

Karyotypic data and attendant systematic implications for the bats of southern Africa

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The standard karyotypic properties of 60 of the 73 species of bats known to occur in southern Africa, are reviewed. The karyotypes of 23 microchiropteran species are described for the first time; our results on a further 14 species are compared with earlier reports for those taxa. The previously published chromosomal information pertaining to 23 species for which we had no information, are cited. Systematic implications of observed patterns of karyotypic variation are briefly discussed. In particular, we conclude that the taxon *Cistugo* (currently recognised as a subgenus of *Myotis*) should be afforded full generic rank; hypothesise that the karyotypes of the two species – *M. (C.) seabrai* and *M. (C.) lesueuri* – in *Cistugo* are probably ancestral for all vespertilionids; and question the wisdom of redefining the taxonomic limits of the genera *Eptesicus* and *Pipistrellus* until molecular data are available to resolve the dilemma posed by conflicting morphological and cytogenetic data suites.

Key words: Bats, karyotypes, chromosome morphology, taxonomy.

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Introduction

The minute quantities of bone marrow harvested from bats in the field often result in very low mitotic indices, so that even standard karyotypic data are lacking for many bat species. The results of field studies where the standard karyotypical properties of southern African bats were prepared, are reported here.

Although standard karyotypes are of limited value in assessing chromosomal evolution and phylogenetic relationships at lower taxonomic levels, such data can, in certain instances, be useful for clarifying systematic relationships (Baker *et al.* 1987); either for detecting cryptic species or for confirming species status. Standard karyotypes also suffice for determining general karyotypic trends within taxa.

The standard karyotypic properties of a total of 60 species of southern African bats are reviewed (Table 1), 37 of which we karyotyped. The karyotypes of 23 species are de-

scribed here for the first time, while results pertaining to 14 species are compared with the earlier findings of other authors. The properties of a further 23 species previously reported in the literature are tabulated for the sake of comprehensiveness (Table 1).

Methods

Bone marrow karyotypes were prepared in the field from 498 live-caught animals using standard *in vivo* (Baker & Qumsiyeh 1988) and *in vitro* (Green *et al.* 1980) techniques, following yeast stressing (Lee & Elder 1980). Since very little bone marrow can be obtained from the long bones of the smaller bat species, their viscera and large muscles were removed and the entire carcasses were diced to pulp with a clean scalpel(s) in a clean flat-bottomed glass dish containing 7 mm of hypotonic solution. This forced the marrow from skeletal elements into suspension. The cell suspensions were subsequently strained from the pulp and transferred to a test tube by pasteur pipette, whereafter normal karyotyping procedures were followed. In the laboratory a minimum of five spreads per individual were microscopically analysed to determine diploid number (2n) and the fundamental number of autosomal chromosome arms (aFN). Photomicrographic enlargements of suitable spreads were used in the final analyses.

Chromosomes were matched and presumptive homologous pairs arranged in large, medium and small-sized metacentric and submetacentric groups while medium to small subtelocentric, and medium to small acrocentric morphological categories were also recorded. The nomenclature and definitions proposed by Patton (1967) and Robbins & Baker (1978) were followed. Sometimes the morphology of presumptive homologous chromosomes was found to vary between spreads as a result of differential contraction. This was particularly the case in the molossid species where it was difficult to determine the centromeric positions of subtelocentric chromosomes, resulting in some interspecific variation in the number of detectable autosomal arms. This underscores Warner *et al.* (1974) suggestion that the determination of biarmed versus acrocentric conditions should be treated with caution and that aFN values are somewhat arbitrary and subjective.

Taxonomic designations follow Meester *et al.* (1986) except for the molossids where Freeman (1981) is followed. The majority of voucher specimens were deposited in the Transvaal Museum's mammal collection, whereas others are accessioned in the collections of the Windhoek State Museum (Namibia) and the Carnegie Museum of Natural History (Pittsburgh, U.S.A.). Idiograms for specimens analysed are deposited in the Transvaal Museum library and copies thereof will be provided upon request to ILR.

Results

SUBORDER Microchiroptera

Family Emballonuridae

Taphozous mauritanus E. Geoffroy, 1818

2n = 42; aFN = 64

This is the first description of the karyotype of the Mauritian tomb bat, which is characterised by five pairs of metacentric, seven pairs of submetacentric, and eight pairs of acrocentric chromosomes. The X is a medium-sized metacentric, whereas the Y is a small submetacentric.

Specimens examined (11): R.S.A., TRANSVAAL: Dirleton farm No 276, Waterberg District (2♀♀); Letaba highwater bridge, 4km NNE Letaba restcamp, KNP (1♂, 2♀♀); Luvuvhu River, Pafuri, KNP (1♂); Lynnwood, Pretoria (1♂); Old picnic site, Pafuri,

KNP (2♂♂, 1♀); Tshalungwa, fountain 16 km NNE Punda Maria, KNP (1♂).

Family Nycteridae

Nycteris woodi K. Andersen, 1914

2n = 42; aFN = 78

This is the first recorded data on the karyotype of Wood's slit-faced bat. The autosomal complement consists of 19 pairs of biarmed chromosomes, as well as a pair of small acrocentrics. The X is a medium-sized metacentric, and the Y a small acrocentric. Due to differential chromosomal contraction it is difficult to consistently distinguish between metacentrics and submetacentrics, but there appears to be four metacentric pairs and 12 pairs of submetacentrics.

Specimen examined (1): R.S.A, TRANSVAAL: Bobomeni research camp, Pafuri, KNP (1♂).

Nycteris thebaica E. Geoffroy, 1813

2n = 42; aFN = 78

The karyotype of this species is very similar to that of *N. woodi* as described above, and agrees with the findings of Peterson & Nagorsen (1975) of nine pairs of metacentrics, seven pairs of submetacentrics, three pairs of subtelocentrics and a pair of small acrocentrics. The X-chromosome is a medium-sized submetacentric and the Y a small metacentric.

Specimens examined (16): NAMIBIA: De Valle, Naukluft National Park, Maltahöhe (4♀♀). R.S.A., NATAL: Goudhoek farm, 10 km NW Babanango, (1♂, 1♀). CAPE PROVINCE: Kersbos farm, 10 km NNE Bitterfontein, (1♂, 3♀♀). TRANSVAAL: Bobomeni research camp, Pafuri, KNP (1♀); Mockford's gardens, Pafuri, KNP (1♂); Mhangadyana Koppie, 14 km N Orpen restcamp, KNP (3♂♂, 1♀).

Family Hipposideridae

Hipposideros commersoni

(E. Geoffroy, 1813)

$2n = 52$; $aFN = ??$

The karyotype of this species is described for the first time. However, only five females were available for study, hence the sex chromosomes cannot be described, neither can the aFN be established since we cannot unequivocally identify the X-chromosomes which are excluded in calculations of the aFN. It is, nevertheless, clear that Commerson's leaf-nosed bat differs karyotypically from other congeners, all of whom have $2n = 32$ biarmed chromosomes; $aFN = 60$ (Table 1). Assuming that the female sex chromosomes of Commerson's leaf-nosed bat are biarmed as in other congeners, the aFN of this species would be 60 as in other hipposiderids. This suggests that the chromosomal complement of this species may have evolved from the typical hipposiderid state by ten centric fissions, leading to a change in diploid number but not aFN.

Specimens examined (5): R.S.A., TRANSVAAL: Figtree forest, Pafuri, KNP (2♀); Old picnic site, Pafuri, KNP (2♀); Maditobe Witsand Dam, Mahogany drive, Punda Maria, KNP (1♀).

Hipposideros caffer (Sundevall, 1846)

$2n = 32$; $aFN = 60$

The autosomal complement of 15 pairs, consists entirely of biarmed chromosomes; seven pairs of which appears to be metacentric, seven pairs submetacentric and two pairs subtelocentric. The X is a large submetacentric (*pace* Dulic & Mutere 1973b and 1974; Peterson & Nagorsen 1975) and the Y is a medium-sized acrocentric element. This is very similar to the findings of Peterson & Nagorsen (1975), except that they identified four pairs of metacentrics, eight pairs of sub-

metacentrics and three pairs of subtelocentrics. The karyotype of this species is similar to other congeners reported previously, i.e. *H. bicolor* (Ray-Chanduri & Patchak 1966), *H. lekaguli* and *H. larvatus* (Harada *et al.* 1982), *H. fulvus* (Harada *et al.* 1985), *H. armiger*, *H. fulvus*, *H. larvatus*, *H. lekaguli* (Hood *et al.* 1988).

Specimens examined (6): R.S.A., NATAL: Dumisa Gold Mine, 1 km E Dumisa railway station (3♀). TRANSVAAL: Mockford's gardens, Pafuri, KNP (1♂); Gwalala, Pafuri, KNP (1♂); 1 km SE Letaba restcamp, KNP (1♂).

