Distribution and systematic relationship of *Tadarida bivittata* and *Tadarida ansorgei* (Chiroptera: Molossidae)

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Morphologically similar *Tadarida bivittata* and *T. ansorgei* inhabit dry, woodland savannah areas of central Africa, where they are partially sympatric. Specimens of these species were divided into population samples based on geographic proximity. Multivariate analysis of variance indicated that both species are sexually dimorphic. Results of principle components analysis illustrated interspecific differences. In areas of sympatry, specimens were subjected to discriminant analysis to confirm their identity. Based on this analysis, classification functions are provided as a useful aid for identifying the two species.

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Les espèces morphologiquement semblables *Tadarida bivittata* et *T. ansorgei* habitent les régions sèches des savanes boisées du centre de l'Afrique où elles sont partiellement sympatriques. Des spécimens de ces espèces ont été divisés en échantillons de population, selon leur proximité géographique. L'analyse multidimensionnelle de la variance indique que les deux espèces font preuve de dimorphisme sexuel. Les résultats de l'analyse des composantes principales illustrent les différences interspécifiques. Dans les régions où les deux espèces sont sympatriques, les spécimens ont été soumis à une analyse discriminatoire permettant d'en confirmer l'identité. Cette analyse a permis d'établir des fonctions de classification qui facilitent la séparation des deux espèces.

[Traduit par le journal]

Introduction

The molossid bat, *Tadarida bivittata* (Fig. 1), described by Heuglin (1861) from three specimens from Keren, Ethiopia, occurs throughout Kenya, Ethiopia, eastern Uganda, and southern Sudan and is also recorded from Zambia (Hayman and Harrison 1966). These authors also examined the syntypes of *T. bivittata* and provided a description of the pelage and external features, as well as external and skull measurements. Thomas (1913) described *T. ansorgei* based on a specimen from Malange, Angola. There are published records of this species for Cameroun, Rhodesia, Zaire, Uganda, and Mozambique. These two species are sympatric in southern Sudan, Ethiopia, and Kenya.

Roberts (1946) named specimens from Chikupo Cave, Bindura District, Rhodesia, as *T. rhodesiae*. Harrison (1959), however, considered *T. rhodesiae* to be a synonym of *T. ansorgei*.

Historically, the genus *Tadarida* has been divided into four subgenera, with *T. bivittata* assigned to the subgenus *Chaerephon* and *T. ansorgei* to the subgenus *Tadarida* (Hayman and Hill 1971). Koopman (1975) suggested that the two species are closely related members of the subgenus *Tadarida*. Using different criteria, the analysis by Freeman (1977) suggested that the two closely associated species are members of *Chaerephon*. The use of subgeneric divisions of *Tadarida* has led to considerable confusion and a more thorough analysis is required before its usefulness can be assessed.

The striking morphological similarity of the two taxa led some authors (Peterson and Nagorsen 1975; Fenton 1975) to assume that the two would prove to be conspecific. Sufficient material has now been accumulated to warrant a critical assessment of the distribution and systematic relationships of these two taxa.

