

## The Chromosomes and Systematic Position of the Marsupial Mole, *Notoryctes typhlops*

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### Abstract

A cytological study showed that the diploid chromosome number in *N. typhlops* is  $2n = 20$ . All autosomes are submetacentric and three pairs are somewhat larger than the remainder. The male is the heterogametic sex, and the unpaired chromosomes are a submetacentric one (*X*) about the same size as the smaller autosomes, and a small acrocentric one (*Y*).

The cytological evidence suggests that *N. typhlops* is not closely related to either the Dasyuridae or Peramelidae, the marsupial families with which the Notoryctidae has been traditionally associated. The only marsupials with chromosomes resembling those of *N. typhlops* are some species of phalangeroids. The authors believe that *N. typhlops* would be better classified in a monotypic superfamily.

### Introduction

*Notoryctes typhlops* (the marsupial mole), the sole member of the family Notoryctidae, is a highly aberrant marsupial closely convergent to the eutherian golden moles (Chrysochloridae) of Africa. Its affinities are obscure because of the extreme specialization of virtually all of its morphological features and the absence of related fossil marsupials, and it has been considered to be either an aberrant dasyuroid or perameloid. The marsupial mole is widely distributed in sparsely inhabited desert regions of Australia in areas of sandy soils along river flats, or vegetated dunes. It does not appear to be excessively rare, but as it is largely subterranean and apparently leaves no burrow when moving through sandy soil, specimens are collected only on infrequent occasions when seen on the soil surface; live examples reach the hands of zoologists even more rarely. The acquisition of a live male specimen of *N. typhlops* from Finke River in the Northern Territory of Australia has enabled collection of material for chromosomal and serological studies. The specimen is preserved as a skin and skeleton in the collection of the CSIRO Division of Wildlife Research, Canberra, registered number CM 6010.

Chromosome number and morphology may give important clues on the relationships of marsupials, especially at the higher taxonomic levels (Sharman 1973). In this note the chromosomes of *N. typhlops* are described and compared with those of dasyuroid, perameloid and other marsupials (Fig. 1).

### Methods

Methods were similar to those used by Bick *et al.* (1973), except that 2 ml of 0.005% colchicine were injected intraperitoneally 2.5 h before the animal was killed, and the chromosomes were stained with Giemsa stain.

## Results and Discussion

The diploid chromosome number in *N. typhlops* was found to be  $2n = 20$  (Fig. 1C). Three pairs of autosomes are distinctly larger than the remainder and all are submetacentric. Members of one pair of the smaller autosomes have a secondary constriction in their short arms, presumably associated with the nucleolar organizer. The unpaired chromosomes are a submetacentric one (*X*) approximately the same size as the smaller autosomes and a small acrocentric one (*Y*). These are presumably the sex chromosomes, the male being the heterogametic sex as in other marsupials and in eutherian mammals.

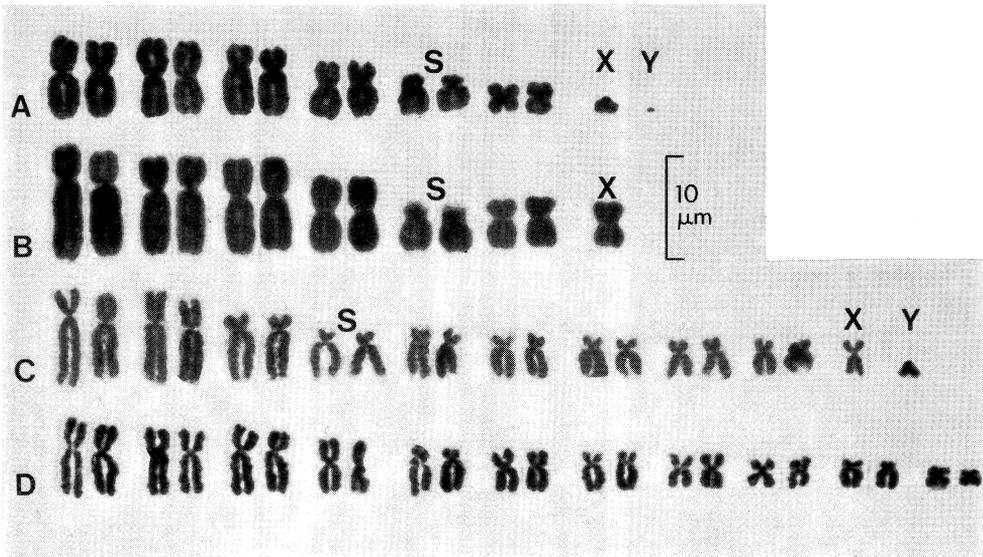


Fig. 1. Chromosomes of several marsupial species from preparations of bone marrow. (A) *Dasyurus hallucatus* ♂ (superfamily Dasyuroidea). (B) *Perameles nasuta* ♀ (Perameloidea). (C) *Notoryctes typhlops* ♂. (D) *Petaurus breviceps* ♀ (Phalangeroidea). S, chromosomes with secondary constrictions in their short arms; X, X chromosome; Y, Y chromosome. The scale applies to all karyotypes.

