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TAXONOMIC REVIEW OF THE GENUS *BANDICOTA* GRAY AND ITS SPECIES WITH A NOTE ON THE INTRASPECIFIC GEOGRAPHICAL VARIATION IN THE LARGE BANDICOOT RAT, *BANDICOTA INDICA* (BECHSTEIN) [MAMMALIA : RODENTIA]

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INTRODUCTION

Bandicoots are regarded as most serious pests, being responsible for food loss and damage to property (Patnaik 1969, Prakash 1976). A good number of taxonomic papers have been published on the genus *Bandicota* Gray and its species and subspecies. In the present paper a taxonomic review of the genus *Bandicota* and its species occurring in the Indian subcontinent was made. Moreover, during the ecological study of *Bandicota indica* (Bechstein) by the first author, a huge number of specimens were collected from different parts of West Bengal. Based on this material, as well as specimens from all over India present in the Zoological Survey of India and Bombay Natural History Society, a study on the intraspecific geographical variation in *B. indica* was made.

All measurements are given in millimetre and taken according to Ellerman (1961). However, external measurements of earlier material are noted from the labels attached to them. Colours given with initial capital letters in the test have been recognised according to Ridgway' s (1886) nomenclature. Population range diagrams have been prepared according to the methods of Dice and Leraas (1936) and Hubbs and Perlmutter (1942).

TAXONOMIC REVIEW

Bandicoots were first separated from Rats (*Mus*) by Gray (1842) under the generic name *Nesokia*. Later, Gray (1873) coined the genus *Bandicota*. Thomas (1907) divided the genus *Nesokia* into three genera and provided the following key :

A) Size small, tail very short, less than two-third of head and body, mammae 2-2 =8 . Skull short and broad; palatal foramina short ..... *Nesokia* Grey

B) Size small ; tail fairly long more than two-third of head and body ; mammae irregular (14-18). Skull broad; palatal foramina long ..... *Gunomys* Thomas

C) Size large; tail long, almost as long as head and body ; mammae 3 -3 = 12. Skull long and narrow; palatal foramina long ..... *Bandicota* Grey

Wroughton (1908) followed the treatment of Thomas (*op. cit.*) and recognised altogether six species under the genus *Bandicota, viz., B. gigantea, B. malabarica, B. setifer, B. elliotana , B. indica and B. nemorivaga.* Thomas (1916) and Kloss (1919) described three more species under the genus, *viz.*, *B. savilei*, *B. mordax* and *B. siamensis*

respectively. Kloss (1921) after comparing the characteristics of the genera *Bandicota* and *Gunomys*, opined that the differences were hardly of generic rank and *Gunomys* must be treated as a synomym of *Bandicota*. Ellerman (1941) also regarded *Gunomys* as a synonym of *Bandicota* and listed as many as eight species under it, *viz.*, *B. bengalensis*, *B. gracilis*, *B. indica*, *B. nemorivaga*, *B. savilei*, *B. gigantea* and *B. malabarica*. Later, based on detailed work with huge material present in the British Museum, Ellerman (1947) recognised only two species under the genus and provided the following key :

1(2) Bullae smaller, usually less than one- fifth of occipitonasal length; nasalsmore than one - third of occipitonasal length as a rule; length of palate usually less than 60% of occipitonasal length; occipitonasal length varies between 46 and 68 mm; braincase as a rule proportionately by narrow. .....*B.indica* (Synonym : *B. gigantea*, *B. savilei* , *B.* siamensis *B. nemorivaga*, *B. malabarica*).

2(1) Bullae larger, normally exceed one-fifth of occipitonasal length ; nasals as a rule less than one -third of occipitonasal length ; length of palate normally more than 60% \of occipitonasal length; occipitonasal length varies between 35 and 49 mm; braincase proportionately wider ..... *B. bengalensis* (Synonym : *B. gracilis*) .

Moreover, Ellerman (*op. cit.*) from the study of coloration and external measurements of the different geographical populations of the above two species in the Indian subcontinent, recognised altogether five subspecies of *B. bengalensis*, *viz.*, *B. b. bengalensis*, *B. b. kok*, *B. b. wardi*, *B. b. varius* and *B. b. gracilis*, and three subspecies of *B. indica*, *viz.*, *B.i indica*, *B. i. nemorivaga* and *B. i. savilei*. Agrawal and Chakraborty (1976) with the help of statistical analysis of the voluminous data available to them, studied the nature and trend of variability of the different geographical populations of *B. bengalensis* and recognised only three subspecies, synonymising *B. b. kok* and *B. b. gracilis* with the nominate subspecies. However, no such detail study with the different geographical populations of *B. indica* was conducted after the revisionary work of Ellerman (*op. cit.*) . Tiwari *et al.* (1971) revived *B. i. malabarica* as a separate subspecies from *B. i. indica* on the basis of larger head and body, hind foot, tail, ear and occipitonasal length. From the study of chromosomes, haemoglobin, external and cranial measurements of the specimens from Goregaon and Malad in Bombay, Deoras and Pradhan (1977) opined that *B. gigantea* which was considered as a synonym of *B. i. indica*, should be regarded as a distinct species or at least subspecies of *B. indica*. Marshall (1977) regarded *savilei* as a distinct species of the genus *Bandicota* on the colour and cranial characters. Dr. D. H. Johnson, Dr. M. Bahmanyar and Dr. G. G. Musser are also of the same opinion (personal communication to Dr. Marshall). Honacki *et al.* (1982) in the Mammal species of the world also listed three species of the genus *Bandicota*, *viz.*, *B. bengalensis*, *B. indica* and *B. savilei*. However, the last one does not occur within the Indian territory.