Materials and Methods

Specimens examined were either study skins and skulls or

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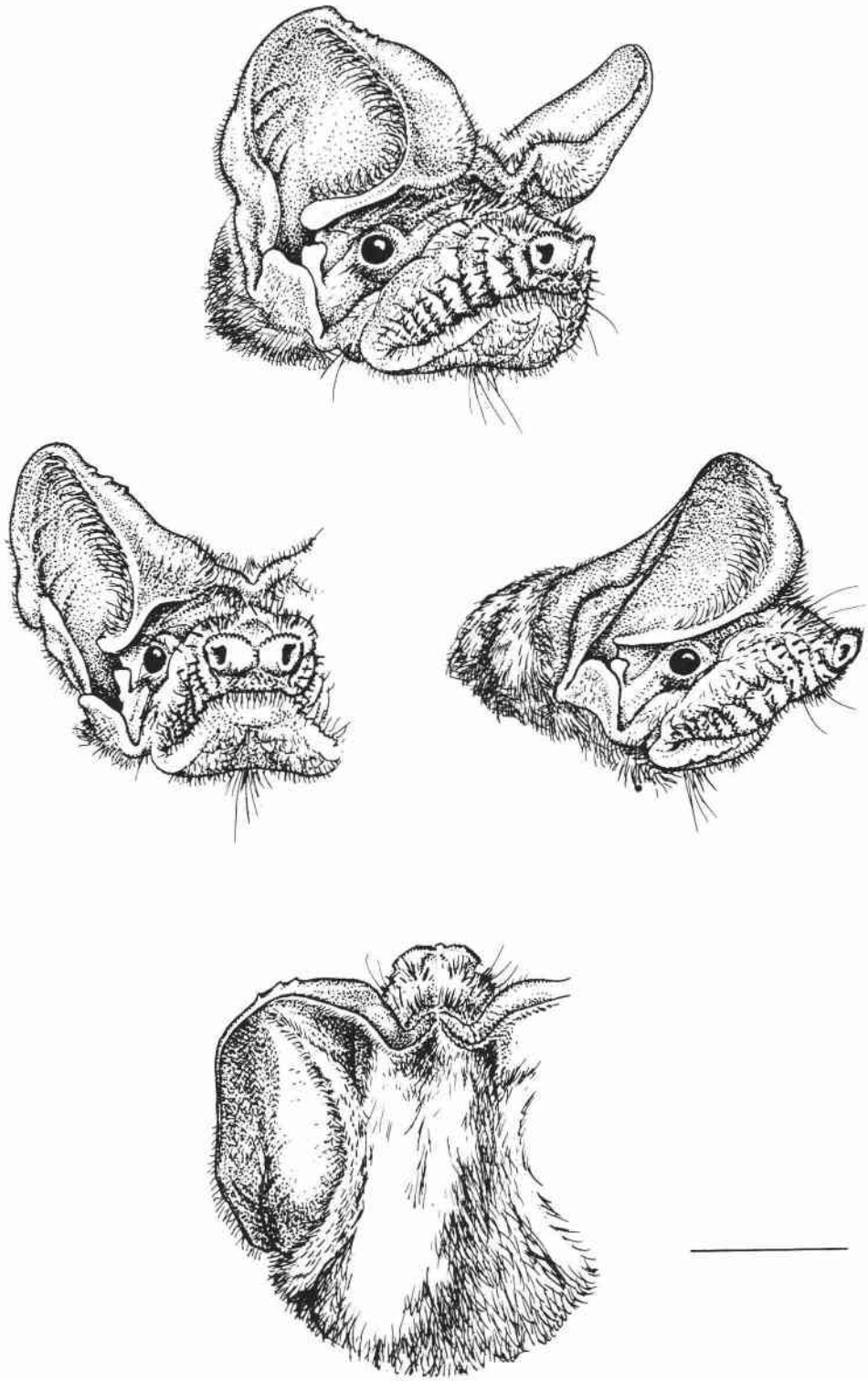

FIG. 1. *Tadarida bivittata*. Scale bar = 10 mm.

specimens preserved in alcohol (with skulls removed). These specimens are in the collections of the following institutions: American Museum of Natural History (AMNH); British Museum (Natural History) (BMNH); Field Museum Natural History (FMNH); Institut Royal Des Sciences Naturelles de Belgique (IRSN); Los Angeles County Museum (LACM); Musée Royal de l'Afrique Central (MRAC); United States National Museum of Natural History (USNM); National Museums and Monuments of Rhodesia (NMR); Northern Arizona University (NAU); Oklahoma State University (OSU); Royal Ontario Museum (ROM); Anthony Start, Private Collection (START), now deposited in BMNH; Transvaal Museum (TM).

Specimens Examined and Literature Records

Tadarida ansorgei

ANGOLA. Malange, 9°36′ S 16°21′ E (holotype BMNH). CAMEROUN. Lake Oku, Banso Highlands, 6°10′ N 10°25′ E (Hill 1968); Mokolo, 10°45′ N 13°48′ E (MRAC); Waza, 11°25′ N 14°34′ E (MRAC). ETHIOPIA. Addis Ababa, 9°03′ N 38°42′ E (J. E. Hill, personal communication); Lake Abiata, 7°36′ N 38°04′ E (J. E. Hill, personal communication); Urso River, 5 mi (1 mi = 1.609 km) N Urso Station, 9°30′ N 41°30′ E (OSU); Gambela area, 8°15′ N 34°35′ E (Largen *et al.* 1974). KENYA. Endoposei River, base of Nguruman Escarpment, 1°45′ S 36°02′ E (ROM); Uasu Nyiru River bridge, Nguruman Escarpment, 1°50′ S 36°07′ E (ROM): Kapenguria, 1°14′ N 35°08′ E (LACM); Lake Hannington, 0°20′ N 36°07′ E (ROM); Kanyangareng, Suam River. 1°47′ N 35°13′ E (ROM); Mt. Nasolet, 6 mi (9.6 km) south of Turkwell Gorge, 1°49′ N 35°18′ E (ROM); Maji-Ya Moto, 0°16′ N 36°04′ E (START); Kampi-Ya Samaki, Lake Baringo, 0°37′ N 36°04′ E (START, ROM); Perakera River, Marigat, 0°29′ N 35°59′ E (ROM); Mara River, 1°05′ S 35°15′ E (ROM); Kisumu, 0°08′ S 34°47′ E (ROM). MOZAMBIQUE. Gbiuta, 15°34′ S 33°17′ E (USNM); Save River, junction with Rhodesian border, 21°20′ S 32°15′ E (Smithers and Tello 1976). RHODESIA. Chikupo Cave, 17°24′ S 31°20′ E (TM, specimens from ROM recorded as *T. bivittata* by Fenton (1975)); Gwelo, 19°25′ S 29°50′ E (Harrison 1959). SUDAN. Torit, 4°24′ N 32°34′ E (FMNH); Lokwi, 30 mi (36 km) southwest of Torit (FMNH); Kibish Wells, 5°14′ N 35°51′ E (Harrison 1959). TANZANIA. Lyamungu, 3°15′ S 37°14′ E (Swynnerton and Hayman 1950); Rukwa, 8°00′ S 32°20′ E (Harrison 1959). UGANDA. Budongo Forest, 1°47′ N 31°40′ E (ROM); Masindi, 1°41′ N 31°45′ E (J. E. Hill, personal communication). ZAIRE. Faradje, 3°44′ N 29°43′ E (AMNH, FMNH); Biadimbi, 4°13′ N 29°21′ E (IRSN); Mpaza, 4°14′ N 29°37′ E (IRSN); Uduku, 4°32′ N 29°33′ E (IRSN); Mwadingusha, 10°45′ S 27°14′ E (MRAC); Parc National Garamba, 4°11′ N 30°00′ E (IRSN); Vitshumbi, 0°41′ S 29°23′ E (Hayman *et al.* 1966). ZAMBIA. Kafue Bridge, 14°40′ S 28°14′ E (Ansell 1967; identified by Ansell as *T. bivittata* but on the basis of the published measurements we consider this specimen to be *T. ansorgei*).

