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AEDES (DICEROMYIA) FURCIFER (EDWARDS) AND *AEDES (DICEROMYIA) CORDELLIERI* HUANG IN SOUTHERN AFRICA: DISTRIBUTION AND MORPHOLOGICAL DIFFERENTIATION

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ABSTRACT. Two species in the *Aedes (Diceromyia) furcifer* complex, *Ae. furcifer* s.s. and *Ae. cordellieri*, occur in southern Africa. They occur either allopatrically or sympatrically in lowland wooded savanna in tropical or subtropical regions in the Northern Province, Mpumalanga Province, and northern KwaZulu-Natal in South Africa and in Zimbabwe. A map of the distribution of these mosquitoes is presented including 2 new locality records where *Ae. cordellieri* is allopatric. A morphological study showed that immatures and adult females of the species are indistinguishable. This included a detailed study of the female terga. Differences in the male gonocoxite remain the only means to distinguish the 2 taxa.

KEY WORDS: *Aedes furcifer, Aedes cordellieri,* distribution, southern Africa, morphological differentiation

INTRODUCTION

In a preliminary publication, Jupp et al. (1993) reported that a reexamination of all the male specimens of the *Aedes furcifer* group housed in the museum collection of the National Institute for Virology (University of the Witwatersrand, Sandringham, South Africa) indicated the occurrence of only *Ae. furcifer* s.s. (Edwards) and *Aedes cordellieri* Huang in southern Africa. Whether *Aedes taylori* Edwards, the 3rd member of the group, is completely absent from the region or not remains to be seen. It is quite possible that mosquito collecting over a wider area could reveal its presence in Zimbabwe and/or northern Mozambique. In the same paper, the localities at which either or both *Ae. furcifer* and *Ae. cordellieri* occurred were listed and the importance of the *Ae. furcifer* group as arboviral vectors was emphasized. The group includes vectors of dengue, yellow fever, and chikungunya viruses in West Africa and chikungunya virus in southern Africa. Each of the 2 species has been encountered either allopatrically or sympatrically in the tropical and subtropical wooded savanna of the Northern Province and Mpumalanga Province (previously called Transvaal), northern KwaZulu-Natal, and the Zimbabwe lowlands. Collecting remains to be done in Mozambique, but at least *Ae. furcifer* and *Ae. cordellieri* are expected to be found there.

Observations on the ecology of *Ae. furcifer* have been made in South Africa. It is a tree hole breeder that feeds on nonhuman primates (vervet monkeys and baboons) at ground level but to a greater extent in the tree canopy or high rocky outcrops (koppies) (McIntosh et al. 1977). This species also feeds on humans when they venture into this habitat. *Aedes cordellieri* appears to have a similar ecology. Such ecological studies as well as the collection of female mosquitoes for vector competence experiments with the 3 viruses would be greatly facilitated if females of the 2 species could be identified. Jupp et al. (1993) reported initial observations on morphology for females of the 2 species. The present paper reports the results of a more detailed study designed to determine whether females and immatures can be identified. A map is also presented showing the known distribution of the 2 species.

MATERIALS AND METHODS

As mentioned in the earlier paper (Jupp et al. 1993), unless population densities of these mosquitoes are high, bait traps and biting catches fail to sample them so the only practical method remaining is to collect eggs deposited in bamboo pots exposed in wooded areas as ovitraps. Such pots were used at Pafuri, Shingwedzi, and Mica (Northern Province), at Skukuza (Mpumalanga Province), and at Ndumu (KwaZulu-Natal) during at least 5 summers. The aedine eggs deposited in each pot were reared and the resulting adults allowed to emerge into a different cage representing each pot. The genitalia of each *Ae. furcifer* group male emerging were checked and the long golden setal tuft on the apex of the gonocoxite used to identify male *Ae. furcifer*; this tuft is entirely absent in male *Ae. cordellieri*. The adult mosquitoes were then allowed to engorge on hamsters and separate families subsequently were reared from individual gravid females. For each family, slide mounts were prepared of the genitalia from several males to confirm their identity according to gonocoxite morphology (Huang 1986). In some of these families, siblings were preserved for detailed taxonomic study; adult males and females were pinned and larval and pupal exuviae were preserved in an ethanol–glycerine mixture. Many families were thus identified from each locality but no *Ae. taylori* specimens were encountered; only *Ae. furcifer* and *Ae. cordellieri* were col-

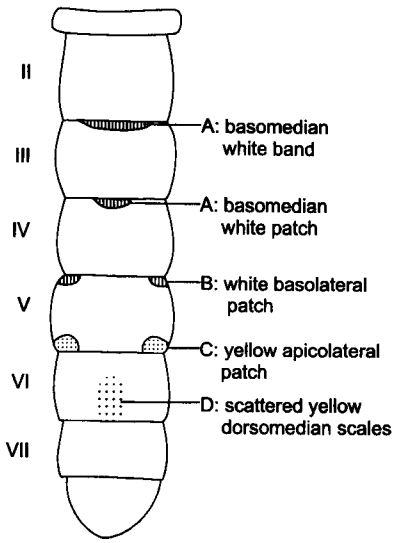

Fig. 1. Diagrammatic representation of abdominal terga showing characters A to D examined on female mosquitoes.

lected and identified. The presence of both species in a pot was unusual during the particular season when the families were being reared and preserved for this morphological study.