INTRASPECIFIC GEOGRAPHICAL VARIATION IN *BANDICOTA INDICA* (BECHSTEIN)

On the background of above knowledge and having advantage of good series of specimens, it was felt necessary to study in detail the intraspecific geographical variations

in *B. indica*. Altogether, 529 specimens from different parts of the country were examined. In addition, measurements given by Ellerman (1961) have also been included for statistical analysis. The results obtained are summarised below.

Colour and nature of fur : Dorsum of the specimens of *B. i. nemorivaga / elliotana* from the rural region of its range (Thakurpukur, Memari, Sagar Island of West Bengal) is blackish brown, black being prominent; underwool slate grey; fur moderately sparse and harsh in most of the specimens, while spiny in a few; many long, stiff and black hairs present in the mid dorsum; sides lighter, smoke grey or drab grey; chin and undersurface of limbs sparsely haired, but rest of the undersurface covered with thick, short hairs; hairs basally smoke grey, apically pale bluish or whitish with a light blue tinge giving an effect of light bluish when seen from a distance; tail wholly dark; covered with thin, minute spiny hairs particularly on the upper surface; hands and feet wholly dark, except at the bases of nails where minute whitish markings could be noticed.

Specimens of *nemorivaga / elliotana* from the urbanised area of their range (Calcutta, Howrah of West Bengal) are similar to the above description, but instead of black, brown is predominent on the dorsum. Moreover, dorsal hairs are relatively more spiny. No fresh specimens of *nemorivaga / elliotana* from northern Bihar, Assam, Nepal of Nurma could be examined. Old specimens from these localities present in the Zoological Survey of India collection tally with the Calcutta and Howrah specimens, but the undersurface is light grayish or yellowish instead of bluish.

Only the old specimens from the range of *indica / malabarica / gigantea* collected from the different localities of Rajasthan, Gujarat, Uttar Pradesh, Madhya Pradesh, Ardhra Pradesh, Orissa, southern Bihar, Goa, Maharashtra, Karnataka, Tamil Nadu, Kerala and Sri Lanka could be examined. Not much geographical variation in the coloration could be marked except that the specimens from northern India tend to be slightly paler on average than those of southern India. However, dorsum is almost light brown with some blackish patch in some specimens irrespective of geographical range. Specimens of *indica / malabarica / gigantea* particularly those collected in summer or monsoon are very poorly haired and much spiny as compared to those from the range of *nemorivaga* or *elliotana* of the same season. A crest of very long and stiff hairs along the mid-dorsum region is much prominent. Sides almost similar to the dorsum in colour but hairs are very short. Undersurface is very sparsely haired and often naked skin could be seen; colour varies from smoke grey to drab grey. Tail, hands and feet similar to that of the *nemorivaga* and *elliotana* specimens.

External measurements : Specimens of *B. indica* from all the areas of its range are very large and not much difference could be marked among the different populations (Table 1, Page 99). Tail is relatively short in the specimens from the range of *nemorivaga/ elliotana* and in 408 out of 463 measureable specimens, it is shorter than head and body, while the tendency is reverse in the specimens from the range of *indica, gigantea* and *malabarica*, tail being longer than head and body, exception in being 24 out of 64 measureable specimens. However, the difference in the relative or absolute length of the tail between the two groups does not hold good even at one standard deviation (Fig. 1, 2). Relative as well as absolute lengths of the hind foot in *nemorivaga / elliotana* specimens

are less than those of the *indica / malabarica / gigantea* specimens, but again the difference does not hold good even at one standard deviation (Fig. 3).

Cranial characters : Skulls of the specimens from West Bengal, northern Bihar, Assam, Nepal and Burma or in other words from the range of *nemorivaga / elliotana* are very large (occipitonasal 57 ± 1.2) and narrow; base of the skull moderately lengthened so that condylobasal length on average slightly less (56.7 ± 2.4) than occipitonasal and out of 398 measureable skulls only in 48, condylobasal exceeds the occipitonasal length. Nasal is moderately long (20.3 ± 1.2) being 35.8 ± 2 per cent of the occipitonasal. Palate is well over half of the occipitonasal (32.6 ± 2) Anterior palatal foramen is long and in most specimens reaching up to the molar toothrow Zygoma is broad and very powerful. Orbit is large (21.5 ± 1.36). Frontal and parietal are powerfully ridged; ridges extending to the occiput. However, on the posterior part of the parietal, the degree of development of ridges varies from specimen to specimen and is somewhat related to the age. Interparietal is well-developed, rectangular in outline and though in most of the specimens sutures are obliterated, yet demarkating lines could be marked. Dental features agree with the description given by Ellerman (1961). Colour of incisors varies from whitish to orange.

