

A Morphological Study of *Culex (Culex) univittatus* Theobald and
Culex (Culex) neavei Theobald from Various African Countries

by

P. G. Jupp
Arbovirus Research Institute
South African Institute for Medical Research
Johannesburg^{1/}

Mosquito samples from various African countries consisting of specimens ascribed to *Culex univittatus* and *Culex neavei* were studied morphologically and compared with these species from South Africa in an attempt to make specific determinations. A few *univittatus* were identified from Niger, Upper Volta and Dahomey in West Africa. However, a similar number of the specimens from Niger and the majority of those from the other 2 countries were identified as *neavei* and an aberrant form close to *neavei*, while these 2 forms only occurred in samples from Nigeria and Mauritania. Small samples from Tanzania, Kenya and Reunion were exclusively *neavei*, while that from Egypt probably contained only the aberrant form. This form, which is recognized from its male genitalia, may represent a distinct species. A single specimen from Ethiopia was *univittatus*.

Culex univittatus Theobald

Culex univittatus Theobald, 1901, Mon. Cul. 2:29; Edwards, 1911, Bull. ent. Res. 2:262; Edwards, 1941, Mosq. Ethiopian Region 3:306; Jupp, 1971, J. ent. Soc. sth. Afr. 34:339. (For complete bibliography, including that of synonyms, see Stone *et al.*, 1959.)

TYPE DATA. Holotype female, 4 paratype females, 5 paratype males and 1 paratype male genitalia, Salisbury, RHODESIA. All types in British Museum.

Note on type locality of *Culex univittatus* Theobald

In the first description Theobald (1901) describes the "habitat" of *univittatus* as Durban (Natal), Salisbury (Rhodesia) and Singapore. Stone *et al.* in their catalogue of mosquitoes (1959) refer to the type localities as Durban and Salisbury. However, it appears that only Salisbury should be considered as the type locality of *C. univittatus*. Edwards (1941) gives this single locality and furthermore, Mattingly (*in litt.*) has informed me that the type material held in the British Museum all originates from Salisbury.

Culex neavei Theobald

Culex neavei Theobald, 1906, Rep. Wellcome Lab. 2:76, and 1907, Mon. Cul. 4:429; Edwards, 1914, Bull. ent. Res. 5:67; Jupp, 1971, J. ent. Soc. sth. Afr. 34:339.

Culex univittatus var *neavei* Edwards, 1922, Bull. ent. Res. 13:85; Edwards, 1941, Mosq. Ethiopian Region 3:308.

TYPE DATA. Holotype female and 1 paratype female, Lualas, SUDAN, 1 paratype female, Lado, SUDAN. Types in British Museum.

^{1/}

Work financed jointly by the South African Institute for Medical Research and the Poliomyelitis Research Foundation.

INTRODUCTION

A study of the morphology, geographical relationship and genetics of 2 forms of *C. univittatus* present in South Africa was recently reported (Jupp, 1971). In this study it was found that one form, restricted to high altitude, was conspecific with type material of *C. univittatus* Theobald, 1901. The other form, of lowland distribution, was conspecific with the types of *C. univittatus* var *neavei* Edwards, 1922, and was raised to specific status. Morphologically the former was identical to *univittatus* and the latter similar to *neavei* except in regard to markings on terga and sterna. Morphological study of specimens collected in the area of contact between the ranges of the 2 forms indicated that they were largely reproductively isolated and cross-mating between laboratory colonies of the 2 forms failed to occur because of ethological isolation. Subsequently, material considered as belonging to the 2 species from other African countries has been made available to the author. In an attempt at specific determinations this material has been compared with South African material with emphasis on characters found to be reliable in the earlier study for distinguishing the 2 species.