Figure 1 shows the 4 characters examined on each tergum I–VII. A character was regarded as present even if the character was only faintly visible as a smaller number of scales. The terga were examined on female specimens that had been pinned laterally to protect the dorsal scale patterns. Other parts of these specimens were also examined in the search for possible differences between the 2 species. A few adult female *Ae. furcifer* and *Ae. cordellieri* were also examined with the scanning electron microscope at 70–700× magnification to investigate whether any structural differences were detectable in the antennae and maxillary palps.

RESULTS

Distribution

The distribution already published for southern Africa (Jupp et al. 1993) can now be updated with 2 additional localities where *Ae. cordellieri* is apparently allopatric, namely Pafuri (22°27′S, 31°21′E) and Shingwedzi (23°50′S, 31°26′E). These are both located in the Northern Province in the northern part of the Kruger National Park and only *Ae. cordellieri* was collected there during 5 successive summers. Figure 2 maps the latest known distribution of both species.

Morphology

Most of the principal features on the adult female mosquitoes were examined critically to see whether a way of differentiating the 2 species could be found. These included scutal ornamentation, maxillary palps and antennae, vertices, wing venation, basal white bands on tarsomeres, and tarsal claws on all legs. Light microscopic examination revealed that these characters were unsuitable for differentiation, so the antennae and maxillary palps were examined further with the scanning electron microscope, also without detecting any differences. Because Huang (1986) had found she could distin-

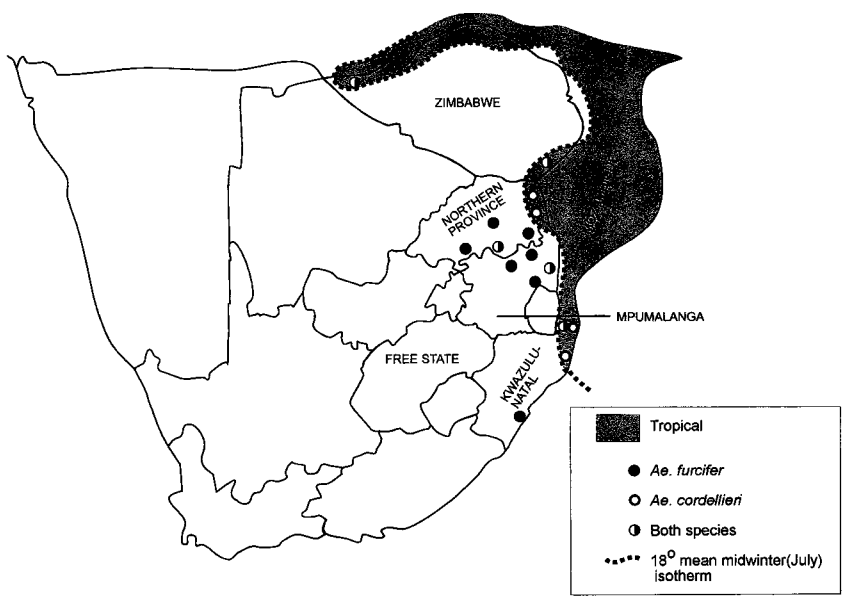

Fig. 2. Map showing known distributions of *Aedes furcifer* and *Aedes cordellieri*.

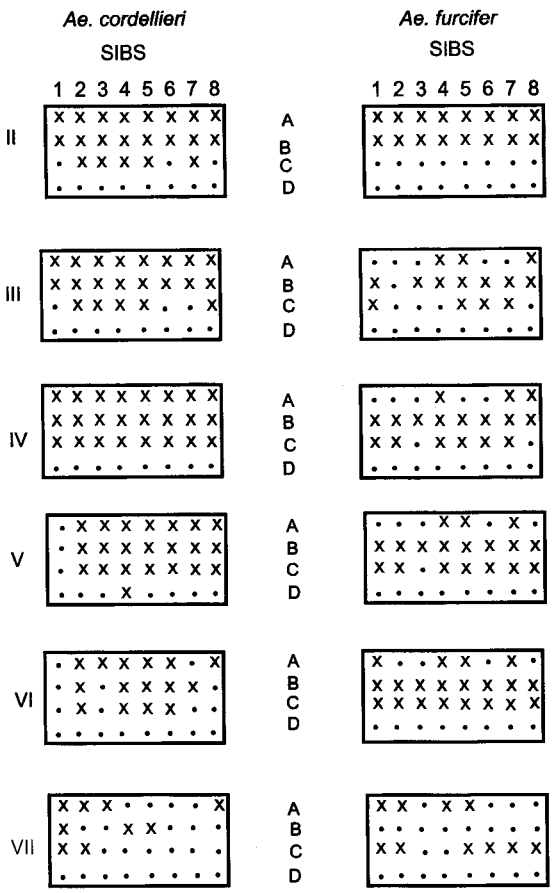

Fig. 3. Variation of the 4 different morphological characters (A–D) on terga II–VII in a sibling group of 8 *Aedes cordellieri* and a sibling group of 8 *Aedes furcifer*, respectively.