Of a total of about 50 Australian carnivorous and insectivorous marsupials (superfamily Dasyuroidea), 16 have been studied cytologically (Sharman 1973). All have a very uniform chromosome complement (Fig. 1A), namely a diploid number of 14, with small *X* chromosomes accounting for 3–4% of the haploid karyotype (Martin and Hayman 1967), and minute *Y* chromosomes. The *X* chromosome is uniformly acrocentric in contrast to the larger metacentric *X* chromosome found in *N. typhlops*. Secondary constrictions (S, Fig. 1) are found on the short arms of acrocentric autosomes of similar size (i.e. occupying approximately the same percentage of the haploid karyotype) but in other respects the karyotypes of dasyuroids and *N. typhlops* are quite dissimilar.

Eight species of bandicoots belonging to the subfamily Peramelinae have  $2n = 14$  (Fig. 1B) and one of the sex chromosomes of both sexes is eliminated from most somatic tissues (Hayman and Martin 1965; Hayman *et al.* 1969). Secondary constrictions are found on autosomes of similar size in *N. typhlops* and the 14-chromosome bandicoots, but there are few other karyotypic similarities. The submetacentric or

metacentric *X* chromosome of bandicoots constitutes 6–10% of the haploid karyotype and that of *N. typhlops* about 6%, but *X* elimination does not occur from bone marrow, or presumably from other somatic tissues, of *N. typhlops*. *Macrotis lagotis* (the rabbit-eared bandicoot), one of two living species that constitute the subfamily Thylacomyiinae, has 18 chromosomes in the female and 19 in the male and is derived from an ancestor with  $2n = 20$ . Inspection of the karyotype of *M. lagotis* (Martin and Hayman 1967) shows that it differs from that of *N. typhlops* in that the six smaller pairs of autosomes are acrocentric. *M. lagotis* has an  $XX^{\ominus}/XY_1Y_2^{\ominus}$  sex-determining mechanism derived by fusion of an ancestral acrocentric *X* chromosome onto a pair of autosomes, but the *X* chromosome of the apparently conventional  $XX^{\ominus}/XY^{\ominus}$  system of *N. typhlops* is submetacentric.

The Phalangerioidea (Australian diprotodont marsupials) is the largest and most diverse of the marsupial superfamilies recognized by Simpson (1945, 1970) and has the greatest range of chromosome numbers and morphology (Sharman 1973). The six species of the subfamilies Petaurinae and Pseudocheirinae thus far studied have between 16 and 22 chromosomes and two species have  $2n = 20$  (cf. *N. typhlops*). The chromosomes of *Petaurus breviceps* ( $2n = 22$ ) bear a remarkable resemblance, both in shape and size distribution, to those of *N. typhlops* (Fig. 1C cf. D).

The Notoryctidae was originally considered to be closest to the Dasyuridae (Gadow 1892) and most authors continue to follow this conclusion, although the view of Bensley (1903) that it is nearer to the Peramelidae has received some support. Simpson (1945) placed the Notoryctidae in the superfamily Dasyuroidea, but later (1970) thought that it might eventually warrant superfamily distinction. In his ordinal classification, Ride (1964) was unable to place the Notoryctidae and left it *incertae sedis*. Kirsch (1968), in another ordinal arrangement, placed the Notoryctidae in his order Polyprotodonta but listed it *incertae sedis* among the suborders. Several authors have shown that *N. typhlops* shares characters with other marsupial families or superfamilies, e.g. the organ of Jacobson is similar to that of the diprotodonts (Sweet 1904), the structure of the tympanic is more in agreement with that of diprotodonts than of any other marsupial group (Klaauw 1931) and Brunner's glands are similar to those of the bandicoots (Krause 1972). Gadow (1892) listed a number of shared characters and remarked that '*Notoryctes* has some characters in common with almost every other existing marsupial family'. In the radical new higher classification of mammals by Turnbull (1971), both marsupial (including *N. typhlops*) and placental forms with zalambdadont dentition are placed in an order Zalambdadonta on the stated grounds that greater weight is given to dental evidence than to 'reproductive (placental) development', a premise we do not accept.

The cytological evidence presented here suggests that *N. typhlops* is not close to either the Dasyuridae or Peramelidae. The resemblances of its chromosomes to those of petaurine (and possibly some pseudocheirine) phalangeroids may be due to parallelism but equally may indicate true affinity. Bensley (1903) expanded Dollo's (1899) studies of foot structure and concluded that the second and third digits showed evidence of syndactyly and that the pes of *N. typhlops* was derived from 'one of ordinary phalangerine type'. Bensley's studies on foot structure, together with evidence from other morphological features, such as a tendency to reduction in incisor number, the similarity of some organs to those of diprotodonts, and our observations on chromosomes, are indications that *N. typhlops* may indeed be a

highly specialized terminal offshoot on the stem leading from the polyprotodonts to the Phalangeroidea and possibly closer to the latter.

We agree with Simpson (1970) that ordinal classification of marsupials is premature because of the difficulties in placing *N. typhlops* and several other highly aberrant forms, and prefer his arrangement of a single order divided into superfamilies. We believe that *N. typhlops* would be better classified in a monotypic superfamily, which would be known formally as Notoryctoidea Ogilby, 1892.

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