MATERIALS AND METHODS

Mosquitoes

All the pinned specimens studied from countries outside South Africa were borrowed from the collection of the Office de la Recherche Scientifique et Technique Outre-Mer held in Bondy, France, except those from Egypt which were borrowed from Dr. K. L. Knight of North Carolina State University, Raleigh. Samples originated from Upper Volta, Dahomey, Nigeria, Mauritania and Niger in West Africa; from Tanzania, Kenya and Ethiopia in East Africa and from Reunion and Egypt. With the exception of Mauritania and Egypt which are Palaearctic, all these countries are within the Ethiopian region. As far as could be ascertained none of the localities in each country exceeded 500 m in altitude, except probably Atalaie in Ethiopia and possibly some localities in Niger.

Identification Procedure

Eight characters were looked for in specimens of both sexes to determine their occurrence and another 2 were studied in the genitalia of males. Table 1 lists all these characters showing the frequency with which each occurs in *univittatus* or *neavei* from South Africa or, in the case of the genitalia, the appearance of the structure concerned. Terminology used to describe structures in the male genitalia is that of Knight and Laffoon (1971). Two structures were examined: the leaflet borne by the subapical lobe of the gonocoxite and the outer division of the lateral aedeagal plate (LAP). The leaflet was inspected to see whether its shape was narrow or broad and this was usually expressed as a leaflet index (R_1) (Jupp, 1971). The spine borne by the outer division of the LAP was classified as short, long or intermediate in length.

The examination of South African material reported previously (Jupp, 1971) and summarized in table 1 showed that *univittatus* and *neavei* may be distinguished in the female by the mid femur and in the male by the leaflet. Female *univittatus* has an anterior white stripe on the mid femur which is missing in *neavei*: male *univittatus* possesses a narrow leaflet on the gonocoxite with an R_1 index of 33-50 while *neavei* possesses a broad leaflet with an R_1 index of 50 or more. The previous study did not include mention of the second character in the male genitalia. Examination of the spine borne by the LAP in South African material

shows that it is always long in *neavei* (fig. 2c) while in *univittatus* it is sometimes long but more often of intermediate length (fig. 2b). Hence, this character is precluded from being suitable for separating the 2 species but it was examined in males in the present study after the discovery that some individuals possessed a short spine (fig. 2a) quite distinct from that of *univittatus* or *neavei*. Thus, in classifying the present material females were identified as *univittatus* or *neavei* on the basis of the mid femur while, depending upon the appearance of the 2 characters in their genitalia, male specimens were identified as follows. Specimens with a narrow leaflet and long or intermediate LAP spine were considered *univittatus*, those with a broad leaflet and long or intermediate LAP spine as *neavei*, while any specimen with a short LAP spine was designated the "short-spined form". The observations made on the remaining 7 characters in both sexes served to indicate any differences from South African *univittatus* or *neavei*.

Technique for male genitalia

The method of Edwards (1941), with modifications, was used for preparing mounts of male genitalia stained with carbol fuchsin. Gonocoxites were mounted separately, the leaflet either being measured while still attached to the subapical lobe or after detachment. Where the size of the sample from a country was large, in a proportion of the specimens the phallosome was mounted intact and the LAP examined in situ. However, in most cases the outer divisions of the LAPs were dissected from the remainder of the phallosome and mounted separately. Preparations were examined under a compound microscope at a magnification of 540. Camera lucida drawings were made of one or more of the leaflets in males from each country. Similar drawings were also made of half or more of the preparations of the LAP from each country before the category of spine borne was determined.

RESULTS

C. univittatus

Only 5 females and 5 males were identified as *univittatus* as shown in table 2. Three of the females had a faint stripe on the mid femur and 2 a clear stripe. The males all possessed leaflets with a narrow shape very similar to that of *univittatus* from South Africa, although in most cases they tended to be shorter and slightly more convex (see figs. 1 a-c). The 2 broadest leaflets belonging to the 2 males from Niger had an R_1 index of 50 which is the bottom of the range determined for *neavei* (Jupp, 1971). However, their shape appeared nearest to that of *univittatus*. For all the males the spine borne by the LAP was of intermediate length as is most usual in *univittatus* from South Africa. The remaining characters assessed in both sexes, where the condition of a specimen permitted a full examination, occurred as in South African material except that one male from Niger lacked pale scales at the base of the costa in the wing.