guish the species from tergal characters, these characters were given close attention under the light microscope, particularly as the 1st observations looked promising. Unfortunately, considerable intraspecific variation was found in tergal morphology within a family. Figure 3 is an example of this, and shows a full analysis of the 4 characters on terga II–VII in 8 siblings of *Ae. cordellieri* from Shingwedzi and 8 siblings of *Ae. furcifer* from Ndumu. A character on a particular tergum varied by being both absent and present within the sibling group or when it was consistently present or absent in one species, either the same applied to the other species or there was variation in the other species. The absence or presence of each character on terga II–VII for the whole sample of *Ae. furcifer* and *Ae. cordellieri*, respectively, is given in Table 1, which shows the numbers and percentages of mosquitoes displaying the character in each sample. Considerable similarity occurred between the 2 species and none of the characters, not even that on a single tergum, would serve to separate the species. Similarly, the immature stages could not be distinguished. At the commencement of the study, the number of denticles on the larval pecten and the number of branches on head seta 9 and the dimensions of the trumpet in the pupa looked promising. However, examination of a series of mounted immature exuviae showed that overlap occurred in both larvae and pupae of both species, rendering these characters unsuitable for diagnosis.

DISCUSSION

The map of the known distributions of the 2 taxa (Fig. 2) shows that each species occurs either allopatrically or sympatrically. The map also indicates that *Ae. cordellieri* usually occurs within or close to the tropical region (east of the 18°C mean midwinter isotherm), whereas *Ae. furcifer* usually occurs in the subtropical regions (west of this isotherm). In Fig. 2, the boundary of the tropical region in South Africa and Zimbabwe can be seen to follow the 18°C mean midwinter month (July) surface isotherm, which separates it from the adjacent subtropical region (Poynton 1964, McIntosh 1980). Therefore, temperature probably limits the distribution patterns of the 2 taxa. Further distributional records in southern Mozambique across the South African border and in Zimbabwe are needed to confirm this pattern.

Table 1. An analysis of the number and percentage (in parentheses) of female mosquitoes displaying each character (A–D) on terga II–VII, respectively.

	Aedes furcifer[1]				*Aedes cordellieri*[2]			
Tergum	A	B	C	D	A	B	C	D
II	73 (99)	71 (96)	55 (74)	4 (5)	44 (98)	44 (98)	34 (76)	0
III	24 (32)	68 (92)	62 (84)	5 (7)	33 (73)	42 (93)	33 (73)	0
IV	41 (55)	70 (95)	65 (88)	5 (7)	33 (73)	41 (91)	37 (82)	1 (2)
V	34 (46)	69 (93)	66 (89)	13 (18)	30 (67)	37 (82)	36 (80)	8 (18)
VI	34 (46)	65 (88)	66 (89)	24 (32)	30 (67)	35 (78)	33 (74)	9 (20)
VII	29 (40)[3]	6 (8)[3]	58 (80)[3]	30 (41)	27 (60)	23 (51)	23 (51)	5 (11)

[1] Seventy-four specimens from 9 families were examined.
[2] Forty-five specimens from 12 families were examined.
[3] Tergum VII was damaged in one specimen, hence these percentages are based on 73 specimens.

The absence of morphological distinctness between adult females of *Ae. furcifer* and *Ae. cordellieri* makes ecological observations on the 2 species difficult to carry out, as all identifications must be confirmed from the male genitalia, unless repeated collections over an extended period show the presence of only one species. This has happened in the case of Pafuri and Shingwedzi in the Northern Province where only *Ae. cordellieri* has been taken in ovitraps over 5 successive summers. However, if female specimens are collected for vector competence experiments from Skukuza, Mica, and Ndumu, where both species occur side by side, the progeny from each individual female must be reared and a male identified before live specimens can be pooled to assemble a homogenous collection of one species for an experiment or for starting a laboratory colony. An outside chance exists that some of the *Ae. furcifer* and *Ae. cordellieri* at these 3 localities may have cross-mated when first reared from ovitraps in the laboratory. However, this is considered very unlikely because of the rarity of *Ae. cordellieri* during the particular summer when specimens of *Ae. furcifer* were extracted from the pots for the present taxonomic study. No *Ae. cordellieri* were identified from Ndumu and only 2 and 8% were identified as such from Skukuza and Mica, respectively. Five of the 9 *Ae. furcifer* families studied came from Ndumu, 3 came from Skukuza, and only 1 came from Mica where the highest proportion of *A. cordellieri* occurred. Furthermore, male genitalic structure of each species has remained constant over the 30-year period that the *Ae. furcifer* group has been studied in my laboratory and no suggestion of intermediates has occurred. Either the long curled golden-yellow gonocoxite setal tuft has been present (in *Ae. furcifer*) or it has been completely absent (in *Ae. cordellieri*). Application of ribosomal DNA sequence analysis may possibly be used to differentiate females of the 2 taxa. This would be of some practical value in the research program, although the disadvantage of this method is having to kill or damage the mosquito in order to identify it.

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