Skulls from the range of *gigantea* (Rajasthan, Gujarat, Uttar Pradesh, parts of Madhya Pradesh), *indica* (Pondicherry, parts of Kerala, Karnataka and Tamil Nadu) and *malabarica* (remaining part of peninsular India and Sri Lanka) are very large and do not differ from each other in the structure. However, the skulls from the range of *indica* are slightly smaller than of the other two on average (occiptonasal : *indica* 56.3 ± 3.2, *gigantea* 61.1 ± 51.1, *malabarica* 59 ± 2.5), but the difference is not significant (Fig. 4). Base of the skull is so lengthened in all of them that condylobasal length is slightly longer than occipitonasal length (condylobasal : *indica* 56.86, *gigantea* 61.24 ± 4, *malabarica* 59.59 ± 3.2) except in four out of 20 skulls with measureable condylobasal. Rostrum is much elongated so that the absolute length of nasal (nasal : *indica* 22.5 ± 0.8, *gigantea* 24.4 ± 2, *malabarica* 24.5 ± 1.1), as well as the relative length of the nasal (nasal as percentage of occipitonasal : *indica* 39.6 ± 1.5, *gigantea* 39.8 ± 1.7, *malabarica* 41 ± 1.2) differ significantly from that of *nemorivaga /elliotana* specimens (Fig. 5,6). Zygoma is relatively narrow and less powerful. Relative length of bullae in all of them on average is shorter than that of *nemorivaga / elliotana* (Table 1). Interparietal is distinct but less developed and almost triangular in outline.

From the above study it is obvious that the supposed size differences between the *B. i. indica* and *B. i. malabarica* are nothing but individual or age variations as the specimens from the same locality in the range of *malabarica* show the same degree of variation between the smallest and largest specimens. Ellerman (1947) also found that "the difference between the smallest *malabarica* skull and largest of the Nilgiri specimens is much smaller than that between the smallest and largest specimens of '*malabarica*' which varies in our material between 56.2 mm and 68.7 mm" From table 1 it is also found that the differences in the head and body, hind foot and ear lengths between the specimens of *indica* and *malabarica* mentioned by Tiwari *et al.* (1971) do not hold good for the subspecific differentiation. Thus, I agree with the Ellerman's (1947) view that *malabarica* is nothing but a synonym of *indica*. The external measurements of the specimens from the range of *gigantea* including the type show that they are relatively larger than the

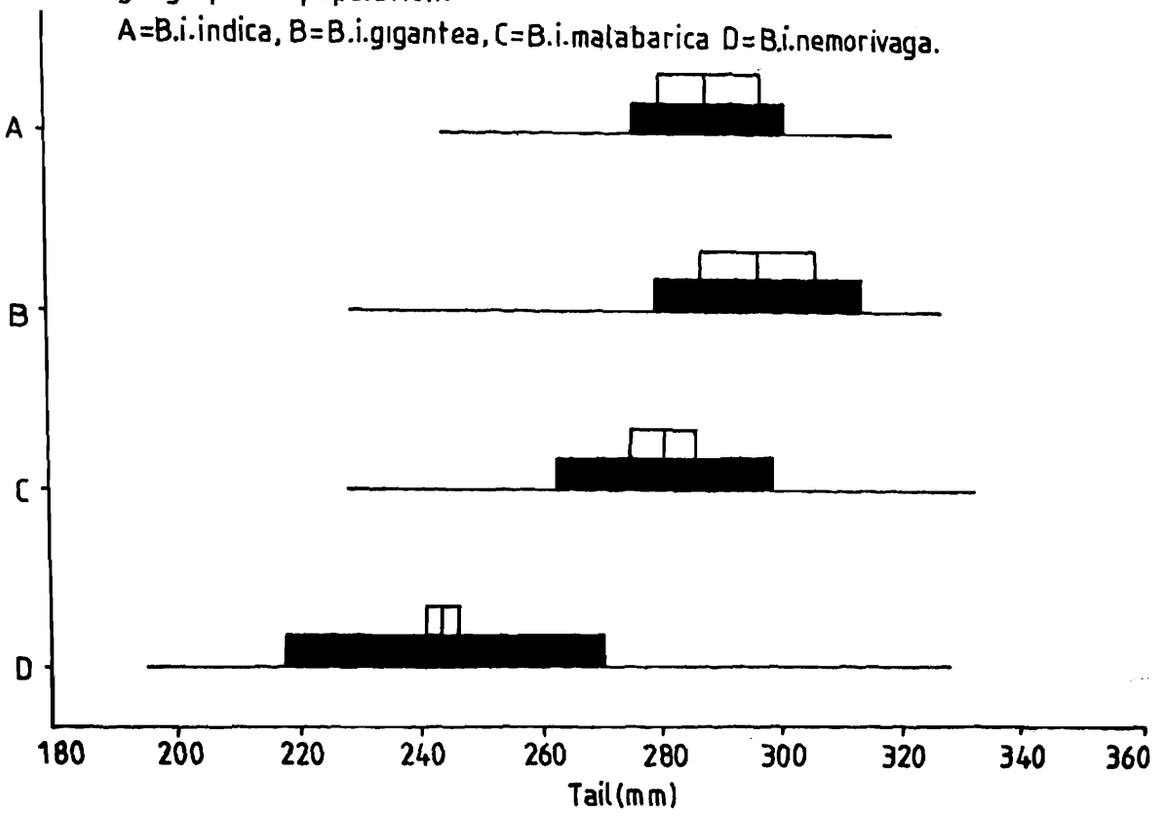
specimens from the range of *indica* or *malabarica* (Table 1). However, only one or two specimens are available from each locality within the range of *gigantea* except in Kathiawar where a series of seven specimens were found. The series from Kathiawar shows similar range of size variation like the specimens of *malabarica* in many of the localities. Moreover, equally giant or large specimens along with relatively smaller ones are also found in the same ecological niche at Sagar Island.