C. neavei

Most of the female specimens were identified as *neavei*. The frequencies at which 5 of the characters occurred in the samples designated *neavei* are given in table 3. The remaining 3 characters, not included in this table, are a striped mid femur, post spiracular scales and an apical

spot on the hind tibia. The first was absent and the others present in all the specimens. From table 3 it can be seen that most of the samples agreed well with *neavei* in all respects. Important exceptions to this were the absence of dark apical lateral markings on the sterna in some individuals from Upper Volta and Egypt and the absence of basal costal scales in the wings of some specimens from Upper Volta and Dahomey.

After the few *univittatus* specimens had been removed from the male material, of the 66 males remaining, 34 were identified as *neavei* and 32 as the short-spined form. Table 4 includes a list of the samples of males identified as *neavei*, together with their R_1 values. These specimens all possessed broad leaflets with R_1 index, when measured, ranging from 50-84. Leaflet shape was very similar to that exhibited by *neavei* from South Africa (figs. 1.e-k), except in the case of males from Egypt (fig. 1.d). In these it appeared to be intermediate between that of *univittatus* and *neavei* in spite of having an R_1 index within the range of that shown by *neavei*. The spine on the LAP was of intermediate length in all the samples (e.g., figs. 2e, h & k) except in those from Tanzania and Kenya where it was long (figs. 2f & i). Drawings of the outer division of the LAP from these 2 countries were identical to that of *neavei* from South Africa shown in fig. 2c. A faintly striped mid femur occurred on the one side of a single specimen from Upper Volta and Reunion respectively, and on both sides of 1 specimen from Dahomey: a striped mid femur has not been encountered in South African *neavei*. The other characters examined occurred in all the specimens except for 2 which lacked basal costal scales on the wing.

Short-spined form

Table 4 also shows those male specimens identified as the short-spined form. Examples of the outer division of the LAP from such specimens can be seen in figs. 2, a, d, g, j, l. & m. Most individuals belonging to this form had the broad leaflet characteristic of *neavei* with R_1 values of 50-81 except 4 specimens which possessed the narrow leaflet characteristic of *univittatus* with R_1 values of 43-48. None of the specimens exhibited a striped mid femur except 1 from Upper Volta and 1 from Dahomey where a faint stripe occurred. The remaining 7 characters were always present.

DISCUSSION

The distribution of *univittatus*, *neavei* and the aberrant short-spined form in the samples examined from each country are given in table 5. Out of a total of 128 specimens only 10 were identified as *univittatus*, the remainder being identified as *neavei*, or the short-spined form. As this aberrant form is only detectable in the male it is thought that some of the female specimens ascribed to *neavei* must have corresponded to it. This is probably the case for all the females from Egypt as all males from this country belonged to the aberrant form. It would appear, therefore, that *univittatus* is not so widespread in Africa as previously believed and that it has frequently been confused with *neavei* or the short-spined form. In South Africa *univittatus* was found to be restricted to the highlands and *neavei* to the lowlands (Jupp 1971). The results of the present study tend to be in accord with this, as *univittatus* was rare and *neavei* common in samples which nearly all originated from localities of low altitude. Also, the collection localities in Ethiopia and Niger where some of the *univittatus* specimens originated may be high.