Tadarida bivittata

ETHIOPIA. 37 km north of Afden, 9°42′ N 40°58′ E (OSU); Doba River, 9°42′ N 40°50′ E (Ingersol 1968); Dacata River, 9°08′ N 42°24′ E (Ingersol 1968); Gota River, 10 km north of Errer, approximately 9°30′ N 41°15′ E (OSU); Jijiga Road, approximately 9°30′ N 42°30′ E (OSU); Keren, 15°46′ N 38°30′ E (holotype, Hayman and Harrison 1966); unknown locality between Anseba River, 17°00′ N 37°24′ E and Keren (Heuglin 1877). KENYA. Akiriamet, 1°20′ N 35°42′ E (ROM); Kabete, 1°16′ S 36°43′ E (Harrison 1961); Kampi-Ya Samaki. Lake Baringo, 0°37′ N 36°04′ E (START, ROM); Kanyangareng. Suam River, 1°47′ N 35°13′ E (ROM): Kapenguria, 1°14′ N 35°08′ E (ROM); 6.5 mi (10.4 km) north, 10.5 mi (12.6 km) east of Kibwezi, 2°25′ S 37°57′ E (NAU); Kisumu, 0°08′ S 34°47′ E (ROM); Kongelai, Kaiboni River, 1°28′ N 35°03′ E (ROM); Lake Amboseli, 2°30′ S 37°15′ E (AMNH); Lake Hannington, 0°20′ N 36°07′ E (ROM); Machakos, 1°32′ S 37°16′ E (FMNH); Maji-Ya Moto, 0°16′ N 36°04′ E (START); Makueni, 1°50′ S 37°48′ E (Hayman and Harrison 1966); Mombasa, 4°04′ S 38°40′ E (FMNH, ROM); Mount Elgon, 1°07′ N 34°35′ E (Hayman and Harrison 1966); Nairobi, 1°17′ S 36°50′ E (Hayman and Harrison 1966); Ngong Hills, 1°22′ S 36°40′ E (Hayman and Harrison 1966); Perakera River, Marigat, 0°29′ N 35°59′ E (ROM); Sigor, Wei Wei River, 1°30′ N 35°29′ E (ROM, START); South Kavirondo, 0°45′ S 34°25′ E (Hayman and Harrison 1966); Turkwell Gorge, 1°50′ N 35°25′ E (ROM); 30 km southeast of Voi, 3°41′ S 38°45′ E (ROM); Yala River (Hayman and Harrison 1966). MOZAMBIQUE. Vila Pery District near Vila de Manica, 19°00′ S 32°30′ E (Smithers and Tello 1976); Save River, junction with Rhodesian border, 21°20′ S 32°15′ E (Smithers and Tello 1976). SUDAN. Ikoto, 4°07′ N 33°08′ E (FMNH); Katire, 4°05′ N 32°46′ E (FMNH). TANZANIA. Bagamoyo, 6°26′ S 38′55° E (Swynnerton and Hayman 1950); Igonda, not located (Swynnerton and Hayman 1950). UGANDA. Busia, 0°29′ N 34°06′ E (AMNH). ZAMBIA. Abercorn, 8°50′ S 34°24′ E (Hayman and Harrison 1966).