Cloeotis percivali Thomas, 1901

$2n = 40$; $aFN = ??$

The karyotypes, prepared from a single female which died prior to colchicine treatment, yielded a very low mitotic index. However, in view of the fact that the karyotype of the short-eared trident bat has not been reported to date, our results are presented. The diploid number is 40. The chromosomal complement consists of 12 pairs of biarmed chromosomes and seven pairs of acrocentrics. The configuration of the sex chromosomes could not be determined, and therefore also not the aFN.

Specimen examined (1): R.S.A., TRANSVAAL: Figaro Mine, 11 km ENE Malelane (1♀).

Family Vespertilionidae

Miniopterus fraterculus Thomas & Schwann, 1906

$2n = 46$; $aFN = 50$

This is the first karyotypic description of the lesser long-fingered bat. The chromosomal complement of *M. fraterculus* consists of 23 chromosome pairs of which two pairs are large submetacentrics, one pair is medium-sized metacentric, and 19 pairs are acrocentric.

ics. The X is a medium-sized submetacentric, and the Y a small acrocentric.

Specimens examined (3): R.S.A., NATAL, Dumisa Gold Mine, 1 km E Dumisa railway station (1♂); Ngome Forest Reserve, 70 km NE Vryheid (2♀♀).

Miniopterus schreibersii (Kuhl, 1819)

2n = 46; aFN = 50

The karyotype of *M. schreibersii* is indistinguishable from that of *M. fraterculus*. Our results conform to those of Manfredi Romanini *et al.* (1975); but differ from those of Bickham & Hafner (1978) who reported the total number of bi-armed autosomal chromosomes (BA) to be eight and aFN = 52 for this species, based upon a single specimen from Yugoslavia.

Specimens examined (25): NAMIBIA, Bat's Hole, Namib National Park (5♂♂, 2♀♀). R.S.A., CAPE PROVINCE: De Hoop Provincial Nature Reserve, 23 km SSE Bredasdorp (4♂♂); Olivewood farm 284, 15 km WNW Hotazel (1♂, 2♀♀). NATAL: Dumisa Gold Mine, 1 km E Dumisa railway station (1♂, 1♀); Goudhoek farm, 10 km NW Babanango (3♂♂). TRANSVAAL: Figaro Mine, 11 km ENE Malelane (2♂♂); Irene Caves, Irene (4♂♂).

Myotis (Chrysopteron) welwitschii
(Gray, 1866)

2n = 44; aFN = 50

Based on a single specimen collected in Natal, Taylor (1992) reported 2n = 44 for this species, but was unable to determine BA, aFN, or the morphologies of the sex chromosomes. Our results confirm that the diploid number in this species is 44, and allow more detailed characterisation of the karyotype of this species. This comprises three pairs of large and one pair of small metacentric autosomes, a graded series of 17 acrocentric autosomes ranging from medium to minute in

size, a medium-sized submetacentric X, and a small submetacentric Y chromosome.

Specimens examined (2): R.S.A., TRANSVAAL: Matukwala, dam 5 km NW Punda Maria, KNP (1♀); Klipfontein farm 53, 30 km NE Ellisras (1♂).

Myotis (Cistugo) seabrai (Thomas, 1912)

2n = 50; aFN = 48

This is the first account of the karyotype of the Angola wing-gland bat. The chromosomal complement consists of a graded series of 24 pairs of acrocentrics, ranging in size from medium to very small. One pair of small acrocentrics exhibited secondary constrictions. This condition was, however, not present in all spreads examined. The X-chromosome was a medium submetacentric, and the Y a small acrocentric.

Specimens examined (11): NAMIBIA: Huab River Mouth (1♂, 2♀♀); Klein Aus farm 8, 3 km W Aus, Luderitz District (5♂♂, 3♀♀).

Myotis (Cistugo) lesueuri (Roberts, 1919)

2n = 50; aFN = 48

Leseuer's wing-gland bat's karyotype is described for the first time. The karyotype of this species is in all respects identical to that of *M. seabrai* described above, including the secondary constriction on a pair of small acrocentric autosomes.

Specimens examined (4): R.S.A., CAPE PROVINCE: Karoo National Park, 9 km W Beaufort West, (1♀); Algeria State Forest, Cederberg, Clanwilliam (1♂, 2♀♀).

Myotis (Selysius) tricolor (Temminck, 1832)

2n = 44; aFN = 50

This represents the first description of the karyotype of Temminck's hairy bat. The karyotype of this species was found to be identical to that of *M. welwitschii* described above.

Specimens examined (23): R.S.A., CAPE PROVINCE: De Hoop Provincial Nature Reserve, Bredasdorp (1♂, 2♀♀). NATAL: Dumisa Gold Mine, 1 km E Dumisa railway station (1♂); Goudhoek farm, 10 km NW Babanango (4♂♂, 4♀♀); Otto's Bluff, Kok's farm, 15 km NNW Pietermaritzburg (3♂♂, 4♀♀). TRANSVAAL: Figtree forest, Pafuri, KNP (1♀). ZIMBABWE: Chirinda Forest, Mount Selinda (2♀♀); Rusito Forest on Rusito River (2♀♀).

Myotis (Selysius) bocagei
(Peters, 1870)

2n = 44; aFN = 50

The karyotype of the rufous hairy bat is described for the first time, and conforms to that of *M. welwitschii* described above.

Specimens examined (13): R.S.A.; TRANSVAAL: Luvuvhu River, Pafuri, KNP (2♂♂); Mockford's gardens, Pafuri, KNP (3♂♂, 7♀♀); Skukuza, KNP (1♂).

Pipistrellus (Vansonia) rueppellii
(Fischer, 1829)

2n = 36; aFN = 54

The autosomal complement of Rüppell's bat, described here for the first time, consists of ten pairs of biarmed chromosomes and seven pairs of acrocentrics. The X is a medium submetacentric and the Y a small acrocentric.

Specimens examined (7): R.S.A., TRANSVAAL: Figtree forest, Pafuri, KNP (1♂, 2♀♀); Luvuvhu River bridge, Pafuri, KNP (1♂); New figtree forest, Pafuri, KNP (1♂); Old picnic site, Pafuri, KNP (1♂, 1♀).

Pipistrellus (Pipistrellus) kuhlii
(Kuhl, 1819)

2n = 42; aFN = 50

The karyotype of Kuhl's pipistrelle in southern Africa consists of five pairs of metacentrics, a graded series of 15 pairs of acrocentrics ranging in size from medium to very small, a medium-sized metacentric X and a small acrocentric Y. Our results differ from the 2n = 44 and aFN = 50 reported for this species in Tunisia (Baker *et al.* 1975) and Greece (Iliopoulou-Georgudaki & Giagia (1986).

Specimens examined (18): R.S.A., NATAL: DukuDuku Forest Reserve, 6 km NNE Mtubatuba (1♂, 1♀); Hluhluwe Game Reserve Research Centre (1♂); Kosi Lake, Kwazulu (3♂♂); Ngome Forest Reserve, 70 km NE Vryheid (3♂♂, 1♀); Umlalazi Nature Reserve, Kwazulu (1♂); TRANSVAAL: Figtree forest, Pafuri, KNP (1♂); 3 km NW Punda Maria, KNP (4♀♀). ZIMBABWE: Rusito Forest on Rusito River (1♂, 1♀).

Pipistrellus (Pipistrellus) anchietai
(Seabra, 1900)

2n = 26; aFN = 32

The karyotype of Anchieta's pipistrelle, described here for the first time, consists of two pairs of small metacentrics, two pairs of large submetacentrics, eight pairs of acrocentrics ranging in size from large to minute, a medium-sized submetacentric X and a small acrocentric Y.

Specimens examined (3): R.S.A., TRANSVAAL: Skukuza, KNP (1♀); 1,5 km NW Skukuza, KNP (1♂, 1♀).

Pipistrellus (Pipistrellus) rusticus
(Tomes, 1861)

2n = 42; aFN = 50

This is the first description of the rusty bat's karyotype, which is characterised by five pairs of metacentric and 15 pairs of acrocentric autosomes and a medium-sized submetacentric X and a small acrocentric Y.

Specimens examined (37): R.S.A., TRANSVAAL: Anthrax camp, Pafuri, KNP (1♂, 1♀); Figtree forest, Pafuri, KNP (3♂♂, 3♀♀); Luvuvhu hippo pool, Pafuri, KNP (2♂♂, 8♀♀); Maditobe Witsand Dam, 2,5 km NE Punda Maria, KNP (1♂); Mahembane, KNP (1♀); Mahogany drive, 2 km N Punda Maria, KNP (1♂, 2♀♀); Old picnic site, Pafuri, KNP (2♂♂, 1♀); Punda Maria, KNP (1♂, 6♀♀); Shashanga windmill, KNP (4♂♂).