In the phallosome of male genitalia only 2 types of LAP were clearly distinguishable - one with a long spine (those classified as intermediate or long) and one with a short spine on the outer division. Males of the short-spined form may represent a sibling species of *neavei*. Further morphological study on larger samples, including reared siblings would be necessary towards an assessment of whether this is so or whether the aberrant form merely represents polymorphism. Crossing experiments would also probably be necessary before the taxonomic status of this form could be finally established. Mattingly (1954) drew attention to 3 forms in Africa based on the LAP character which he ascribed to *univittatus* and suggested might be climatypes. These were a western Mediterranean form (long spine), an eastern Mediterranean form (short-spine) and an intermediate form (spine of intermediate length). According to Mattingly the western Mediterranean form agrees closely with the type form of *univittatus*. Senevet *et al.* (1957) have also reported intermediate and eastern Mediterranean forms in Algeria. The eastern Mediterranean form with the short spine is said to correspond to *Culex perexiguus* Theobald, one of the synonyms of *univittatus*. However, examination of the holotypes of this synonym (Mattingly - *in litt.*) reveals that it differs from typical *univittatus*: the female holotype lacks a striped mid femur as does *neavei*, while the leaflet in the male holotype is similar to that of *univittatus*. It would seem likely therefore, that the eastern Mediterranean form is the same as the short-spined form of the present study. The latter occurred in the collections from all West African countries and from Egypt which is in agreement with the distribution of the eastern Mediterranean form given by Mattingly (1954). As males of the short-spined form and of *neavei* occurred together in 4 of the West African countries, often originating from the same localities, this precludes them from being climatypes.

Since both *univittatus* and the short-spined form are important as viral vectors, the taxonomic status of the form concerned needs to be established. In South Africa *univittatus* is believed to be the maintenance vector of West Nile and Sindbis viruses (McIntosh *et al.*, 1967; Jupp and McIntosh, 1967). In Egypt "*univittatus*" which, in the light of the present study, almost certainly belongs to the short-spined form is an important vector of West Nile and probably also Sindbis viruses (Taylor *et al.*, 1955, 1956). Furthermore, in Israel this same form of mosquito may be involved in the transmission of West Nile virus. It is noteworthy that the Egyptian form has host preferences which differ from those of *univittatus* in South Africa (Hurlbut and Weitz, 1956; Jupp and McIntosh, 1967).

ACKNOWLEDGEMENTS

I wish to thank Dr. J. Hamon of the Office de la Recherche Scientifique et Technique Outre-Mer and Dr. K. L. Knight of North Carolina State University for kindly lending me specimens from their collections. I am also grateful to Dr. P. F. Mattingly of the London Museum for examining type material on my behalf.

LITERATURE CITED

Edwards, F. W. 1922. Mosquito Notes - III. Bull. ent. Res. 13:85

- Edwards, F. W. 1941. Mosquitoes of the Ethiopian region. III. Culicine adults and pupae. The British Museum (Natural History) London.
- Hurlbut, H. S. and Weitz, B. 1956. Some observations on the bionomics of the common mosquitoes of the Nile Delta. Amer. J. trop. Med. Hyg. 5:901-908.
- Jupp, P. G. and McIntosh, B. M. 1967. Ecological studies on Sindbis and West Nile viruses in South Africa. II. Mosquito bionomics. S. Afr. J. med. Sci. 32: 15-33.
- Jupp, P. G. 1971. The taxonomic status of *Culex (Culex) univittatus* Theobald (Diptera: Culicidae) in South Africa. J. ent. Soc. sth. Afr. 34: 339-357.
- Knight, K. L. and Laffoon, J. L. 1971. A mosquito taxonomic glossary. V. Abdomen (except female genitalia). Mosquito Systematics Newsletter. 31:8-24.
- Mattingly, P. F. 1954. The distribution of some African mosquitoes. Proc. Linn. Soc. London, 165: 49-61.
- McIntosh, B. M., Jupp, P. G., Dickinson, D. B., McGillivray, B. M. and Sweetnam, J. 1967. Ecological studies on Sindbis and West Nile viruses in South Africa. I. Viral activity as revealed by infection of mosquitoes and sentinel fowls. S. Afr. J. med. Sci. 32: 1-14.
- Senevet, G., Andarelli, L. and Lieutaud, A. 1957. A propos de *Culex univittatus* Theobald. Arch. Inst. Pasteur Alger. 35: 52-53.
- Stone, A., Knight, K. L. and Starke, M. 1959. A synoptic catalogue of the mosquitoes of the World. The Thomas Say Foundation; Vol. VI. (The Entomological Society of America, Washington, U. S. A.).
- Taylor, R. M., Hurlbut, H. S., Work, T. H., Kingston, J. R. and Frothingham, T. E. 1955. Sindbis virus: a newly-recognized arthropod-transmitted virus. Amer. J. trop. Med. 4: 844-862.
- Taylor, R. M., Work, T. H., Hurlbut, H. S. and Rizk, F. 1956. A study of the ecology of West Nile virus in Egypt. Amer. J. trop. Med. Hyg. 5: 579-620.
- Theobald, F. V. 1901. A Monograph of the Culicidae. 2: 29. The British Museum (Natural History) London.