Deoras and Pradhan (1977) opined that in Bombay, there are two species or at least subspecies of large bandicoot rat, *viz.*, *gigantea* (larger ones), and *indica* (smaller ones), and each has a different niche in the ecosystem. Pradhan *et al.* (1989) regarded *gigantea* as a distinct species. Their conclusion was supported from external and cranial measurements as well as karyological and haemoglobin studies. But as it is obvious that the size variations among the specimens of the same population *Bandicota indica* is too high, it is not worthwhile to designate larger specimens as *gigantea* and smaller as *indica*. Moreover karyological and haemoglobin studies should also be carried out with specimens of different sizes from other parts of the country to draw conclusion about the status of *gigantea*. At the moment owing to lack of any definite external or cranial characteristics, it is worthwhile to maintain *B. indica gigantea* as synonym of *B. i. indica*. Wroughton (1908) maintained *elliotana* as a distinct species from *nemorivaga* on the basis of almost blackish dorsum against brown of the latter. As the specimens from different localities within the range of *elliotana* and *nemorivaga* show considerable colour variation from brown to black, the separation of the two on the basis of colour is not possible and Ellerman (1947) is justified in synonymizing *elliotana* with *nemorivaga*. The specimens of *nemorivaga* (with *elliotana*) differ from the specimens of *indica* (with *malabarica* and *gigantea*) by the combination of a number of characters, like average smaller size, nature of fur, colour of the undersurface, relative length of tail and condylobasal, relative and absolute length of the nasal and shape of the interparietal. Though number of differentiating characters are many and one may incline to give them separate species rank, but most of the characters are on average and there is considerable overlap in each character. From the figures 5 and 6 it is obvious that only the difference in the absolute and relative length of the nasal between the *B. i. nemorivaga* (*elliotana*) and *B. i. indica* (along with *gigantea* and *malabarica*) are significant for subspecific differentiation. Thus, within the Indian range only two subspecies of *B. indica* ,*viz.*, *B. i. indica* and *B. i. nemorivaga* should be maintained on the basis of nasal length. Within the Indian limit, former ranges from eastern Rajasthan and Uttar Pradesh, south to Kerala and Tamil Nadu and east to Southern Bihar, while the latter ranges from northern Bihar and West Bengal, east to Manipur. Synonyms of the two subspecies are as follows :

Bandicota indica indica (Bechstein)

Mus indicus Bechstein, 1800. *Uber Vierf. Thiere*, 2 : 497.
Mus bandicota Bechstein, 1800. *Uber Vierf. Thiere*, 2 : 498.
Mus malabarica shaw, 1801. *Genl. Zool.*, 2 : 54.
Mus perchal shaw, 1801. *Genl. Zool.*, 2 : 55.
Mus giganteus Hardwicke, 1804. *Trans. Linn. Soc. Lond.*, 7 : 306.

Fig.1. Graphic comparison of the length of tail in different geographical population.
A=B.i.indica, B=B.i.gigantea, C=B.i.malabarica D=B.i.nemorivaga.



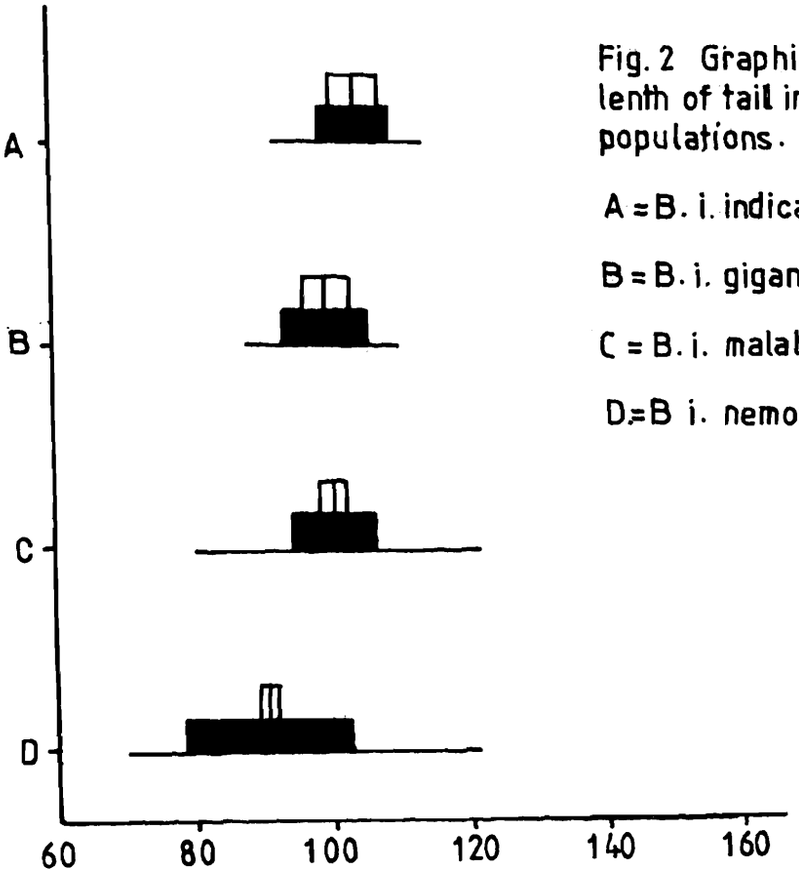


Fig. 2 Graphic comparison of the relative lenth of tail in different geographical populations.

A = B. i. indica.

B = B. i. gigantea

C = B. i. malabarica

D=B i. nemorivaga

Fig.3. Graphic comparison of the absolute and relative length of hind foot in different geographical population.
A=B.i.indica, B=B.i.gigantea, C=B.i.malabarica, D=B.i.nemorivage.