Twenty-seven morphological characters were measured using methods described by Eger (1977). These characters are the following: external: forearm length (FOAR); length of metacarpals 3, 4, and 5 (3DME, 4DME, 5DME); length of phalanges 1 and 2 (1P, 2P) of third, fourth, and fifth digits. Skull: greatest length (GLNG); condyloincisive length (CBLN); palatal length (PALL); zygomatic width (ZYGO); mastoid width (MAST); braincase breadth (BBCA); braincase height (HBCA); lachrymal width of rostrum (ROWL); interorbital width (IOWA); postorbital constriction (POCO); width across the third molars (M^3–M^3), maxillary toothrow (C–M^3); canine width (C^1–C^1). Mandible: condyloincisive paired length (CIMA); greatest length (GRLG); mandibular toothrow (C–M_3); canine width (C_1–C_1).

Such characters as total length, tail vertebrae, hind foot, ear, weight, and wingspan as measured in the field by collectors vary considerably due to different measuring techniques and thus were not used in the multivariate analyses but were recorded.

Statistical Methods

The localities for *T. bivittata* and *T. ansorgei* (Fig. 2) include specimens analyzed as well as immature specimens and records from the literature. In a study of sexual dimorphism, Turner (1970) found that *T. bivittata* was dimorphic in 10 of 12 characters. The sexes were therefore treated separately in our analyses. To make an independent assessment of sexual dimorphism, a multivariate analysis of variance (MANOVA, Wilk's likelihood ratio method) of males against females was performed using specimens of *T. bivittata* from West Pokot, Kenya, and *T. ansorgei* from Rhodesia and Cameroun.

In the following analyses, OTUs were drawn from single localities where possible; however, for some it was necessary to group specimens from contiguous localities. Table 1 lists the distribution of groups studied.

Only adult specimens were used in statistical analyses to limit variation due to age. Individuals with complete fusion of the epiphyses of metacarpals and phalanges and with complete fusion of the sphenoid bones in the skull were considered to be adults. Specimens with more than two variables missing were deleted from the data set. Where one or two values were missing, data were estimated using linear regression equations derived from the best available predictors.

The OTUs were analyzed using principal components analysis (PCA) (Sneath and Sokal 1973). The first principal

