aegypti* *Culex decens* *Culex horridus*
2.5 m. Rabilais Gate — Satara	2431 Bc	Marula tree-hole	*Aëdes calceatus* *Aëdes furcifer* *Aëdes metallicus* *Aëdes unilineatus*

* Rabelais Gate has since been renamed Orpen Gate.

Locality.	Locus.	Habitat.	Species.
		Seepage hole	*Anopheles coustani* *Aëdes ochraceus* *Aëdes lineatopennis*
5.3 m. Rabalais Gate — Satara	2431 Bc	Marula tree-hole	*Aëdes fulgens* *Aëdes marshalli*
8 m. Rabalais Gate —	2431 Bc	Marula tree-hole	*Aëdes furcifer* *Aëdes fulgens* *Aëdes marshalli* *Aëdes metallicus*
13.6 m. Rabalais Gate — Satara	2431 Bc	Marula tree-hole	*Aëdes marshalli* *Aëdes fulgens* *Culex nebulosus* *Culex decens*
		Hardekool tree-hole	*Orthopodomyia sp.* *Aëdes calceatus* *Culex decens* *Culex horridus*
17 m. Rabalais Gate — Satara	2431 Bc	Marula tree-hole	*Aëdes calceatus*
17 m. Rabalais Gate — Satara	2431 Bc	Marula tree-hole	*Aëdes aegypti* *Aëdes marshalli* *Aëdes metallicus* *Aëdes fulgens* *Aëdes haworthi* *Culex decens*
3.4 m. Satara — Gorge	2431 Bd.	Acacia nig. tree-hole	*Orthopodomyia sp.*
3.9 m. Satara — Gorge	2431 Bd.	Acacia nig. tree-hole	*Aëdes fulgens* *Aëdes furcifer* *Aëdes marshalli* *Orthopodomyia sp.*

Locality.	*Locus.*	*Habitat.*	*Species.*
5.3 m. Satara — Gorge	2431 Bd.	Marula tree-hole	*Aëdes metallicus* *Aëdes unilineatus* *Aëdes marshalli*
		Acacia nig. tree-hole	*Aëdes fulgens* *Aëdes marshalli* *Aëdes aegypti* *Aëdes unilineatus* *Aëdes metallicus*
		Comb. apic. tree-hole	*Aëdes fulgens* *Aëdes unilineatus* *Aëdes marshalli*
11.1 m. Satara — Gorge	2431 Bd.	Marula tree-hole	*Aëdes metallicus* *Aëdes marshalli*
20.4 m. Gorge — Nwanedzi	2431 Bd.	Marula tree-hole	*Aëdes metallicus* *Aëdes marshalli* *Aëdes aegypti*
		Hardekool tree-hole	*Aëdes metallicus* *Aëdes unilineatus* *Aëdes marshalli*
22.2 m. Gorge — Nwanedzi	2431 Db	Marula tree-hole	*Aëdes marshalli* *Aëdes fulgens* *Aëdes aegypti*
		Acacia nig. tree-hole	*Aëdes furcifer* *Aëdes unilineatus*
Gudsana River	2431 Db	Pools	*Culex simpsoni* *Culex ethiopicus* *Culex annulioris* group
4 m. Nwanedzi — Skukuza	2431 Db	Comb. apic. tree-hole	*Aëdes furcifer* *Aëdes marshalli*
6.8 m. Nwanedzi — Skukuza	2431 Db	Acacia nig. tree-hole	*Aëdes aegypti* *Aëdes metallicus* *Aëdes unilineatus* *Aëdes marshalli*

Locality.	*Locus.*	*Habitat.*	*Species.*
17.4 m. Nwanedzi — Skukuza	2431 Db	Acacia nig. tree-hole	*Aëdes fulgens* *Aëdes marshalli* *Aëdes unilineatus*
44.1 m. Nwanedzi — Skukuza	2431 Dc	Acacia nig. tree-hole	*Aëdes marshalli* *Culex decens*
3.3 m. Skukuza — Newington	2431 Dc	Marula tree-hole	*Aëdes fulgens* *Aëdes marshalli*
4.6 m. Skukuza — Newington	2431 Dc	Acacia nig. tree-hole	*Aëdes fulgens* *Aëdes furcifer* *Aëdes metallicus* *Aëdes unilineatus* *Aëdes marshalli* *Aëdes aegypti*
7.5 m. Skukuza — Newington	2431 Dc	Comb. apic. tree-hole	*Aëdes marshalli* *Aëdes fulgens* *Aëdes furcifer* *Aëdes metallicus* *Aëdes aegypti* *Aëdes calceatus*
15.7 m. Skukuza — Newington	2431 Cd	Biting in grass	*Aëdes dentatus*
22 m. Skukuza — Malelane	2531 Ba	Rock-pools in river	*Anopheles coustani* *Anopheles rufipes* *Anopheles squamosus* *C. annulioris* group *C. simpsoni*
37 m. Skukuza — Malelane	2531 Bc	Rock-pools in river	*Anopheles rufipes*

Locality.	*Locus.*	*Habitat.*	*Species.*
4 m. Lower Sabie — Crocodile Bridge	2531 Bb	Acacia nig. tree-hole	*Aëdes metallicus* *Aëdes marshalli* *Aëdes unilineatus*
10 m. Hectorspruit — Komatipoort	2531 Bc	Acacia nig. tree-hole	*Aëdes marshalli* *Aëdes aegypti*
14 m. Hectorspruit — Komatipoort	2531 Bd	Marula tree-hole	*Aëdes marshalli*
Habitats unspecified			*Aëdes metallicus* *Aëdes aegypti* *Aëdes vittatus*

SNAIL-SHELLS.

At one place breeding was proceeding in an upturned snail-shell. The species found was *Aëdes fulgens.*

SPECIES FOUND IN ASSOCIATION WITH HUMAN HABITATIONS.

In table 3 an analysis is given of the species and numbers of mosquitoes found in association with human habitations. Thus all mosquitoes which were caught either as larvae or adults near any dwelling, were grouped together. Mosquitoes found breeding in clay-pots, or biting, or nesting under cover, such as in tents or huts comprise the greater number in this grouping, while a small number are included as "unclassified". On the above grouping it can be stated that approximately 20% of all mosquitoes taken in the Park were found in close association with man. The following species are grouped together in this manner: *Aëdes metallicus, Aëdes aegypti, Aëdes vittatus, Aëdes marshalli, Aëdes haworthi, Aëdes dentatus* and *Aëdes furcifer.*

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