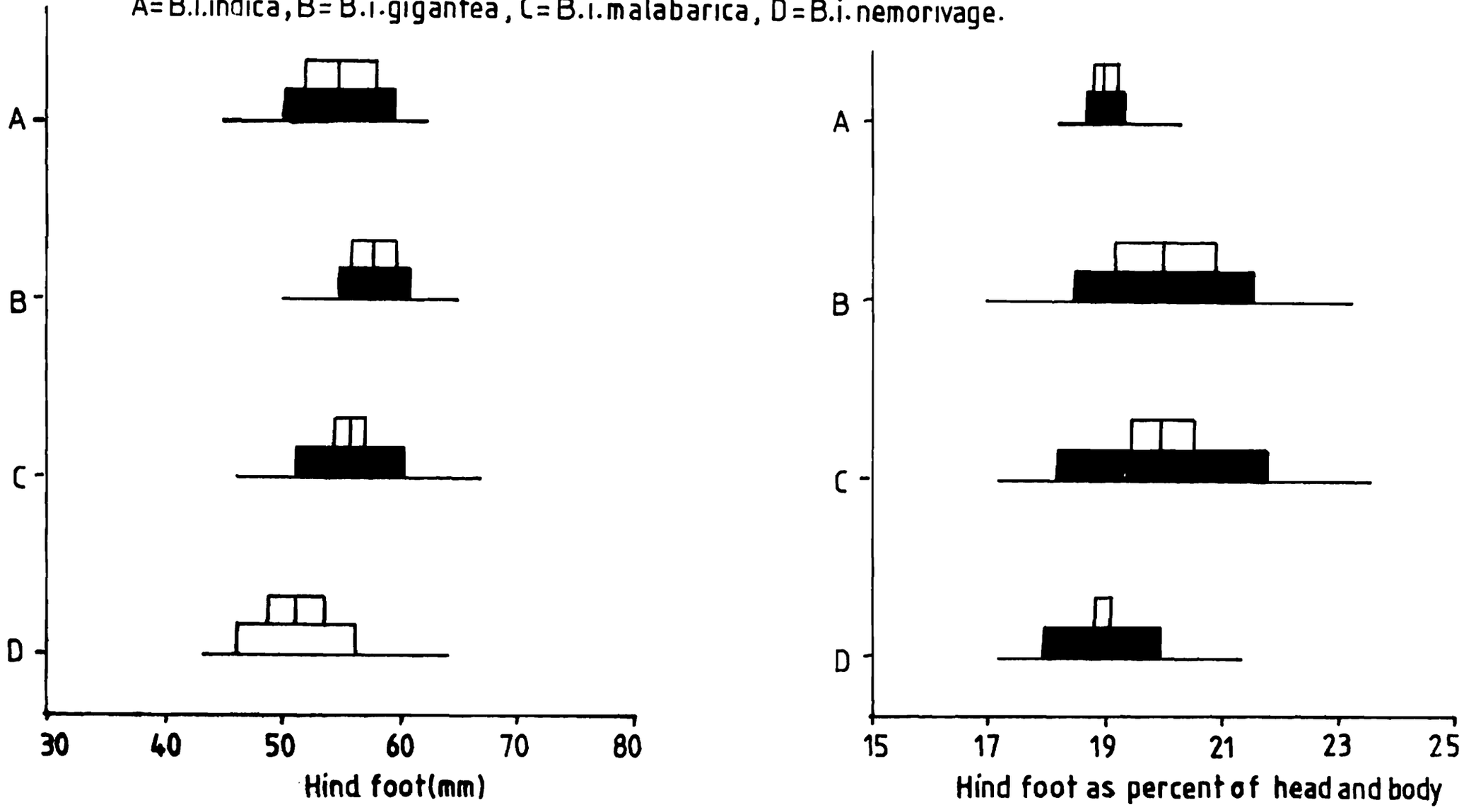


Fig. 4. Graphic comparison of occipitonasal length in different geographical populations.
A = B.i. indica, B = B.i. gigantea, C = B.i. malabarica, D = B.i. nemorivaga.