Pipistrellus (Pipistrellus) nanus (Peters, 1852)

2n = 36; aFN = 50

The karyotype of the banana bat has eight pairs of metacentric autosomes, nine pairs of acrocentrics, a medium-sized metacentric X and a minute acrocentric Y. Our findings are in accordance with those of Peterson & Nagorsen (1975).

Specimens examined (44): R.S.A., NATAL: Hazelmere Dam Nature Reserve, Verulam (1♂); Kosi Lake, Kwazulu (1♀); Ngome Forest Reserve, 70 km NE Vryheid (2♂♂, 2♀♀); Rob Roy Hotel, Bothas Hill (1♂, 3♀♀); Um-doni Park, 14 km SSW Scottburgh (2♂♂, 2♀♀). TRANSVAAL: Anthrax camp, Pafuri, KNP (1♂); Culling camp, Pafuri, KNP (2♀♀); Barberton Municipal Caravan Park, Barberton (1♂); Chamberie Nursery, 10km NNE Barberton (1♂, 1♀); Figtree forest, Pafuri, KNP (1♀); 4 km NNE Letaba highwater bridge (2♂♂); 1 km SE Letaba restcamp, KNP (1♂); Mockford's gardens, Pafuri, KNP (2♂♂, 2♀♀); New figtree forest, Pafuri, KNP (3♀♀); Old picnic site, Pafuri, KNP (5♀♀); Satara restcamp, KNP (2♂♂). ZIMBABWE: Chirinda Forest, Mount Selinda (4♂♂); Rusito Forest on Rusito River (2♂♂).

Chalinolobus (Glaconycteris) variegatus (Tomes, 1861)

2n = 18; aFN = 32

The karyotypes of the butterfly bat, described here for the first time, has an autosomal complement of eight pairs of bi-armed chromosomes, two pairs of which are metacentric, five pairs are submetacentric and one pair is subtelocentric. The X is a medium-sized subtelocentric and the Y a small metacentric.

Specimens examined (8): R.S.A., NATAL: DukuDuku Forest Reserve, 6 km NNE Mtubatuba (1♀). TRANSVAAL: Figtree forest, Pafuri, KNP (1♀); Magamba windmill, 18 km SE Punda Maria, KNP (1♂); Mockford's gardens, Pafuri, KNP (2♂♂, 2♀♀); Old picnic site, Pafuri, KNP (1♂).

Laephotis botswanae Setzer, 1971

2n = 34; aFN = 50

This is the first description of the karyotype of the Botswana long-eared bat. The autosomal chromosomes consist of a size-graded series of nine pairs of bi-armed chromosomes, and seven pairs of acrocentric chromosomes. There are 50 autosomal arms represented in the complement. The X is a submetacentric and the Y a small acrocentric.

Specimens examined (4): R.S.A., TRANSVAAL: Lapalala wilderness area, 65 km N Vaalwater (1♂); Maditobe Witsand Dam, 2,5 km NE Punda Maria, KNP (1♂, 2♀♀).

Laephotis namibensis Setzer, 1971

2n = 34; aFN = 50

This first description of the Namib long-eared bat's chromosomal complement, reveals it to be similar to that of *L. botswanae*.

Specimens examined (10): NAMIBIA: De Valle, Naukluft National Park, 70 km W

Maltahöhe (1♀); Klein Aus farm 8, 3 km W Aus (2♂♂); Zwartmodder farm 101, 70 km W Maltahöhe (2♂♂, 5♀♀).

Laephotis wintoni Thomas, 1901

2n = 34; aFN = 50

Although based on a single specimen, our data indicate Winton's long-eared bat's karyotype to be similar to that of *L. botswanae*.

Specimens examined (1): R.S.A., CAPE PROVINCE: Algeria State Forest, Cederberg (1♀).

Eptesicus hottentotus (A. Smith, 1833)

2n = 50; aFN = 48

Our findings support those of Peterson & Nagorsen (1975) in that the long-tailed serotine bat has a size-graded series of 24 acrocentric autosomal chromosomes. The X sex chromosome is a medium-sized submetacentric and the Y a small acrocentric.

Specimens examined (15): NAMIBIA: Brandberg West Mine, 75 km WNW Uis (1♂); De Valle, Naukluft National Park (2♀♀); Huns farm 106, 95 km S Bethanie (1♀); Kanaän farm 104, 69 km W Helmeringhausen (9♀♀). R.S.A., TRANSVAAL: Greefswald farm 37, 64 km W Messina (1♀); Tshalungwa, fountain 16 km NNE Punda Maria, KNP (1♂).

Eptesicus cf. *melckorum* Roberts, 1919

2n = 40; aFN = 50

This is the first published description of the karyotype of this, as yet unnamed, species which resembles the classical description of *E. melckorum*. Specimens from the interior of South Africa answering to the description of *E. melckorum* display the karyotypic prop-

erties of *E. capensis*, and our unpublished morphometric results furthermore unambiguously show *E. melckorum* to be a synonym of *E. capensis*. Specimens collected in the eastern Transvaal agree in many respects with the description of *E. melckorum*. However, they have a completely different karyotype consisting of one large, four medium-sized, and one small pair of submetacentrics, plus a graded series of 13 pairs of acrocentrics. The sex chromosomes consist of a large submetacentric X and a small acrocentric Y.

Specimens examined (15): R.S.A., TRANSVAAL: Anthrax camp, Pafuri, KNP (3♂♂, 1♀); Culling camp, Pafuri, KNP (1♂, 1♀); Figtree forest (1♂); Mockford's gardens, Pafuri, KNP (1♀); New figtree forest, Pafuri, KNP (1♂, 1♀); Old picnic site, Pafuri, KNP (1♂, 1♀); Greefswald farm 37, 64 km W Messina (1♀). ZIMBABWE: Mana Pools National Park (3♀♀).

Eptesicus zuluensis Roberts, 1924

2n = 28; aFN = 48

This first description of the karyotype of the aloe serotine bat reveals differences with *E. somalicus* in that it has an additional pair of chromosomes, although their aFNs are similar, suggesting a centric fusion. The autosomal chromosomes of *E. zuluensis* consist of 11 pairs of bi-armed chromosomes ranging in size from large to small, and two pairs of small acrocentrics. The X sex chromosome is a medium-sized subtelocentric and the Y a small acrocentric. Based on interspecific chromosomal differences, we are of the opinion that *E. zuluensis* can be regarded as taxonomically distinct from *E. somalicus*.

Specimens examined (9): NAMIBIA: Gobabeb, Namib Park (2♀♀). R.S.A., TRANSVAAL: Anthrax camp, Pafuri, KNP (1♀); New figtree forest, Pafuri, KNP (1♂); Culling camp, Pafuri, KNP (1♂); Shashanga, windmill 5 km NW Punda Maria, KNP (2♂♂, 2♀♀).

Eptesicus capensis (A. Smith, 1829)

2n = 32; aFN = 48

Our results concur with those of Peterson & Nagorsen (1975), with the species' chromosomal complement comprising ten pairs of large to small bi-armed autosomal chromosomes, and five pairs of small acrocentrics. The X sex chromosome is a medium-sized metacentric and the Y a small acrocentric.

Specimens examined (55): NAMIBIA: Omega, West Caprivi (3♀); Oranjemund (7♀). R.S.A., CAPE PROVINCE: Goraas farm Q29, 62 km W Carnavon (1♂, 1♀); Karoo National Park, 9 km W Beaufort West (4♀); Narap, 28 km SSE Springbok (3♀); Wagondrift farm 230, 16 km SSE Lamberts Bay (2♀). TRANSVAAL: Anthrax camp, Pafuri, KNP (6♂♂, 1♀); Culling camp, Pafuri, KNP (2♂♂); Figtree forest, Pafuri, KNP (1♀); Greefswald farm 37, 64 km W Messina (1♀); Luvuvhu hippo pool, Pafuri, KNP (1♂); Maditobe Witsand Dam, 2.5 km NE Punda Maria, KNP (1♂); Malelane, KNP (2♀♀); Mockford's gardens, Pafuri, KNP (1♂, 1♀); New figtree forest, Pafuri, KNP (1♂); North bank Sabie River, 3 km NNE Skukuza, KNP (1♀); Punda Maria, KNP (1♂); Ratsegaai farm 204, 13 km W Ventersdorp (1♂, 8♀♀); Skukuza, KNP (3♂♂, 2♀♀).