Table 1. *C. univittatus* and *C. neavei* from South Africa; the frequency with which 8 morphological characters occur in both sexes and the nature of 2 characters in genitalia of males.

	<i>C. univittatus</i>		<i>C. neavei</i>	
	Female	Male	Female	Male
Post-spiracular scales	Present	Present	Present	Present
Terga; basal white bands	"	"	Rarely absent	"
Sterna; median dark scales	"	"	Sometimes absent	"
Sterna; dark apical lateral triangles	"	"	Present	"
Hind tibia; apical white spot	"	"	"	"
Hind tibia; anterior white stripe	"	"	Rarely absent	Rarely absent
Mid femur; anterior white stripe	"	Usually present	Absent	Absent
Wing; pale scales at base of costa	"	Present	Present	Often absent
<u>Genitalia</u>				
Subapical lobe of gonocoxite; leaflet shape		Narrow R ₁ * 33-50		Broad R ₁ 50 or more
LAP ⁺ ; length of spine borne by outer division		Intermediate length or long		Long

*Leaflet index. + Lateral aedeagal plate.

Table 2. Number of female (F) and male (M) specimens identified as *C. univittatus*; values for the leaflet index (R₁) are given for males.

		No.	R ₁
Upper Volta	F	1	
	M	1	48
Dahomey	F	1	
	M	2	43,47
Niger	F	2	
	M	2	50,50
Ethiopia	F	1	

Table 3. Female specimens identified as *C. neavei*; the occurrence of certain morphological characters - all specimens lacked a striped mid femur.

Country	No.	TERGA	STERNA		HIND TIBIA	WING
		white basal bands	Median dark scales	Dark apical lateral triangles	anterior white stripe	pale basal costal scales
WEST AFRICA						
Upper Volta	18	9	3/17*	0/4	14	16
Dahomey	5	2/4	2	3/3	4	4
Nigeria	1	1	1	1	1	1
Mauritania	4	4	3/3	2/2	4	4
EAST AFRICA						
Tanzania	1	1	0	?	1	1
Kenya	2	2	2	?	2	1/1
REUNION	2	2	1/1	?	2	2
EGYPT	19	19	11/18	6/8	19	19

*Where the condition of some specimens precluded the assessment of a character for the whole sample, the numerator is the number of specimens possessing the character and the denominator the number on which it could be examined.

Table 4. Male specimens identified as *C. neavei* and the short-spined form; appearance of leaflet and values for the leaflet index (R_1).

Country	<i>C. neavei</i> (all with broad leaflets)		Short-spined form			
	No.	R_1	No.	No. with broad leaflet	No. with narrow leaflet	R_1
WEST AFRICA						
Upper Volta	13	51-71(10)*	12	10	2	50-81(9) 47(2)
Dahomey	8	50-62(7)	6	5	1	50-58(3) 43(1)
Nigeria			3	3		52-56
Mauritania	2	50(1)	2	1	1	48(1)
Niger	2	52,53	2	2		56,56
EAST AFRICA						
Tanzania	4	56-73				
Kenya	2	67,84				
REUNION	3	54-67				
EGYPT			7	7		50-60

* The bracketed figures indicate the number of individuals for which R_1 values were calculated when determinations were not made on the full sample.