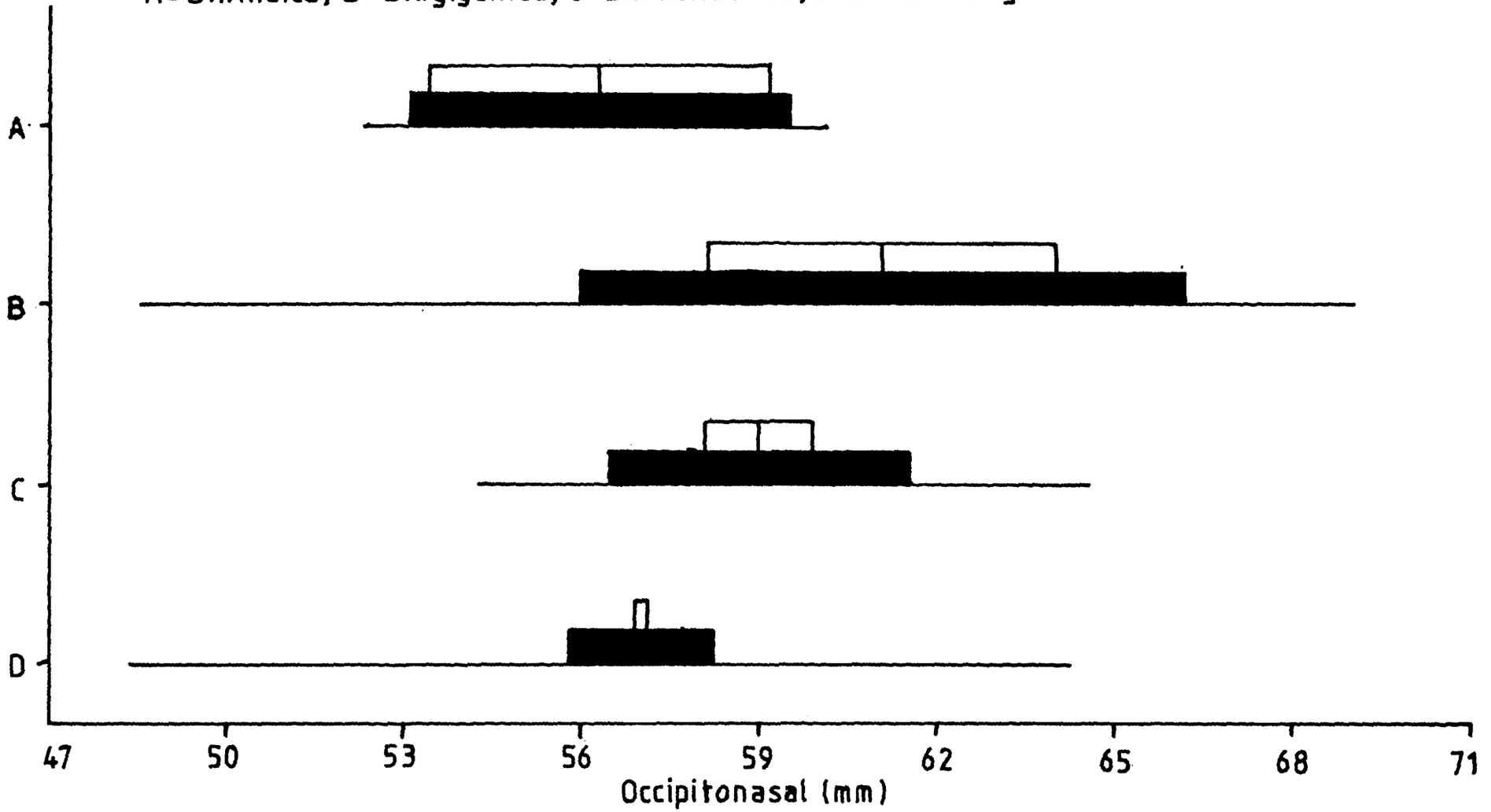


Fig.5.Graphic comparison of nasal length in different geographical populations.

A= B.i. indica, B= B.i. gigantea, C= B.i. malabarica, D= B i nemorivaga.