Nycticeius schlieffenii (Peters, 1859)

2n = 42; aFN = 50

We found that the karyotype of *N. schlieffenii* in Southern Africa comprises one pair of metacentric, four pairs of submetacentric, and 15 pairs of acrocentric autosomes, a small metacentric X and a very small acrocentric Y. This, however, differs markedly for the 2n = 34; aFN = 52 karyotype reported for this species from specimens collected in Somalia (Ruedas *et al.* 1990).

Specimens examined (22): R.S.A., TRANSVAAL: Figtree forest, Pafuri, KNP (4♂♂, 5♀♀); Luvuvhu hippo pool, Pafuri, KNP

(1♂); Matukwala, dam 5 km NW Punda Maria, KNP (1♀); Punda Maria, KNP (1♀); Shashanga, windmill 5 km NW Punda Maria, KNP (1♂, 5♀♀); Maditobe Witsand Dam, 2.5 km NE Punda Maria, KNP (1♂, 1♀); North bank Sabie River, 3 km NNE Skukuza, KNP (2♀♀).

Kerivoula lanosa (A. Smith, 1847)

2n = 28; aFN = 50

These karyotypic data are the first recorded for the Damara woolly bat and, albeit based on only two specimens, indicate presence of three pairs of metacentric, six pairs of submetacentric, three pairs of subtelocentric and one pair of acrocentric autosomes. The X is a large metacentric and the Y a small acrocentric.

Specimens examined (2): R.S.A., NATAL: Kosi Lake, Kwazulu (1♂). TRANSVAAL: Junction Main and Nyalala roads, Pafuri, KNP (1♂).

Family Molossidae

Sauromys petrophilus (Roberts, 1917)

2n = 48; aFN = 62

The chromosomal complement of the flat-headed free-tailed bat, recorded here for the first time, includes one pair of large metacentric, three pairs of medium metacentric, four pairs of medium subtelocentric, and 15 pairs medium to small acrocentric chromosomes. The X chromosome is a medium-sized submetacentric, and the Y a small acrocentric.

Specimens examined (26): NAMIBIA: De Valle, Naukluft National Park, Maltahöhe (4♂♂, 1♀); Ganab waterhole, Tumasberg, Namib Park (6♂♂, 1♀); Gobabeb, Namib Park (12♂♂, 1♀); R.S.A., CAPE PROVINCE: Augrabies Falls National Park, 88 km W. Upington (1♀).

Tadarida fulminans (Thomas, 1903)

2n = 48; aFN = 66

The karyotype of *T. fulminans* consists of one large and three medium pairs of metacentric autosomes, six pairs of medium to small subtelocentrics, and 13 pairs of medium to small acrocentrics. The X is a medium metacentric, and the Y a small acrocentric. Peterson & Nagorsen (1975) reported difficulty in distinguishing between subtelocentric and acrocentric chromosomes, hence their uncertainty as to the total number of bi-armed chromosomes and the aFN.

Specimens examined (3): R.S.A., TRANSVAAL: Luvuvhu River bridge, Pafuri, KNP (1♂); Old picnic site, Pafuri, KNP (1♂, 1♀).

Tadarida aegyptiaca (E. Geoffroy, 1818)

2n = 48; aFN = 68

The karyotype of this species is very similar to *T. fulminans*, except that it appears to have one extra pair of subtelocentric autosomes in the place of an acrocentric pair. Our results disagree with those based on a single specimen from Kenya by Nagorsen *et al.* (1976), who reported aFN=54 for this species. This difference can be ascribed to the small sample used by these authors, and their admitted subjective categorisation of the morphology of 14 subtelocentric chromosomes which approach the acrocentric configuration, but which were nonetheless accorded a value of one when calculating the fundamental number (Nagorsen *et al.* 1976)

Specimens examined (21): NAMIBIA: Omega, West Caprivi (1♂, 1♀); Kanaän farm 104, 70 km W Helmeringhausen (1♂). R.S.A., CAPE PROVINCE: Algeria State Forest, 28 km SSE Clanwilliam (3♂♂); De Tuins Noord farm 161, 52 km W Kenhardt (2♂♂, 1♀); Storms River State Forest, 82 km W Humansdorp (6♂♂, 4♀♀). TRANSVAAL: Rat-

segaai farm 204, 13 km W Ventersdorp (1♀); Transvaal Museum buildings, Pretoria (1♀).

Chaerephon ansorgei (Thomas, 1913)

2n = 48; aFN = 68

The karyotype of Ansoerge's free-tailed bat consists of one large and three medium pairs of bi-armed autosomes, seven pairs of medium to small subtelocentrics, and 12 pairs of medium to small acrocentrics. The X is a medium submetacentric, and the Y a small acrocentric. This essentially agrees with the findings of Smith *et al.* (1986), who identified one pair of subtelocentric autosomes as acrocentric, hence their recorded aFN = 66.

Specimens examined (7): R.S.A., TRANSVAAL: 1 km SE Letaba restcamp, KNP (2♂♂); Maditobe Witsand Dam, 2,5 km NE Punda Maria, KNP (1♀); New picnic site, Pafuri, KNP (1♂); WNLA Dam, 1 km N Nwanetzi restcamp, KNP (2♂♂, 1♀).

Chaerephon nigeriae (Thomas, 1913)

2n = 48; aFN = 62

The Nigerian free-tailed bat, described here for the first time, is karyotypically similar to *S. petrophilus*.

Specimens examined (4): NAMIBIA: Makuri Pan, Bushmanland (1♀); Nama Pan, Bushmanland (2♂♂). ZIMBABWE: Sengwa Wildlife Research Station (1♂).

Chaerephon chapini (J.A. Allen, 1917)

2n = 48; aFN = 64

This is the first record of the karyotype of the pale free-tailed bat. It consists of one pair of large metacentrics, three pairs of medium metacentrics, one pair of medium submetacentrics, four pairs of subtelocentrics

and 14 pairs of acrocentrics. The X is a large subtelocentric and the Y a small acrocentric.

Specimens examined (5): NAMIBIA: Omega, West Caprivi (2♀). ZIMBABWE: Sengwa Wildlife Research Station (2♂, 1♀).

Chaerephon pumila (Cretzschmar, 1830-1831)

2n = 48; aFN = 66

In all respects the karyotype is similar to that of *T. fulminans*, except that whereas the Y appears to be acrocentric it may, in fact, be a small subtelocentric. Our results differ from those of Dulic & Mutere (1973a) and Smith *et al.* (1986) in that we identify four pairs of medium-sized chromosomes as subtelocentric instead of acrocentric, hence resulting in an aFN of 66 instead of 58.

Specimens examined (38): NAMIBIA: Drie Krone farm 516, Damaraland (2♂, 2♀); Kanaän farm 104, 70 km W Helmeringhausen (6♂, 3♀); Witwatersrand farm 521, 59 km SW Khorixas (2♂, 2♀). R.S.A., CAPE PROVINCE: Algeria State Forest, 28 km SSE Clanwilliam (8♂). TRANSVAAL: Gwalala, Pafuri, KNP (1♂, 2♀); Luvuvhu River, Pafuri, KNP (1♂); Mockford's gardens, Pafuri, KNP (1♂, 2♀); Punda Maria, KNP (4♂, 2♀).

Mops midas (Sundevall, 1843)

2n = 48; aFN = 66

The chromosomal complement is similar to our description of *T. fulminans*, except that the X-chromosome appears to be a sub-metacentric. Our findings corroborate those of Smith *et al.* (1986) on this species.

Specimens examined (13): NAMIBIA: Dumushe water, 2 km S Dose, Bushmanland (3♂, 3♀). R.S.A., TRANSVAAL: Gwalala, Pafuri, KNP (2♂, 2♀); Old picnic site, Pafuri, KNP (1♂); Punda Maria, KNP (2♀).

Mops condylurus (A. Smith, 1833)

2n = 48; aFN = 66

These karyotypic data are similar to those of *T. fulminans*, and are in accord with those of Smith *et al.* (1986), but at variance with those of Dulic & Mutere (1973a) who regard the five pairs of subtelocentric chromosomes as being acrocentric in morphology.

Specimens examined (13): R.S.A., NATAL: Ndumu Game Reserve, Tongaland (3♂, 1♀); Ngome Forest Reserve, 70 km NE Vryheid (4♀). TRANSVAAL: Crocodile Bridge restcamp, KNP (1♂, 1♀); Letaba restcamp, KNP (1♂); Skukuza, KNP (1♂); Luvuvhu hippo pool, Pafuri, KNP (1♂).

Discussion

Our results confirm and extend Baker's (1970) suggestion that the Molossidae are karyotypically conservative. Interestingly, the Rhinolophidae display the same degree of conservatism, while the Vespertilionidae are generally more diverse. Certain genera in this family appear, however, to have a very low rate of chromosomal evolution and are karyotypically quite conservative (Baker & Bickham 1980).