Table 5. Numbers of specimens of *C. univittatus*, *C. neavei* and the short-spined form in the collections from different African countries; figures in parenthesis are female specimens and the others are male specimens.

Species	South Africa	Upper Volta	Dahomey	Nigeria	Mauritania	Niger	Tanzania	Kenya	Ethiopia	Reunion	Egypt
<i>C. univittatus</i>	Present	1(1)	2(1)			2(2)		(1)	(1)		
<i>C. neavei</i>	Present	13(18)	8(5)	(1)	2(4)	2	4(1)	2(2)		3(2)	(19)
Short-spined form		12	6	3	2	2					7

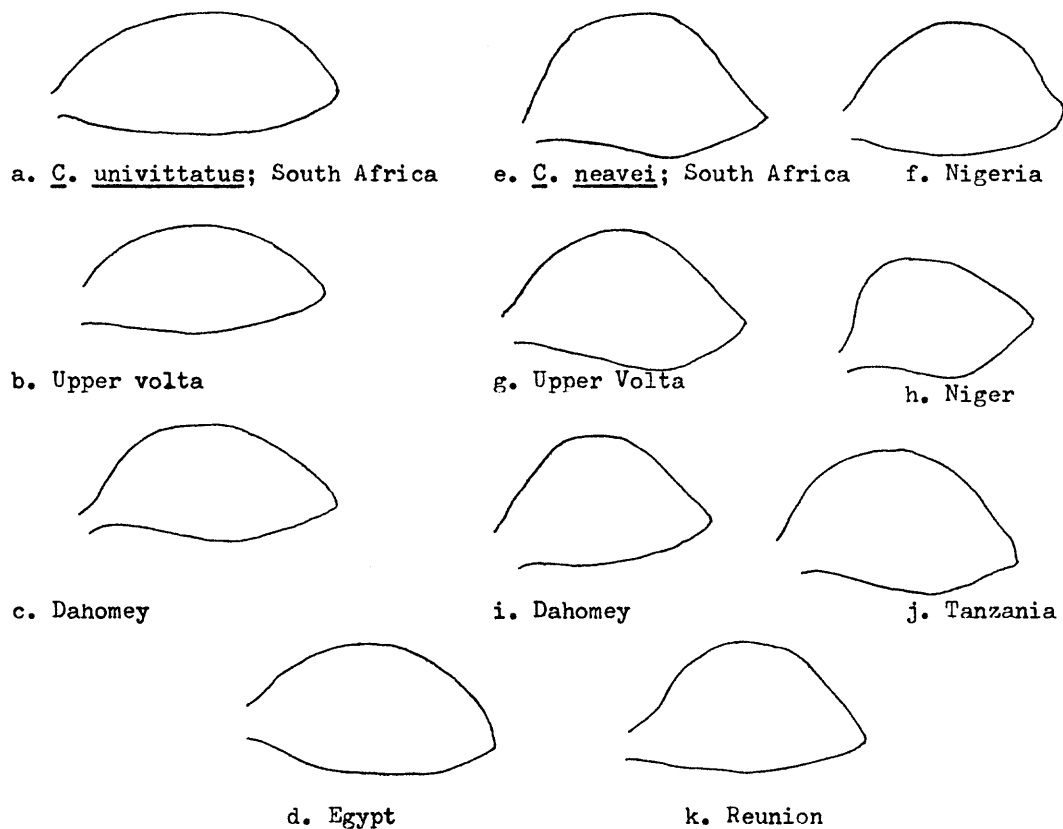


Fig. 1 Drawings of the leaflet from the gonocoxite of various male specimens; b and c are similar to that from *C univittatus* (a), f-k are similar to that from *C. neavei* (e), while d appears intermediate in shape.