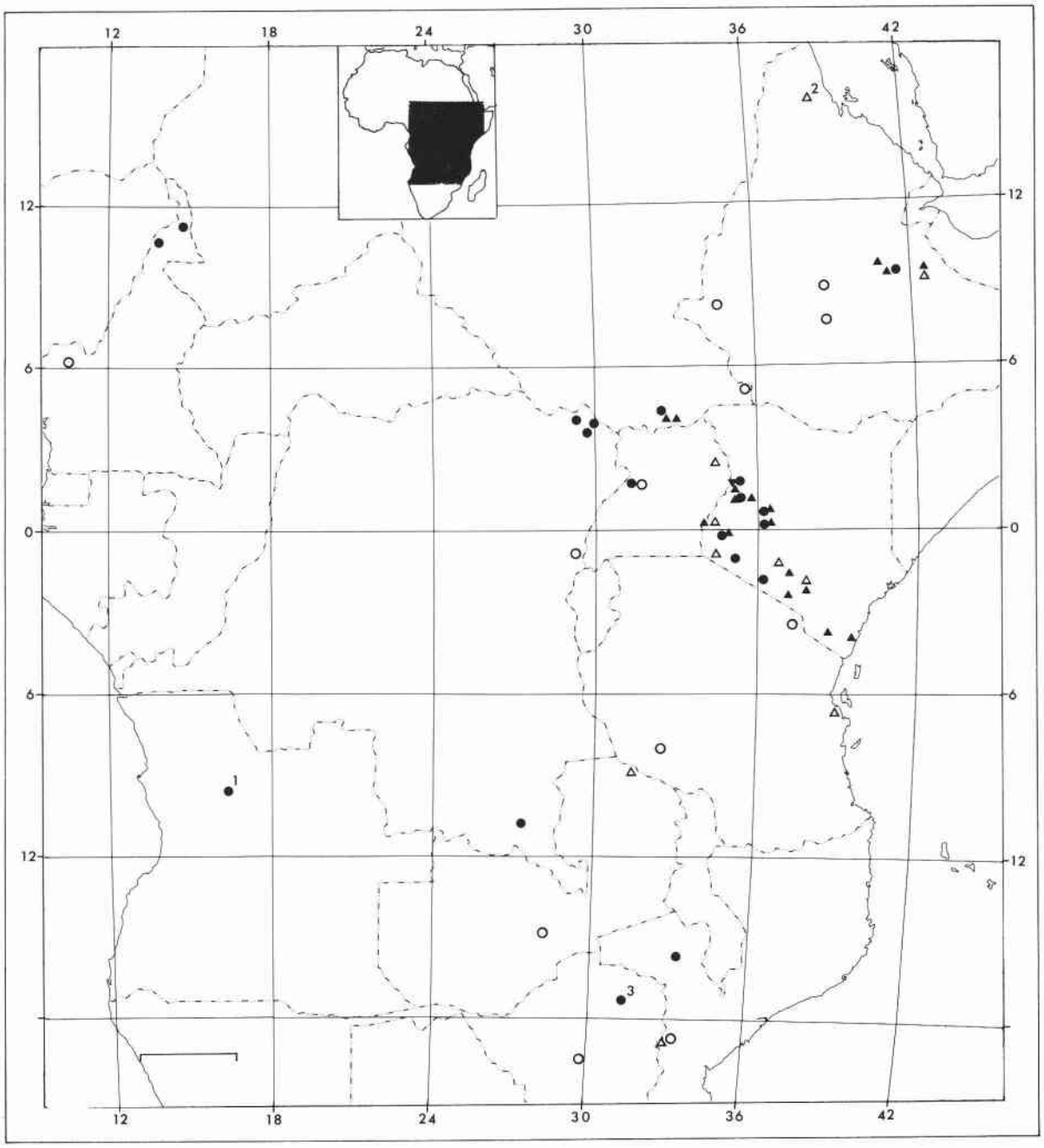

FIG. 2. Distribution of *Tadarida ansorgei* and *Tadarida bivittata*. ●, *T. ansorgei* specimens examined; ○, *T. ansorgei* other records; ▲, *T. bivittata* specimens examined; △, *T. bivittata* other records; 1, type locality *T. ansorgei*; 2, type locality *T. bivittata*; 3, type locality *T. rhodesiae*. Scale bar = 200 km.

component explains maximum character variance; the second is orthogonal to the first and explains a maximum of the remaining variance. To detect possible distortion among similar OTUs, a shortest minimally connected network (Rohlf 1970) was computed from the original distance matrix and superimposed on the diagram (Figs. 3 and 4). See Kishpaugh (1973) for these procedures.

Relationships among OTUs were analyzed using discriminant analysis (SPSS) (see Nie *et al.* 1975), in which all variables were entered into the analysis concurrently. This technique maximizes separation of established groups and also identifies "unknown" specimens. The programme computes linear discriminant functions between groups and, for each specimen, the two groups to which it is most closely allied. A stepwise discriminant analysis was performed subsequently to discriminate between the two species; at the same time individuals of un-

TABLE 1. Distribution and number of specimens studied

OTUs	Localities	*n* Males	*n* Females
	Tadarida bivittata		
West Pokot (WPOK)	Kenya: Wei Wei River, Sigor; Kongelae; Kanyangareng; Akiriamet; Turkwell Gorge	35	33
Baringo (BARO)	Kenya: Maji-Ya Moto; Lake Hannington; Perakera River, Marigat; Kampi-Ya Samaki	5	7
Kisumu (KISU)	Kenya: Kisumu	6	—
Voi (VOI)	Kenya: Maungu Hill, 30 km SE Voi	11	—
	Tadarida ansorgei		
Cameroun (CAME)	Cameroun: Waza; Mokolo	14	16
Rhodesia (RHOD)	Rhodesia: Chikupo Cave	17	25
Maji-Ya Moto (MAJA)	Kenya: Maji-Ya Moto; Kampi-Ya Samaki; Marigat	7	15
Mwadingusha (MWAD)	Zaire: Mwadingusha	—	6
Endoposei (ENDO)	Kenya: Endoposei River, base of Nguruman Escarpment	6	—

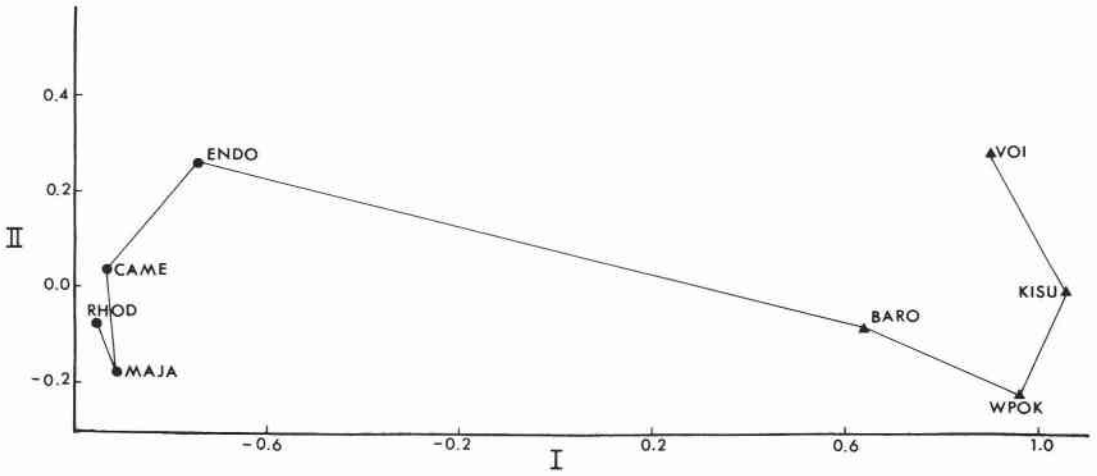

FIG. 3. OTUs of male *Tadarida ansorgei* and *T. bivittata* projected onto the first two principal components of a matrix of correlations among characters with a minimum spanning tree superimposed upon the OTUs. See Table 1 for explanation of abbreviations.

known taxonomic affinities were classified. Classification of unknown specimens was performed using classification functions; these are derived from the pooled within groups covariance matrix and the centroids of the discriminating variables. The resulting classification coefficients are multiplied by the raw data values, summed, and added to the associated constant. The unclassified specimen is placed in the group whose classification function provides the highest score (Nie *et al.* 1975).