Meester *et al.* (1986) regard *E. zuluensis* as a synonym of *E. somalicus*. Our results, however, show this to be unlikely since *E. zuluensis* has 2n = 28 and aFN = 48, whereas *E. somalicus* displays 2n = 26, aFN = 48 (McBee *et al.* 1987). Baker (1970) points out that inter-specific karyotypic variation is rare in bats and consequently the karyotypical differences found between *E. zuluensis* and *E. somalicus* suggest that the former should be recognised as a valid species. This would support Hayman & Hill (1971), Corbet & Hill (1980), and Swanepoel *et al.* (1980), but contrasts with the views of Koopman (1975), Ansell (1978), and Honacki *et al.* (1982). Likewise, the divergence found in karyotypic characteristics between *P. kuhlii* specimens from southern Africa, Tunisia (Baker *et al.*

Table 1

The 73 species of bats known to occur in southern Africa, with a summary of karyotype morphologies of 60 species. The karyotypic properties of the 13 species not given, are still to be recorded. 2n = diploid number; aFN = fundamental number of autosomal arms; BA = total number of bi-armed autosomal chromosomes; X and Y = male and female sex chromosomes; M = metacentric; SM = submetacentric; ST = subtelocentric; T = Telocentric; A = acrocentric

Species	2n	aFN	BA	X	Y	Citation
SUBORDER: Megachiroptera						
Family: Pteropodidae						
<i>Epomophorus wahlbergi</i>	36	68	17	SM	A	Dulic & Mutere 1973b, 1977
	36	68	36	SM	?	Peterson & Nagorsen 1975
<i>Epomophorus crypturus</i>	35(♂)	68	34	SM	?	Peterson & Nagorsen 1975
	36(♀)			?	?	Peterson & Nagorsen 1975
<i>Epomophorus angolensis</i>	-	-	-	-	-	
<i>Epomops dobsonii</i>	-	-	-	-	-	
<i>Eidolon helvum</i>	34	?	?	?	?	Matthey 1962
<i>Rousettus aegyptiacus</i>	36	66	16	SM	Minute	Dulic & Mutere 1973b, 1977
SUBORDER: Microchiroptera						
Family: Emballonuridae						
<i>Taphozous mauritanus</i>	42	64	24	M	SM	This study
<i>Taphozous perforatus</i>	-	-	-	-	-	
<i>Coleura afra</i>	-	-	-	-	-	
Family: Nycteridae						
<i>Nycteris hispida</i>	42	78	38	M	M	Lee <i>et al.</i> 1989
<i>Nycteris grandis</i>	-	-	-	-	-	
<i>Nycteris woodi</i>	42	78	38	M	A	This study
<i>Nycteris macrotis</i>	40	74	36	M	M	Lee <i>et al.</i> 1989
<i>Nycteris thebaica</i>	42	78	38	SM	M	Peterson & Nagorsen 1975
	42	78	38	SM	M	This study
<i>Nycteris vinsoni</i>	-	-	-	-	-	
Family: Rhinolophidae						
<i>Rhinolophus hildebrandtii</i>	58	60	4	ST	ST	Peterson & Nagorsen 1975
	58	60	4	ST	ST	Rautenbach 1986
<i>Rhinolophus fumigatus</i>	58	60	4	ST	M	Rautenbach 1986
<i>Rhinolophus clivosus</i>	58	62	6	Large A	Small A	Dulic & Mutere 1974
	58	60	4	SM	SM	Rautenbach 1986
<i>Rhinolophus darlingi</i>	58	60	4	ST	ST	Peterson & Nagorsen 1975
	58	60	4	ST	ST	Rautenbach 1986
<i>Rhinolophus landeri</i>	58	60	4	SM	?	Rautenbach 1986
<i>Rhinolophus blasii</i>	58	60	4	M	A	Qumsiyeh <i>et al.</i> 1985
	58	60	4	SM	M	Rautenbach 1986
<i>Rhinolophus capensis</i>	58	60	4	SM	SM	Rautenbach 1986
<i>Rhinolophus simulator</i>	58	60	4	SM	SM	Rautenbach 1986
<i>Rhinolophus denti</i>	58	62	6	ST	?	Peterson & Nagorsen 1975
	58	62	6	ST	M	Rautenbach 1986
<i>Rhinolophus swinnyi</i>	58	62	6	ST	M	Rautenbach 1986

... / continued

Table 1 (continued)

Species	2n	aFN	BA	X	Y	Citation
Family: Hipposideridae						
<i>Hipposideros commersoni</i>	52	60?	10?	?	?	This study
<i>Hipposideros caffer</i>	32	60	30	ST	A	Peterson & Nagorsen 1975
	32	60	30	M	?	Dulic & Mutere 1973b, 1974
	32	60	30	SM	A	This study
<i>Cloeotis percivali</i>	40	?	?	?	?	This study
<i>Triaeonops persicus</i>	-	-	-	-	-	
Family: Vespertilionidae						
<i>Miniopterus inflatus</i>	46	50	6	M	A	Ruedas <i>et al.</i> 1990
<i>Miniopterus fraterculus</i>	46	50	6	SM	A	This study
<i>Miniopterus schreibersii</i>	46	50	6	SM	A	Manfreddi Romanini <i>et al.</i> 1975
	46	52	8	SM	A	Bickham & Hafner 1978
	46	50	6	SM	A	This study
<i>Myotis welwitschii</i>	44	50	8	SM	SM	This study
<i>Myotis seabrai</i>	50	48	0	SM	A	This study
<i>Myotis lesueuri</i>	50	48	0	SM	A	This study
<i>Myotis tricolor</i>	44	50	8	SM	A	This study
<i>Myotis bocagei</i>	44	50	8	SM	A	This study
<i>Pipistrellus rueppellii</i>	36	54	20	SM	A	This study
<i>Pipistrellus kuhlii</i>	44	50	8	SM	A	Baker <i>et al.</i> 1975
	44	50	8	M	M	Iliopoulou-Georgudaki & Giagia 1986
	42	50	10	M	A	This study
<i>Pipistrellus anchietai</i>	26	32	8	SM	A	This study
<i>Pipistrellus rusticus</i>	42	50	10	SM	A	This study
<i>Pipistrellus nanus</i>	36	50	16	M	A	Peterson & Nagorsen 1975
	36	50	16	M	A	This study
<i>Chalinolobus variegatus</i>	18	32	16	ST	M	This study
<i>Laephotis botswanae</i>	34	50	18	SM	A	This study
<i>Laephotis namibensis</i>	34	50	18	SM	A	This study
<i>Laephotis wintoni</i>	34	50	18	SM	A	This study
<i>Eptesicus rendalli</i>	38	50	14	SM	?	McBee <i>et al.</i> 1987
	38	50	14	SM	A	Rautenbach & Fenton 1992
<i>Eptesicus hottentotus</i>	50	48	0	SM	?	Peterson & Nagorsen 1975
	50	48	0	SM	A	This study
<i>Eptesicus cf. melckorum</i>	40	50	12	M	A	This study
<i>Eptesicus somalicus</i>	26	48	24	ST	A	McBee <i>et al.</i> 1987
<i>Eptesicus zuluensis</i>	28	48	22	ST	A	This study
<i>Eptesicus capensis</i>	32	50	20	SM	A	Peterson & Nagorsen 1975
	32	50	20	M	A	This study
<i>Scotophilus nigrata</i>	-	-	-	-	-	
<i>Scotophilus dinganii</i>	36	?	?	?	?	Peterson & Nagorsen 1975
	36	52	18	A	M	Schlitter <i>et al.</i> 1980
	36	50	16	SM	T	Ruedas <i>et al.</i> 1990.
<i>Scotophilus borbonicus</i>	36	54	20	A	M	Schlitter <i>et al.</i> 1980
	36	50	16	A	M	Ruedas <i>et al.</i> 1990
<i>Nycticeius schlieffenii</i>	34	52	20	M	A	Ruedas <i>et al.</i> 1990
	42	50	10	M	A	This study
<i>Scotoecus albofuscus</i>	-	-	-	-	-	
<i>Kerivoula argentata</i>	-	-	-	-	-	
<i>Kerivoula lanosa</i>	28	50	18	M	A	This study

.../ continued

Table 1 (continued)