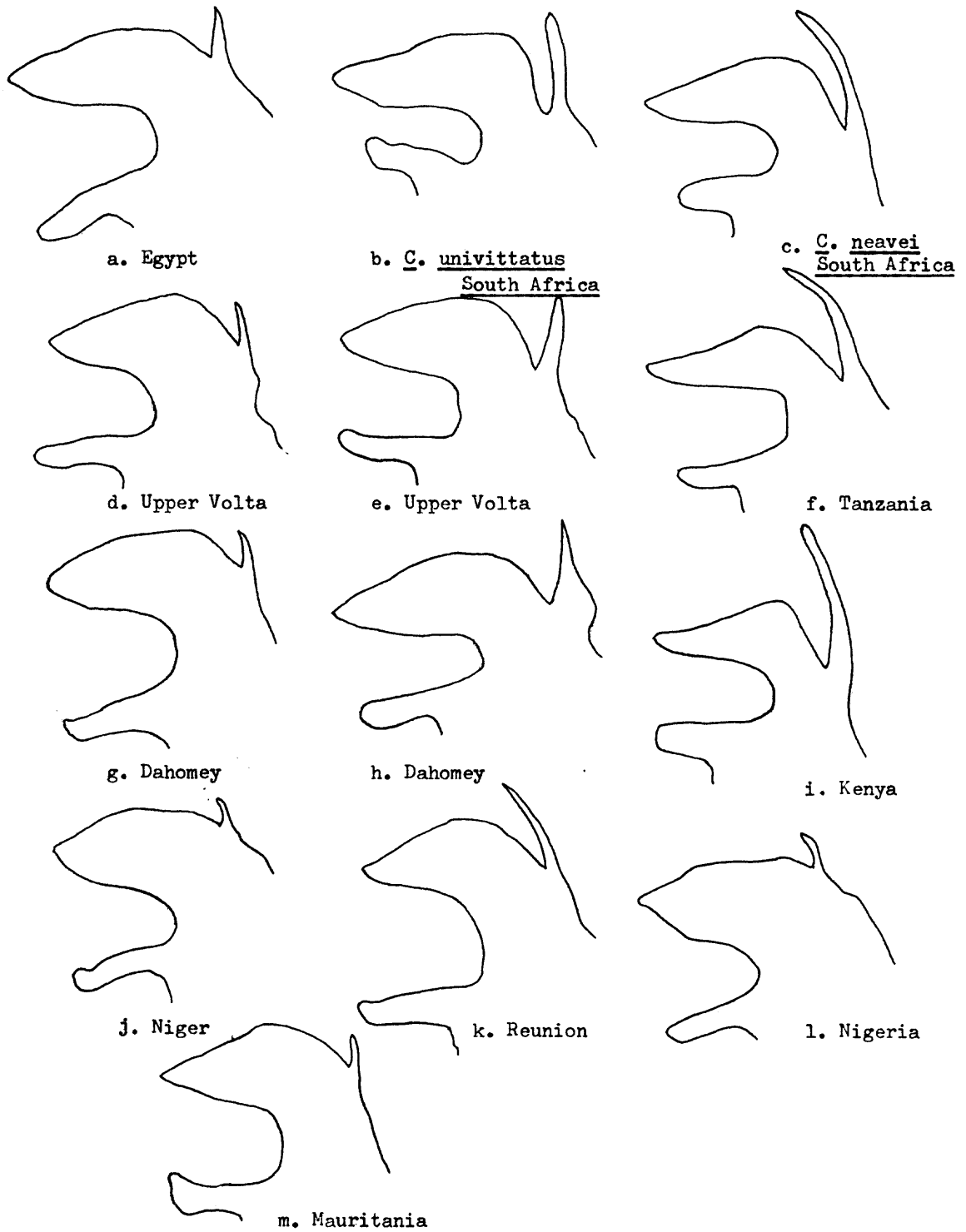


Fig. 2 The outer division of the lateral aedeagal plate; drawings to show different spine lengths.