Means ($\bar{X}$) and standard error (SE) were calculated for the variables of each species and are summarized in Tables 2 and 3. Differences between species for each character were examined using Student's *t*-test (Sokal and Rohlf 1969).

Results

Multivariate analysis of variance on all variables indicates that males and females differ significantly in size (*T. bivittata* WPOK, *F* transformation of Wilk's lambda = 6.158, df = 27 and 40, $P < 0.001$; *T. ansorgei* CAME, *F* transformation of Wilk's lambda = 23.498, df = 27 and 2, $P < 0.05$; *T. ansorgei*, RHOD, *F* transformation of Wilk's lambda = 6.221, df = 27 and 14, $P < 0.001$). In the following analyses, males and females have been analyzed separately.

The results of *t*-tests indicate that all characters of *T. bivittata* are significantly larger than those of *T. ansorgei* ($P < 0.001$) for both males and females.

Principal components I and II respectively account for 92.73 and 3.49% of total character vari-

TABLE 2. Sample statistics of *Tadarida bivittata*

Character	Males, $n = 71$			Females, $n = 57$		
	$\bar{X}$	±SE	Range	$\bar{X}$	±SE	Range
FOAR	49.6	0.12	47.0–51.7	49.2	0.12	46.3–51.3
3DME	50.4	0.14	47.2–53.8	50.0	0.13	47.1–53.1
3D1P	21.4	0.09	19.4–24.0	21.2	0.08	20.0–23.0
3D2P	19.2	0.09	17.5–21.0	18.8	0.11	17.0–20.7
4DME	48.7	0.15	45.6–52.2	48.2	0.13	45.5–50.9
4D1P	17.7	0.07	16.3–19.1	17.4	0.08	16.3–18.7
4D2P	11.4	0.08	10.2–13.7	11.3	0.10	10.0–14.6
5DME	30.3	0.10	28.2–32.7	30.0	0.10	27.7–32.1
5D1P	14.5	0.07	13.0–16.0	14.2	0.07	13.0–15.4
5D2P	4.6	0.04	3.8–5.5	4.6	0.05	3.8–5.4
GLNG	20.8	0.03	20.0–21.3	20.1	0.04	19.5–20.8
CBLN	19.1	0.03	18.3–19.8	18.4	0.04	17.8–19.0
PALL	8.1	0.03	7.5–8.6	7.7	0.03	7.1–8.1
ZYGO	12.6	0.03	12.0–13.1	12.2	0.03	11.7–12.8
MAST	11.7	0.02	11.3–12.2	11.5	0.03	11.0–11.9
BBCA	10.5	0.02	10.1–11.1	10.3	0.03	9.7–10.7
HBCA	7.3	0.03	6.7–8.0	7.1	0.02	6.6–7.4
ROWL	7.5	0.03	6.9–8.0	7.2	0.04	6.3–7.8
IOWA	6.7	0.03	6.1–7.3	6.5	0.03	6.0–7.0
POCO	4.3	0.02	3.9–4.7	4.2	0.02	3.9–4.5
M^3–M^3	9.0	0.02	8.6–9.5	8.8	0.03	8.4–9.3
C–M^3	7.6	0.02	7.3–8.0	7.4	0.02	7.0–7.7
C^1–C^1	5.5	0.02	5.2–5.8	5.1	0.02	4.7–5.4
CIMA	13.4	0.03	12.8–14.0	12.9	0.03	12.4–13.4
GRLG	14.0	0.03	13.4–14.6	13.5	0.03	13.0–14.2
C–M_3	8.3	0.02	7.7–8.7	8.0	0.03	7.5–8.5
C_1–C_1	3.1	0.02	2.7–3.5	2.7	0.02	2.4–3.2