Species	2n	aFN	BA	X	Y	Citation
Family: Molossidae						
<i>Otomops martiensseni</i>	48	56	10	SM	A	Dulic & Mutere 1973a
<i>Sauromys petrophilus</i>	48	62	16	SM	A	This study
<i>Mormopterus acetabulosus</i>	-	-	-	-	-	
<i>Tadarida lobata</i>	-	-	-	-	-	
<i>Tadarida ventralis</i>	-	-	-	-	-	
<i>Tadarida fulminans</i>	48	54?	16?	M	A	Peterson & Nagorsen 1975
	48	66	20	M	A	This study
<i>Tadarida aegyptiaca</i>	48	54	8	SM	A	Nagorsen <i>et al.</i> 1976
	48	68	22	M	A	This study
<i>Chaerephon bivittata</i>	48	54?	16?	SM	A	Peterson & Nagorsen 1975
<i>Chaerephon ansorgei</i>	48	66	20	ST	A	Smith <i>et al.</i> 1986
	48	68	22	SM	A	This study
<i>Chaerephon nigeriae</i>	48	62	16	SM	A	This study
<i>Chaerephon chapini</i>	48	64	18	ST	A	This study
<i>Chaerephon pumila</i>	48	58	12	M	A	Dulic & Mutere 1973a
	48	58	12	SM	A	Smith <i>et al.</i> 1986
	48	66	20	M	A	This study
<i>Mops midas</i>	48	66	20	SM	A	Smith <i>et al.</i> 1986
	48	66	20	SM	A	This study
<i>Mops condylura</i>	48	56	10	SM	A	Dulic & Mutere 1973a
	48	66	20	SM	A	Smith <i>et al.</i> 1986
	48	66	20	SM	A	This study

1975) and Greece (Iliopoulou-Georgudaki & Giagia 1986), and those in *N. schlieffenii* from southern Africa and Somalia (Ruedas *et al.* 1990) warrant closer attention since the southern African forms may represent unrecognised cryptic species.

The Old World genus *Myotis* includes seven subgenera (Ellerman & Morrison-Scott 1951) of which six are listed from Africa (Hayman & Hill 1971). Of these, one is confined to southern Africa, i.e. *Cistugo* Thomas, 1912. This subgenus comprises the only two, albeit poorly known species, endemic to the southern African subregion, *M. seabrai* and *M. lesueuri*. Of the remaining 11 African species in this genus, five are limited to northern Africa (Hayman & Hill 1971) and are consequently not part of the sub-Saharan fauna.

The karyotypes of *M. welwitschii*, *M. tricolor* and *M. bocagei* are similar to the majority of

species in the subgenera of *Myotis* recorded from both the New and Old World (2n = 44; aFN = 50; see Bickham *et al.* 1986), and thus underscore the karyotypically conservative nature of this large and world-wide genus. In contrast, *M. seabrai* and *M. lesueuri* show unique karyotypes (2n = 50, aFN = 48) for the genus *Myotis*. Likewise, these two species which are grouped in the subgenus *Cistugo*, are morphologically quite distinct from the other species of *Myotis*. The karyotypic evidence therefore clearly support the morphological criteria with both data sets distinguishing *Cistugo* as the most distinct subgenus in *Myotis*. We feel that in view of these considerations this taxon should be afforded full generic rank.

Based on the distribution of 2n and aFN numbers in the Vespertilionidae, Baker (1970) argued that the ancestral karyotype of the family was probably characterised by 2n = 44-50 and aFN = 50. Bickham (1979) and

Bickham & Baker (1980) presented G-banding evidence that the primitive vesperilionid karyotype comprised only acrocentric chromosomes, and hypothesised that the $2n=44$ and $aFN = 50$ karyotype recorded for most *Myotis* species is probably closest to the ancestral condition. The karyotypes of *M. seabrai* and *M. lesueuri* ($2n = 50$, $aFN = 48$) reported here approach the proposed primitive karyotype even more closely, and thus may represent the surviving ancestral karyotype, both for the genus and family. Since chromosomal evolution in vesperilionids is dominated by centric fusions (Bickham 1979), the more common *Myotis* karyotypes may have arisen from the condition in *Cistugo* by a single pericentric inversion (increasing aFN to 50), and three fusions of acrocentric pairs (thus increasing BA to eight and reducing $2n$ to 44, without changing the fundamental number). This hypothesis is to be tested using G and C-banding data currently being collected by ILR and GNB.

Heller & Volleth (1984), Volleth (1987), and Volleth & Tidemann (1989) argued that *Eptesicus* is chromosomally conservative, and that all species not exhibiting what they regard as the "true generic karyotype" (of $2n = 50$ and $aFN = 48$) should be assigned to the karyotypically variable genus *Pipistrellus*. This was followed by Hill & Harrison (1987) using baculum morphology as the investigatory procedure. Bickham (1979), however, argued that while *Eptesicus* and *Pipistrellus* differ karyotypically (the latter being chromosomally more similar to *Myotis*), these genera show strong morphological affinities, so that *Pipistrellus* may represent a central lineage ancestral to other vesperilionids. Hill & Francis (1984) also questioned a karyologically-based taxonomic arrangement on the grounds that chromosomal data are not yet available for many species of the nominal genera, whereas McBee *et al.* (1987) have shown that four species of *Eptesicus* from Africa do not display the presumed conservative chromosomal characteristics of the genus, thus

illustrating that conventionally recognised *Eptesicus* is karyotypically variable.

Our study adds two more species to the list of deviants from the proposed conservative model, *E. cf. melckorum* and *E. zuluensis*. All the *Eptesicus* specimens we examined lacked the first upper premolar (a diagnostic feature), whereas this tooth is consistently present in the *Pipistrellus* specimens from southern Africa. (However, elsewhere in Africa this discriminating character has been found to be inconsistent — Koopman 1975). We thus question the presumed chromosomal conservatism of the genus *Eptesicus*, as well as the wisdom of redefining taxonomic affinities of *Eptesicus* and *Pipistrellus* until such time as more data are available. Preliminary electrophoretic data for eight species belonging to these genera (Morales *et al.* 1991) also support the need for caution when attempting to delineate the generic limits of *Eptesicus* and *Pipistrellus*.

Our data confirm the existence of a distinct, yet undescribed species from the eastern Transvaal lowveld, which is intermediate in size between *E. capensis* and *E. hottentotus*. The karyotypic properties of this species are not only distinct from what some would regard as typical for *Eptesicus*, but are also distinct from species in either *Eptesicus* or *Pipistrellus*. We seriously question the taxonomic validity of *E. melckorum*, but the species is provisionally regarded as being closely allied to this taxon since it has no doubt been mistaken by several authors as *E. melckorum*. The distinctiveness of this species was confirmed by Morales *et al.* (1991), who included tissues from the specimens we karyotyped in their allozyme study. This new species will be formally described in a taxonomic review of all sub-Saharan species of *Eptesicus* currently under way.