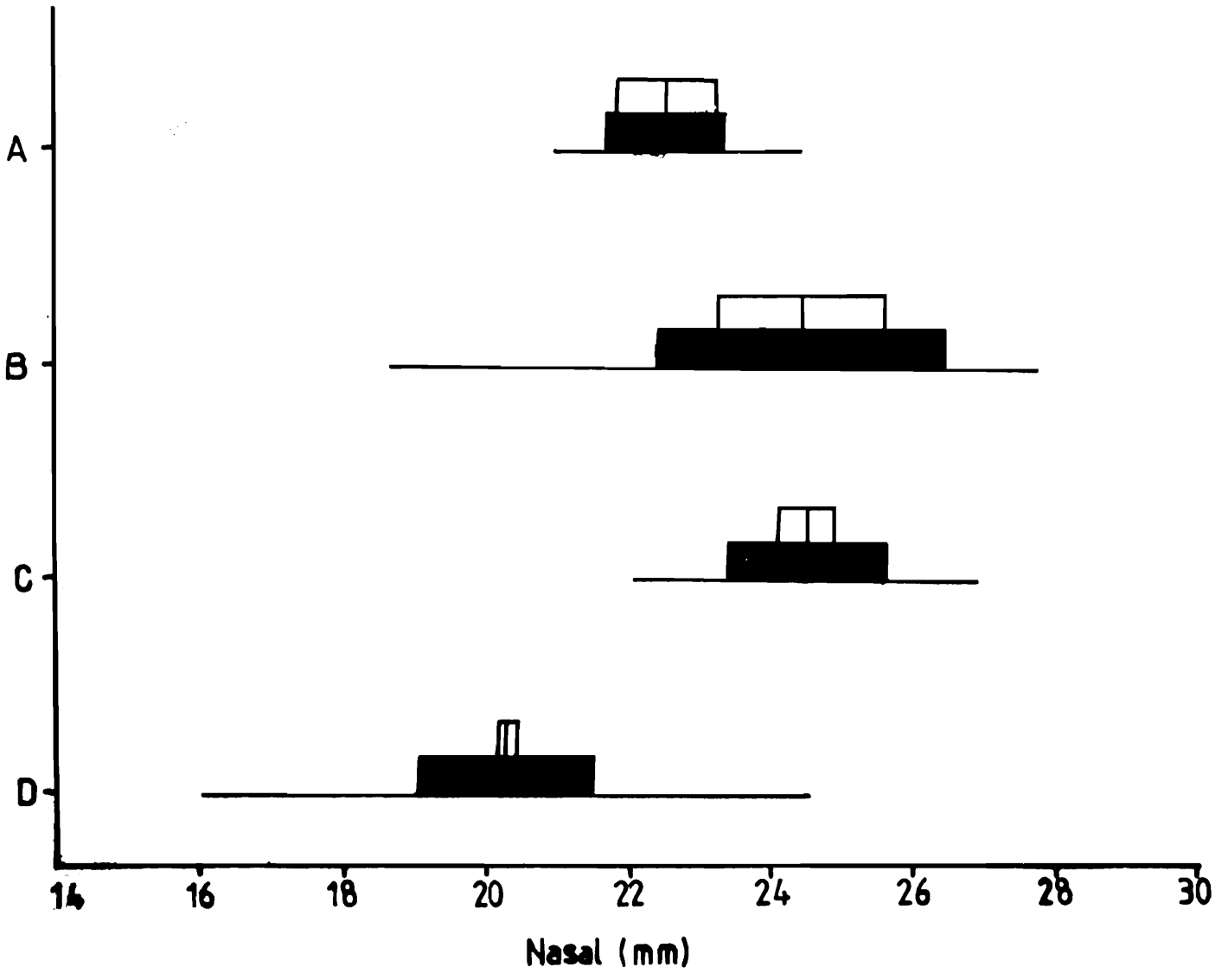
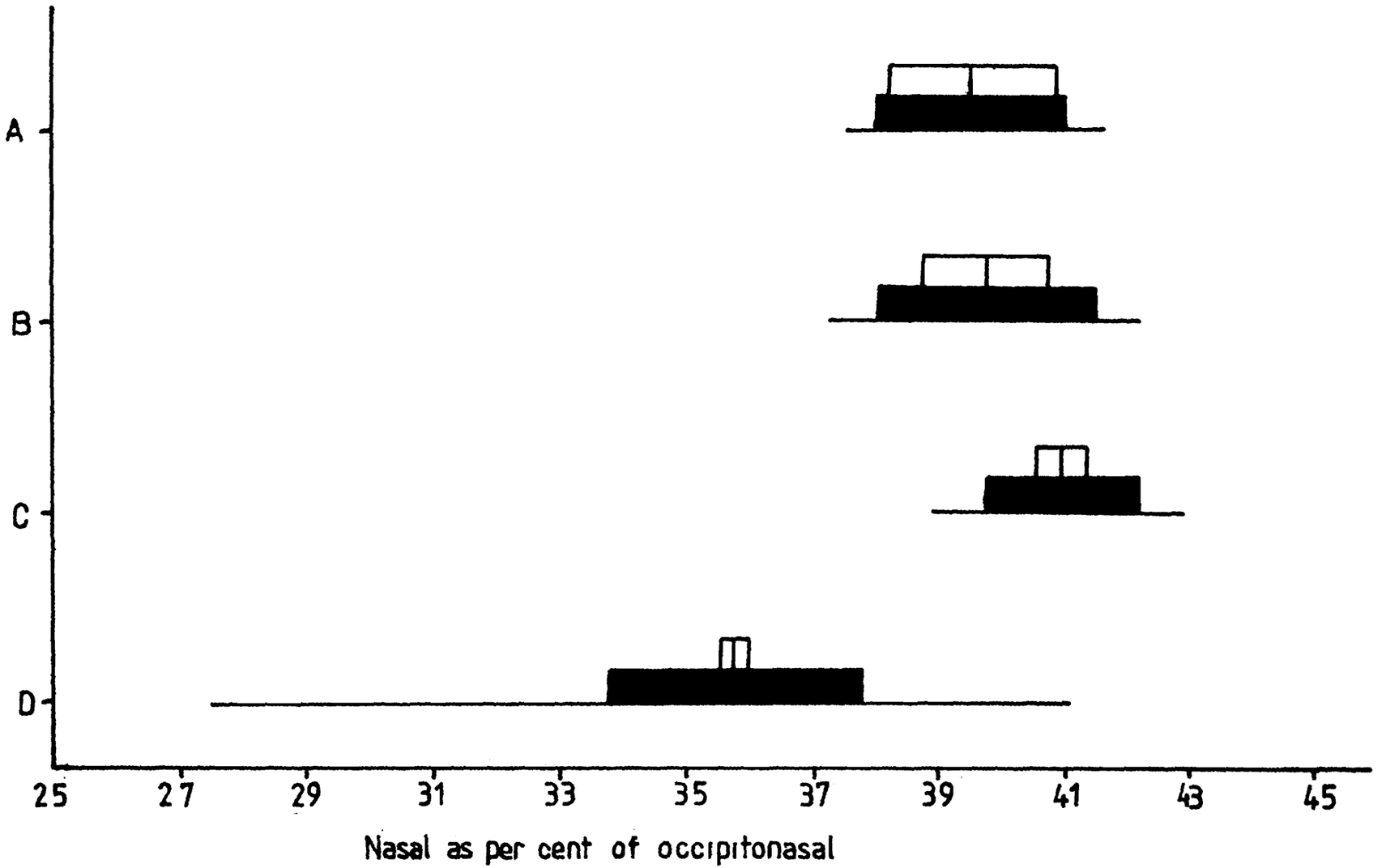


Fig. 6. Graphic comparison of relative length of nasal in defferent geographical population A=B. i. indica, B=B. i. gigantea C. B. i malabarica, D= B i. nemorivaga.