TABLE 3. Sample statistics of *Tadarida ansorgei*

Character	Males, $n = 60$			Females, $n = 79$		
	$\bar{X}$	±SE	Range	$\bar{X}$	±SE	Range
FOAR	46.2	0.12	44.4–48.3	45.8	0.12	43.0–47.9
3DME	46.9	0.13	44.8–48.9	46.7	0.13	43.8–49.0
3D1P	19.4	0.08	18.0–20.9	19.1	0.08	17.7–20.6
3D2P	17.6	0.08	16.0–19.1	17.6	0.08	15.7–19.5
4DME	45.5	0.14	43.1–47.9	45.3	0.12	42.9–47.4
4D1P	15.7	0.08	14.0–17.0	15.6	0.07	14.1–17.2
4D2P	10.0	0.10	8.1–12.6	9.8	0.07	8.4–11.4
5DME	28.1	0.10	26.5–30.0	27.9	0.09	26.4–29.6
5D1P	13.1	0.07	11.1–13.9	13.2	0.06	11.8–14.6
5D2P	4.3	0.04	3.6–5.2	4.2	0.03	3.5–4.8
GLNG	19.8	0.04	19.1–20.5	19.4	0.04	18.6–20.3
CBLN	18.1	0.04	17.3–18.9	17.7	0.03	17.0–18.5
PALL	7.7	0.04	6.9–8.3	7.5	0.02	6.8–8.0
ZYGO	11.8	0.03	11.1–12.2	11.4	0.03	11.0–12.2
MAST	10.8	0.03	10.2–11.2	10.7	0.03	10.2–11.1
BBCA	9.8	0.03	9.4–10.3	9.7	0.02	9.2–10.3
HBCA	6.6	0.02	6.0–7.0	6.5	0.02	6.0–7.0
ROWL	6.8	0.04	6.3–7.4	6.5	0.03	6.0–7.3
IOWA	6.2	0.02	5.8–6.5	6.0	0.02	5.6–6.3
POCO	3.9	0.02	3.6–4.1	3.9	0.02	3.5–4.2
M^3–M^3	8.5	0.02	8.0–8.9	8.4	0.02	8.0–9.0
C–M^3	7.3	0.02	7.0–7.7	7.2	0.01	6.8–7.6
C^1–C^1	5.2	0.03	3.9–5.6	4.9	0.02	4.5–5.3
CIMA	12.7	0.03	12.3–13.2	12.4	0.03	11.7–13.0
GRLG	13.2	0.03	12.6–13.8	12.9	0.02	12.3–13.5
C-M_3	7.8	0.03	7.4–8.2	7.6	0.02	7.3–8.1
C_1–C_1	2.8	0.02	2.8–3.1	2.5	0.01	2.3–2.8

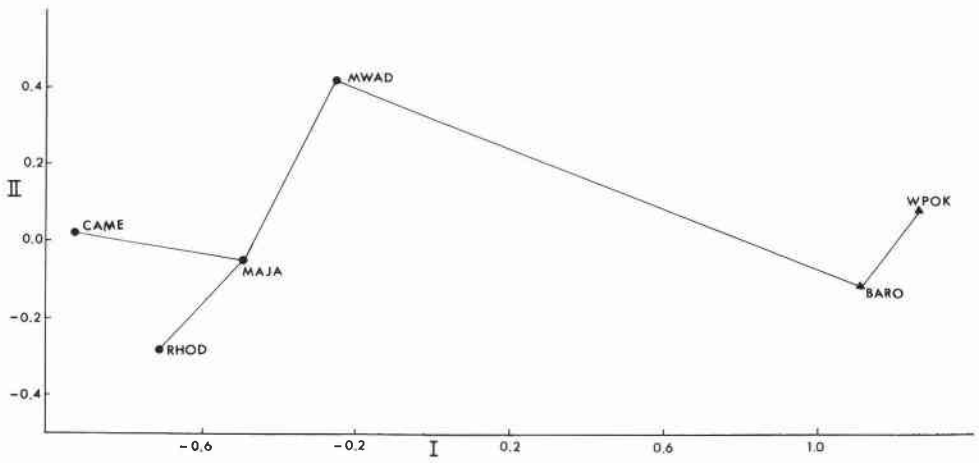

FIG. 4. OTUs of female *Tadarida ansorgei* and *T. bivittata* projected onto the first two principal components of a matrix of correlations among characters with a minimum spanning tree superimposed upon the OTUs. See Table 1 for explanation of abbreviations.

ance for males and 90.98 and 5.66% for females. Therefore, with 96% of character variance explained by two axes, a reduction of character space to two dimensions should not unduly distort distances between OTUs (Figs. 3 and 4). Principal component I is a size factor and separates the *T. bivittata* and *T. ansorgei* groups. All characters have high loadings on this component except length of palate and width across canine teeth in females and $C-M_3$ and second phalanx of fifth digit in males. These characters have high loadings on the second component (Table 4). Figures 3 and 4 illustrate that the amount of shape variation (as represented by PC II) is similar in the two species.

In areas of sympatry (Kenya, Sudan, and Ethiopia), groups were identified using discriminant analysis before they were assigned to a species (e.g. MAJA, BARO, KISU). Individual specimens were identified in the same manner using stepwise discriminant analysis. For males, 100% separation of the two species was obtained using only two variables: mastoid width and height of braincase; for females, four variables were required to obtain 100% separation: second phalanx of fourth digit, mastoid width, height of braincase, and interorbital width. Table 5 lists classification coefficients for each species. These functions provide an easy method of identification if the sex of the individual is known and if the required measurements are available, i.e. MAST, HBCA for males and 4D2P, MAST, HBCA, and IOWA for females.