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References

- ANSELL, W.F.H. 1978. *The mammals of Zambia*. National Parks and Wildlife Service, Chilanga.
- BAKER, R.J. 1970. Karyotypic trends in bats. Pp. 65-96. In: WIMSATT, S.A. (ed.). *Biology of bats*. New York: Academic Press.
- BAKER, R.J. AND J.W. BICKHAM. 1980. Karyotypic evolution in bats: evidence of extensive and conservative chromosomal evolution in closely related taxa. *Systematic Zoology* 29(3): 239-253.
- BAKER, R.J., B.L. DAVIS, R.J. JORDAN, AND A. BINOUS. 1975. Karyotypic and morphometric studies of Tunisian mammals: bats. *Mammalia* 38: 697-710.
- BAKER, R.J. AND M.B. QUMSIYEH. 1988. Methods in chiropteran mitotic chromosomal studies. Pp. 425-436. In: KUNZ, T.H. (ed.). *Ecological and behavioural methods for the study of bats*. Washington D.C.: Smithsonian Institution Press.
- BAKER, R.J., M.B. QUMSIYEH AND C.S. HOOD. 1987. Chromosomal evolution in mammals: role of differentially-stained chromosomes. Pp. 69-96. In: GENOWAYS, HUGH H. (ed.). *Current mammalogy*. New York: Plenum Press.
- BICKHAM, J.W. 1979. Chromosomal variation and evolutionary relationships of vespertilionid bats. *Journal of Mammalogy* 60: 350-363.
- BICKHAM, J.W. AND J.C. HAFNER. 1978. A chromosomal banding study of three species of vespertilionid bats from Yugoslavia. *Genetica* 48(1):1-3.
- BICKHAM, J.W., K. MCBEE AND D.A. SCHLITTER. 1986. Chromosomal variation among seven species of *Myotis* (Chiroptera: Vespertilionidae). *Journal of Mammalogy* 67(4): 746-750.
- CORBET, G.B. AND J.E. HILL. 1980. *A World list of mammalian species*. London and Ithaca: British Museum (Natural History) and Cornell University Press.
- DULIC, B. AND F.A. MUTERE. 1973a. Comparative study of the chromosomes of some molossid bats from eastern Africa. *Periodicum Biologorum* 75: 61-65.
- DULIC, B. AND F.A. MUTERE. 1973b. Les chromosomes de trois especes de Magachiropteres (Mammalia, Chiroptera) d'Afrique orientale. *Caryologia* 26: 389-396.
- DULIC, B. AND F.A. MUTERE. 1974. The chromosomes of two bats from East Africa: *Rhinolophus clivosus* Cretzschmar 1928 and *Hipposideros cafifer* (Sundevall, 1946). *Periodicum Biologorum* 76: 31-34.
- DULIC, B. AND F.A. MUTERE. 1977. Chromosomes of some East African bats. *Säugetierkundliche Mitteilungen* 25: 231-233.
- ELLERMAN, J.R. AND T.C.S. MORRISON-SCOTT. 1951. *Checklist of Palaearctic and Indian Mammals 1758 to 1946*. London: Trustees of the British Museum (Natural History).
- FREEMAN, P.W. 1981. A multivariate study of the Molossidae (Mammalia, Chiroptera): morphology, ecology, evolution. *Fieldiana, Zoology N.S.* 7(1316): 1-173.
- GREEN C.A., H. KEOGH, D.H. GORDON, M. PINTO AND E. HARTWIG. 1980. The distribution, identification and naming of the *Mastomys natalensis* species complex in Southern Africa. *Journal of Zoology, London* 192: 17-23.
- HARADA, M., M. MINEZAWA, S. TAKADA, S. YENBUTRA, P. NUNPAKDEE AND S. OHTANI. 1982. Karyological analysis of 12 species of bats from Thailand. *Caryologia* 35 (2): 269-278.
- HARADA, M., S. YENBUTRA, K. TSUCHIYA AND S. TAKADA. 1985. Karyotypes of seven species of bats from Thailand (Chiroptera: Mammalia). *Experientia* 41: 1610-1611.
- HAYMAN, R.W. AND J.E. HILL. 1971. Part 2. Order Chiroptera. Pp. 1-73. In: MEESTER, J. AND H.W. SETZER. (eds.). *The mammals of Africa: an identification manual*. Washington D.C.: Smithsonian Institution Press.
- HELLER, K.-G. AND M. VOLLETH. 1984. Taxonomic position of "*Pipistrellus societatis*" Hill, 1972 and the karyological characteristics of the genus *Eptesicus* (Chiroptera: Vespertilionidae). *Zeitschrift für Zoologische Systematik und Evolutionsforschung* 22: 65-77.
- HILL, J.E. AND C.M. FRANCIS. 1984. New bats (Mammalia: Chiroptera) and new records of bats from Borneo and Malaya. *Bulletin of the British Museum (Natural History), London* 47: 305-329.
- HILL, J.E. AND D.L. HARRISON. 1987. The baculum in the Vespertilioninae (Chiroptera: Vespertilionidae) with a systematic review, a synopsis of *Pipistrellus* and *Eptesicus* and the description of a new genus and subgenus. *Bulletin of the British Museum (Natural History) Zoology* 52: 225-305.
- HONACKI, J.H., K.E. KINMAN AND J.W. KOEPL. 1982. *Mammal species of the world*. Lawrence, Kansas: Allen Press and Association of Systematics Collections.
- HOOD, G.S., D.A. SCHLITTER, J.I. GEORGUDAKI, S. YENBUTRA AND R.J. BAKER. 1988. Chromosomal studies of bats (Mammalia: Chiroptera) from Thailand. *Annals of Carnegie Museum* 57(4): 99-109.
- ILIOPOULOU-GEORGUDAKI J. AND E.B. GIAGIA. 1986. The chromosomes of Kuhl's pipistrelle bat *Pipistrellus kuhli* (Kuhl, 1819) from Greece. *Säugetierkundliche Mitteilungen* 33: 245-248.
- KOOPMAN, K.F. 1975. Bats of the Sudan. *Bulletin of the American Museum of Natural History* 154: 354-444.
- LEE, M.R. AND F.F.B. ELDER. 1980. Yeast stimulation of bone marrow mitosis for cytogenetic investigations. *Cytogenetics and Cell Genetics* 26: 36-40.

- LEE JR., T.E., J.W. BICKHAM AND D.A. SCHLITTER. 1989. Karyotypes of two nycterid bats from Somalia. *Mammalia* 53(1): 120-121.
- MANFREDI ROMANINI, M.G., C. PELLICCIARI, F. BOLCHI AND E. CAPANNA. 1975. Donnees nouvelles sur le contenu en ADN des noyaux postkinetiques chez les chiropteres. *Mammalia* 39: 675-683.
- MATTHEY, R. 1962. Les nombres diploides de mammiferes eutheriens. Liste critique. *Mammalian Chromosome Newsletter* 8: 17-25.
- MCBEE, K., D.A. SCHLITTER AND R.L. ROBBINS. 1987. Systematics of African bats of the genus *Eptesicus* (Mammalia: Vespertilionidae). 2. Karyotypes of African species and their generic relationships. *Annals of Carnegie Museum* 56(11): 213-222.
- MEESTER, J.A.J., I.L. RAUTENBACH, N.J. DIPPENAAR AND C.M. BAKER. 1986. Classification of Southern African Mammals. *Transvaal Museum Monograph* 5: 1-359.
- MORALES, J.C., S.W. BALLINGER, J.W. BICKHAM, I.F. GREENBAUM AND D.A. SCHLITTER. 1991. Genetic relationships among eight species of *Eptesicus* and *Pipistrellus* (Chiroptera: Vespertilionidae). *Journal of Mammalogy* 72(2): 286-291.
- NAGORSEN D.W., J.L. EGER AND R.L. PETERSEN. 1976. Somatic chromosomes of three African species of bats (Chiroptera), *Scotoecus hindei*, *Tadarida aegyptiaca*, and *Tadarida bemmeleni*. *Mammalian Chromosomes Newsletter* 17(3): 9-12.
- PATTON, J.L. 1967. Chromosome studies of certain pocket mice, genus *Perognathus* (Rodentia: Heteromyidae). *Journal of Mammalogy* 48(1): 27-37.
- PETERSON, R.L. AND D.W. NAGORSEN. 1975. Chromosomes of fifteen species of bats (Chiroptera) from Kenya and Rhodesia. *Occasional Papers, Royal Ontario Museum Life Sciences* 27: 1-14.
- QUMSIYEH, M.B., D.A. SCHLITTER AND A.M. DISI. 1985. New records and karyotypes of small mammals from Jordan. *Zeitschrift für Säugetierkunde* 51: 139-146.
- RAUTENBACH, I.L. 1986. Karyotypical variation in southern African Rhinolophidae (Chiroptera) and non-geographic morphometric variation in *Rhinolophus denti* Thomas, 1904. *Cimbebasia Series A* 8(15): 129-139.
- RAUTENBACH, I.L. AND M.B. FENTON. 1992. Bats from Mana Pools National Park in Zimbabwe and the first record of *Eptesicus rendalli* from the country. *Zeitschrift für Säugetierkunde* 57(2): 112-115.
- RAY-CHAUDHURI, S.P. AND S. PATHAK. 1966. Studies on the chromosomes of bats: list of worked out Indian species of Chiroptera. *Mammalian Chromosome Newsletter* 22: 206.
- RUEDAS, L.A., T.E. LEE, J.W. BICKHAM AND D.A. SCHLITTER. 1990. Chromosomes of five species of vespertilionid bats from Africa. *Journal of Mammalogy* 71(1): 94-100.
- SCHLITTER, D.A., I.L. RAUTENBACH AND D.A. WOLHUTER. 1980. Karyotypes and morphometrics of two species of *Scotophilus* in South Africa (Mammalia: Vespertilionidae). *Annals of the Transvaal Museum* 32(9): 231-240.
- SMITH, S.A., J.W. BICKHAM AND D.A. SCHLITTER. 1986. Karyotypes of eleven species of molossid bats from Africa (Mammalia: Chiroptera). *Annals of Carnegie Museum* 55(7): 125-136.
- SWANEPOEL, P., R.H.N. SMITHERS AND I.L. RAUTENBACH. 1980. A checklist and numbering system of the extant mammals of the Southern African Subregion. *Annals of the Transvaal Museum* 32(7): 155-196.
- TAYLOR P.J. 1992. First record of Welwitsch's hairy bat (*Myotis welwitschii*) from Natal. *Durban Museum Novitates* 16: 35-36.
- VOLLETH, M. 1987. Differences in the location of nucleolus organizer regions in European vespertilionid bats. *Cytogenetics and Cell Genetics* 44: 186-197.
- VOLLETH, M. AND C.R. TIDEMANN. 1989. Chromosome studies in three genera of Australian vespertilionid bats and their systematic implications. *Zeitschrift für Säugetierkunde* 54: 215-222.
- WARNER, J.W., J.L. PATTON, A.L. GARDNER AND R.J. BAKER. 1974. Karyotypic analyses of twenty-one species of molossid bats (Molossidae: Chiroptera). *Canadian Journal of Genetics and Cytology* 16: 165-176.