Bandicota indica nemorivaga Hodgson

Mus (Rattus) nemorivagus Hodgson, 1836. *J. Asiat. Soc. Beng.*, 5 : 234.
Mus macropus Hodgson, 1845. *Ann. Mag. nat. Hist.*, 15 : 268.
Mus (Nesokia) elliotanus Anderson, 1878. *J. Asiat. Soc. Beng.*, 46 : 231.
Mus Kagii Kuroaka, 1912. *J. nat. Hist. Soc. Taiwan*, 6 : 7. *nom. nud.*
Bandicota mordax Thomas, 1916. *J. Bombay nat. Hist. Soc.*, 24 : 642.
Rattus eloquens Kishida, 1926. *Kyozal no Konponteki Kenkyu*, 144.
Nesokia nemorivaga taiwanus Tokuda, 1941. *Buogeog. Tokyo*, 4 : 74.

SUMMARY

A taxonomic review of the genus *Bandicota* and its species was made. Intraspecific geographical variation in *B. indica* was studied. It was found that differentiating characters among most of the subspecies are marked with individual variations. However, on the basis of nasal length two subspecies ,*viz.*, *B. i. indica* and *B. i. nemorivaga* can be distinguished within Indian limit.

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Table 1. External and cranial measurements of different geographical populations of ***Bandicota indica***. S. D. = Standard deviation. n=Sample size, Figures in parentheses indicate mean values.

Name	Head and body	Tail	Tail as percent of head and body	Hind foot	Ear	Occipitonasal	Condylobasal
B.i. indica	245-305 (278) n=8 S.D.=17	*245-315 (289) n=8 S.D.=12	92-109 (104) n=8 S.D.=5	45-60 (55) n=8 S.D.=4.5	30-34 (31.5) n=8 S.D=1.2	52.7-60.5 (56.3) n=5 S.D.=3.2	156.86 n=1
B.i. gigantea	209-366.6 (300) n=13 S.D.=24	**229-330.2 (297) n=13 S.D.=17	90.5-111.5 (99.5) n=13 S.D=6	50-63 (58) n=12 S.D.=3	28-39 (31) n=12 S.D.=3.5	48.5-68.7 (61.1) n=12 S.D.=5.1	+ 49-66.9 (61.24) n=4 S.D.=4
B.i. malabarica	205-345 (280.5) n=44 S.D.=21	π210-340 (281) n=43 S.D.18	83-122 (100.4) n=43 S.D.=6	48-70 (56) n=44 S.D.=4.5	26-43 (32) n=44 S.D.=5	54.8-66.3 (59) n=33 S.D.=2.5	@ 55-64 (59.59) n=15 S.D.=3.2
B.i. nemorivaga	210-335 (269) n=464 S.D.=24	ππ 185-317 (244) n=463 S.D.=26	72-118 (90.5) n=463 S.D.=12	46-60 (51.5) n=463 S.D.=5	20-40 (27.5) n=464 S.D.=5.5	48.3-64.1 (57) n=421 S.D.=1.2	$ 47.2-63.4 (56.7) n=398 S.D.=2.4

* In one specimen tail shorter than head and body ; ** In six specimens tail shorter than head and body ; π In 17 specimens tail shorter than head and body ; ππ In 408 specimens tail shorter than head and body ; 1 Condylobasal more than occipitonasal ; + Condylobasal more than occipitonasal in all the four specimens ; & In 11 specimens Condylobasal is greater than occipitonasal ; $ In 48 specimens Condylobasal is greater than occipitonasal.

Name	Condylobasal as percent	Palate of occipitonasal	Nasal of occipitonasal	Nasal as percent	Palatal foramen	Bullae	Bullae as percent of occipitonasal	Upper toothrow
B.i. indica	101.2	31.7-35.6 (33.4) n=5 S.D.=1	20.3-24.4 (22.5) n=5 S.D.=0.8	37.6-41.7 (39.6) n=5 S.D.=1.5	10.2-11.7 (10.9) n=5 S.D.=0.3	8.8-10.1 (9.5) n=5 S.D=0.4	16.6-16.7 (16.65) n=5 S.D.=0.01	9.2-10.9 (9.37) n=5 S.D.=0.4
B.i. gigantea	100.5-103 (101.32) n=4 S.D.=0.4	25.4-38.9 (35.16) n=12 S.D.=3	18.6-27.7 (24.4) n=12 S.D.=2	38.3-42.4 (39.8) n=12 S.D.=1.7	9.1-12.1 (11.25) n=12 S.D.=1	8.9-11 (9.98) n=11 S.D.=0.6	15.3-18.3 (16.53) n=11 S.D.=0.3	9.5-11.4 (10.57) n=11 S.D.=0.6
B.i. malabarica	98.5-103 (100.83) n=15 S.D.=0.6	30.5-39.6 (35) n=27 S.D.=2.3	22-27 (24.5) n=32 S.D.=1.1	38.9-43.4 (41) n=32 S.D.=1.2	10-12.7 (11.48) n=28 S.D.=0.6	8.6-10.7 (9.88) n=26 S.D.=0.3	14.4-18.5 (16.43) n=26 S.D.=0.7	9.4-11.6 (10.2) n=27 S.D.=0.4
B.i. nemorivaga	97.4-102.4 (99) n=398 S.D.=0.8	28.3-36.7 (32.6) n=416 S.D.=2	16-25 (20.3) n=421 S.D.=1.2	27.4-41 (35.8) n=421 S.D.=2	8.7-11.6 (10.3) n=416 S.D.=0.7	8.5-11.5 (9.7) n=402 S.D.=0.6	15.4-18.9 (17.4) n=394 S.D.=1.1	8.2-10.6 (10.3) n=409 S.D.=0.7