Several external features, some difficult to quantify, are useful to identify the two species. *Tadarida bivittata* appears to be more robust than *T. ansorgei* when live or preserved specimens are compared and this is confirmed by the following weights in grams: *T. ansorgei*, 24 males: 16.50 (12.5–22.0); 46 females: 15.77 (9.0–22.0); *T. bivittata*, 35 males: 23.49 (18.0–36.0); 41 females, 22.59 (15.0–30.0). In addition to being smaller (on average) than *T. bivittata* in most external characters, i.e., total length, tail vertebrae, hind foot, and wingspan, *T.*

TABLE 4. Loadings of characters for the first two principal components based on matrices of correlations among characters of male and female *T. bivittata* and *T. ansorgei*

	Males		Females	
Character	I	II	I	II
FOAR	0.990	0.006	0.983	−0.037
3DME	0.993	−0.015	0.977	0.022
3D1P	0.986	−0.075	0.994	−0.039
3D2P	0.972	0.101	0.941	−0.094
4DME	0.986	0.050	0.980	0.037
4D1P	0.995	0.018	0.990	0.003
4D2P	0.976	−0.123	0.973	−0.216
5DME	0.983	−0.105	0.995	0.060
5D1P	0.995	−0.006	0.974	−0.177
5D2P	0.562	0.799	0.921	−0.255
GLNG	0.993	0.038	0.985	0.013
CBLN	0.987	0.024	0.983	0.156
PALL	0.947	0.069	0.679	0.678
ZYGO	0.983	0.059	0.982	−0.044
MAST	0.989	−0.073	0.994	0.082
BBCA	0.989	−0.109	0.923	−0.308
HBCA	0.973	−0.006	0.986	0.117
ROWL	0.997	0.017	0.980	0.138
IOWA	0.968	−0.119	0.977	−0.160
POCO	0.930	−0.310	0.937	−0.303
M^3-M^3	0.981	0.005	0.985	−0.133
$C-M^3$	0.977	0.182	0.992	0.080
C^1-C^1	0.941	0.063	0.755	0.541
CIMA	0.983	0.006	0.995	−0.036
GRLG	0.990	−0.048	0.997	−0.041
$C-M_3$	0.866	−0.263	0.963	−0.237
C_1-C_1	0.972	0.118	0.829	0.503

TABLE 5. Classification coefficients* for identifying *Tadarida bivittata* and *T. ansorgei*

Character	Males		Females	
	T. bivittata	*T. ansorgei*	*T. bivittata*	*T. ansorgei*
4D2P	—	—	23.348	19.856
MAST	265.566	245.951	157.622	147.249
HBCA	127.719	114.110	150.046	136.855
IOWA	—	—	124.704	111.817
Constant	−2015.968	−1701.556	−1977.650	−1656.052

*Each character measurement of the unknown specimen is multiplied by the corresponding coefficient. These products are summed and added to the constant to give a classification score. The unknown specimen is a member of the species whose classification functions provide the higher score.

ansorgei has paler wings, less spotting of the dorsal pelage, and more contrast between the abdomen and the dark throat. Two colour phases occur in both species, reddish brown and greyish brown. In our specimens the latter colour predominates in *T. ansorgei* and the former in *T. bivittata*. See Fig. 1 for drawing of head of *T. bivittata*.

Discussion

Principal components analysis reveals extensive size differences between *T. bivittata* and *T. ansorgei*. As the complement of OTUs studied differed for males and females, results differed intraspecifically for each sex. However, there is a general agreement between species for each sex. *Tadarida bivittata* is the larger, but both species exhibit about equal amounts of variation in shape. Insufficient specimens were available to allow us to analyze adequately geographic variation within each species, which might account for some of the shape variation.

The two species are sympatric in Kenya, southern Sudan, and central Ethiopia. This sympatry is of interest considering the morphological similarities of the two species and the possible resulting competition between them. The two species inhabit basically similar habitats: in the north, dry, wooded savannah with abundant *Acacia* and *Comiphora* and in the south, woodland savannah with *Brachystegia* and *Julbernardia* predominant (Keay 1959). Thus they occur peripheral to the Congo basin but apparently not within it. This pattern of distribution is found in other bats, e.g. *T. aloysiisabaudiae* and *T. midas*.

In Kenya *T. bivittata* is more common (based on specimens collected), whereas *T. ansorgei* is common only in the Rift Valley (Endoposei and Maji-Ya Moto). Records of *T. bivittata* indicate that this species is primarily eastern in distribution, occurring as far west as the edge of the western Rift Valley. To date, *T. ansorgei* has a wider known distribution, from Cameroun in the north to Rhodesia in the south and occurs in closer proximity to the Congo basin than does *T. bivittata*. However, with more extensive collecting, we would expect to find a more or less continuous distribution of *T. ansorgei* surrounding the Congo basin.

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