Gazetteer

Algeria State Forest, Cederberg, 28 km SSE Clanwilliam, C.P.	32°22'S, 19°03'E	Bat's Hole, Namib National Park, Namibia	22°39'S, 15°31'E
Anthrax camp, Pafuri, KNP, Transvaal	22°25'S, 31°12'E	Bobomeni research camp, Pafuri, KNP, Transvaal	22°25'S, 31°12'E
Augrabies Falls National Park, 88 km W Upington, C.P.	28°35'S, 20°21'E	Brandberg West Mine, 75 km WNW Uis, Namibia	21°00'S, 14°11'E
Barberton Municipal Caravan Park, Barberton, Transvaal	25°47'S, 31°02'E	Chamberie Nursery, 10km NNE Barberton, Transvaal	25°42'S, 30°58'E

Chirinda Forest, Mount Selinda, Zimbabwe	20°24'S, 32°42'E	Kanaän farm 104, 70 km W Helmeringhausen, Namibia	25°53'S, 16°07'E
Crocodile Bridge restcamp, KNP, Transvaal	25°21'S, 31°54'E	Karoo National Park, 9 km W Beaufort West, C.P.	32°20'S, 22°33'E
Culling camp, Pafuri, KNP, Transvaal	22°25'S, 31°15'E	Kersbos farm, 10 km NNE Bitterfontein, C.P.	30°57'S, 18°12'E
De Hoop Provincial Nature Reserve, 23 km SSE Bredasdorp, C.P.	34°25'S, 20°20'E	Klein Aus farm 8, 3 km W Aus, Luderitz District, Namibia	22°26'S, 18°06'E
De Tuins Noord farm 161, 52 km W Kenhardt, C.P.	29°20'S, 20°36'E	Klipfontein farm 53, 30 km NE Ellisras, Transvaal	24°08'S, 28°18'E
De Valle, Naukluft National Park, 110 km NW Maltahöhe, Namibia	24°18'S, 16°00'E	Kosi Lake, Kwazulu, Natal	26°57'S, 32°49'E
Dirleton farm 276, 29 km NE Alldays, Transvaal	22°32'S, 29°26'E	Lapalala wilderness area, 65 km N Vaalwater, Transvaal	23°52'S, 28°09'E
Drie Krone farm 516 SE, Damaraland, Namibia	20°31'S, 14°01'E	Letaba highwater bridge, 4 km NNE Letaba restcamp, KNP, Transvaal	23°49'S, 31°35'E
DukuDuku Forest Reserve, 6 km NNE Mtubatuba, Natal	28°18'S, 32°13'E	Letaba restcamp, 1 km SE; KNP, Transvaal	23°51'S, 31°34'E
Dumisa Gold Mine, 1 km E Dumisa railway station, Natal	30°15'S, 30°27'E	Luvuvhu hippo pool, Pafuri, KNP, Transvaal	22°26'S, 31°11'E
Dumushe water, 2 km S Dose, Bushmanland, Namibia	18°14'S, 20°53'E	Luvuvhu River, Pafuri, KNP, Transvaal	22°26'S; 31°11'E
Figaro Mine, 11 km ENE Malelane, Transvaal	25°27'S, 31°38'E	Luvuvhu River bridge, Pafuri, KNP, Transvaal	22°25'S, 31°11'E
Figtree forest, Pafuri, KNP, Transvaal	22°25'S, 31°11'E	Lynnwood, Pretoria	25°45'S, 28°14'E
Ganab waterhole, Tumasberg, Namib Park, Namibia	23°03'S, 15°08'E	Maditobe Witsand Dam, 2,5 km NE Punda Maria, KNP, Transvaal	22°41'S, 31°02'E
Gobabeb, Namib Park, Namibia	23°30'S, 15°03'E	Magamba, windmill 18 km SE Punda Maria, KNP, Transvaal	22°46'S, 31°10'E
Goraas farm Q29, 62 km W Carnavon	31°10'S, 21°35'E	Mahembane, 7 km N Punda Maria, KNP, Transvaal	22°39'S, 31°02'E
Goudhoek farm, 10 km NW Babanango, Natal	28°18'S, 31°01'E	Mahogany Drive, 2 km N Punda Maria, KNP, Transvaal	22°41'S, 31°01'E
Greefswald farm 37, 64 km W Messina	22°13'S, 29°22'E	Makuri Pan, 9 km W ; Bushman- land, Namibia	19°41'S, 20°39'E
Gwalala, Pafuri, KNP, Transvaal	22°25'S, 31°17'E	Malelane, KNP, Transvaal	25°28'S, 31°30'E
Hazelmere Dam Nature Reserve, Verulam, Natal	29°35'S, 31°01'E	Mana Pools National Park, Zimbabwe	15°44'S, 29°20'E
Hluhluwe Game Reserve Research Centre, Hluhluwe, Natal	28°04'S, 32°02'E	Matukwala, dam 5 km NW Punda Maria, KNP, Transvaal	22°41'S, 30°57'E
Huab River Mouth, Namibia	20°55'S, 13°15'E	Mhangadyana Koppie, 14 km N Orpen, KNP, Transvaal	24°24'S, 31°24'E
Huns farm 106, 95 km S Bethanie	27°24'S, 17°12'E	Mockford's gardens, Pafuri, KNP, Transvaal	22°25'S, 31°18'E
Junction main and Nyala roads, Pafuri, KNP, Transvaal	22°25'S, 31°11'E	Ndumu Game Reserve, Tongaland, Natal	26°53'S, 32°15'E
Irene Caves, Irene	25°52'S, 28°14'E		

Nama Pan, Bushmanland, Namiba	19°55'S, 20°43'E	Rusito Forest on Rusito River, 20 km SE Melssetter, Zimbabwe . .	20°02'S, 32°59'E
Narap, 28 km SSE Springbok, C.P.	29°53'S, 17°45'E	Satara restcamp, KNP, Transvaal	24°24'S, 31°46'E
New figtree forest, Pafuri, KNP, Transvaal	22°25'S, 31°16'E	Sengwa Wildlife Research Station, 75 km W Gokwe, Zimbabwe . .	18°10'S, 28°13'E
New picnic site, Pafuri, KNP, Transvaal	22°25'S, 31°15'E	Shashanga, windmill 5 km NW Punda Maria, KNP, Transvaal . .	22°40'S, 30°59'E
Ngome Forest Reserve, 70 km NE Vryheid, Natal	27°50'S, 31°24'E	Skukuza, KNP, Transvaal	24°59'S, 31°35'E
North bank Sabie River, 3 km NNE Skukuza, KNP, Transvaal . .	24°58'S, 31°40'E	Skukuza, 1,5 km NW; KNP, Transvaal	24°59'S, 31°35'E
Old picnic site, Pafuri, KNP, Transvaal	22°25'S, 31°18'E	Storms River State Forest, 83 km W Humansdorp, C.P.	33°58'S, 23°53'E
Olivewood farm 284, 15 km WNW Hotazel, C.P.	27°11'S, 22°49'E	Transvaal Museum buildings, Pretoria, Transvaal	25°45'S, 28°11'E
Omega, West Caprivi, Namibia . .	18°03'S, 22°11'E	Tshalungwa, fountain 16 km NNE Punda Maria, KNP, Transvaal . .	22°31'S, 31°05'E
Oranjemund, Namibia	28°33'S, 16°25'E	Umdoni Park, 14 km SSW Scottburgh, Natal	30°24'S, 30°41'E
Otto's Bluff, Kok's farm, 15 km NNW Pietermaritzburg, Natal	29°30'S, 30°21'E	Umlalazi Nature Reserve, Zululand, Natal	28°58'S, 31°48'E
Punda Maria, KNP, Transvaal . .	22°41'S, 31°01'E	Wagondrift, farm 230, 16 km SSE Lamberts Bay, C.P.	32°13'S, 18°21'E
Punda Maria, 3 km NW; KNP, Transvaal	22°40'S, 31°00'E	Witwatersrand farm 521, 59 km SW Khorixas, Namibia	20°38'S, 14°25'E
Ratsegaai farm 204, 13 km W Ventersdorp, Transvaal	26°22'S, 26°40'E	WNLA Dam, 1 km N Nwanetzi restcamp, KNP, Transvaal	24°27'S, 31°58'E
Rob Roy Hotel, Bothas Hill, Natal	29°45'S, 30°45'E	Zwartmodder farm 101, 70 km W Maltahöhe, Namibia	24°54'S, 16°17'E