

SMALL CARNIVORE CONSERVATION

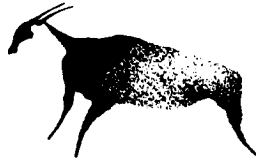


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Binturong (*Arctictis binturong*). Photo by J.W. Louwman, Wassenaar Wildlife Breeding Centre, Holland.



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Morphometric variation in the Badger (*Meles meles*): Clinal variation in cranial size and shape across Eurasia

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The Eurasian badger (*Meles meles*) currently occupies most of the woodland and steppe zones of the Palaearctic. The northern limit of the species range is about 65° in Scandinavia, whilst the southern boundary runs through Palestine, Iran, Tibet, and southern China. The species has a subalpine distribution (below 1,600-1,700 m; Henry et al., 1988) within these regions and only rarely penetrates the Arctic Circle. Insular populations are found in Ireland, Britain, Sicily, Crete, Rhodes, Korea, and Japan (Corbet, 1978).

Despite this widespread Palaearctic distribution, there have been few studies of osteometric variation across the range of the species. Geographical variation is known to be considerable but there has been little consolidated examination of this variation. Ellerman & Morrison-Scott (1951) recognise 24 subspecies, while Long & Killingley (1938) retain 15 subspecies, but recommend that systematic revision was very much necessary. Most published studies have examined temporal variation since the end of the Pleistocene (Degerböl, 1933; Kurtén, 1965, 1967; Clutton-Brock, 1990; Grundbacher et al., 1990). These studies have found a general increase in the mean size of cranial and dental measurements over the last 10,000 years. Other studies have presented data on variation within restricted geographic areas. For example, Hell & Paule (1989) provide an examination of variation patterns within 210 crania from the Slovak Carpathians. In addition to comparing their data to other published univariate studies they offer an examination of sexual dimorphism within the species, concluding that, although the crania of males were significantly larger than those of the females, it was impossible to sex specimens accurately on the basis of cranial morphology, echoing the results of Hysing-Dahl (1954). Wiig (1986) re-examined Hysing-Dahl's data using a combination of various multivariate statistical methods, and found that, although there were size differences between the sexes, the primary difference was one of shape.

Lynch (1993) provides an analysis of craniometric variation among badgers from Europe. Substantial variation was found both in gross craniometry between populations from Ireland, England, Scotland, Czechoslovakia, and Norway, and in the degree of cranial sexual dimorphism exhibited within these

populations (Lynch, in prep.). As part of this study, an attempt was made to quantify variation in the species across Eurasia. Crania of adult specimens were examined in museum collections throughout the British Isles. In total, 347 crania were available from 14 countries, with samples belonging to six putative subspecies, namely: *M. m. meles*, *M. m. marianensis*, *M. m. anakuma*, *M. m. leptorhynchus*, *M. m. ponticus*, and *M. m. tianschanensis* (Ellerman & Morrison-Scott, 1951). Eleven standard craniometric measurements were taken from each specimen and population means obtained separately for males and females. These data were log-transformed, and subjected to a principal component analysis (separately for each sex).

Full details of these procedures are given in Lynch (1993), suffice it to say that this analysis results in new variables (principal components) that allow the separation of size and shape variation. The analysis demonstrates the significant morphological variation in the badger across its Eurasian range. Male badgers could be differentiated both in skull size (PC1, 93.0% of total variation; Fig. 1), and relative skull breadth independent of size (PC2, 4.9% of variation). There was a general clinal trend in this variation, with western badgers having larger, relatively broader skulls and eastern badgers having small, relatively narrow skulls. Japanese specimens were characterised as having short skulls which were relatively as broad as those from western specimens. A similar pattern of variation exists for female badgers (Fig. 2).

Badger subspecies have traditionally been described on the basis of coat colour, form of the head stripe and presence or absence of the vestigial first premolar (Long & Killingley, 1983). While it must be recognised that further study is required, it would appear that East-West clinal variation occurs across Eurasia and the sole cranially distinct form occurs in Japan, although the sample sizes must be recognised as being rather small. Thus, *Meles* may be represented by two subspecies, the nominate form (occurring throughout Eurasia) and *M. m. anakuma* in Japan. Indeed, the results of this analysis also support the elevation of *M. m. anakuma* to specific status (as proposed by Baryshnikov & Potapova, 1990), giving two allopatric species in the genus *Meles*.

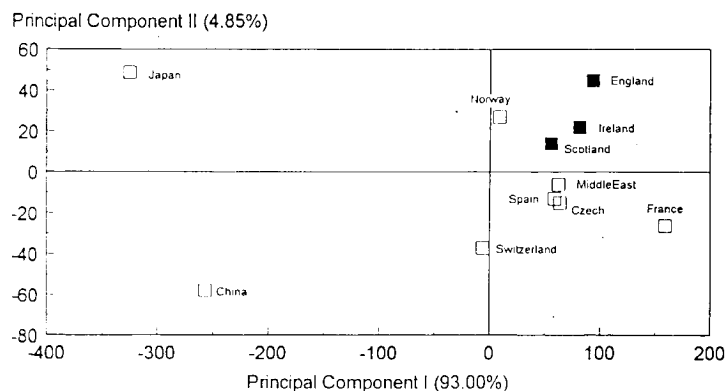


Fig. 1. Separation of male badger specimens on the basis of the first two principal components extracted from log-transformed population means.

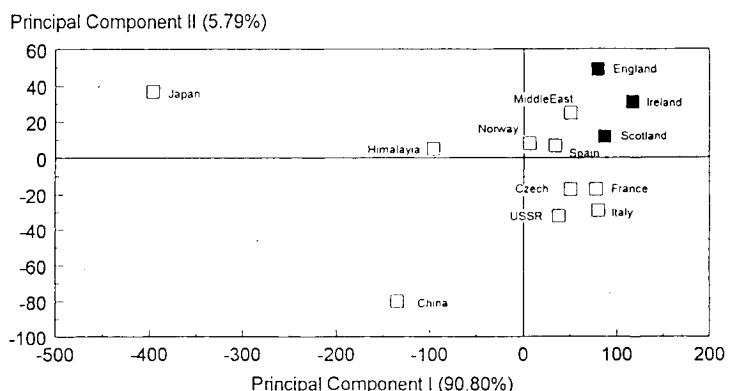


Fig. 2. Separation of female badger specimens on the basis of the first two principal components extracted from log-transformed population means.

There is no craniometric evidence for the proposed subspecific status of British Isles populations as *M. m. britannicus* Satunin, 1906, thus following the observations of Miller (1912) and Dadd (1970). As Long & Killingley (1983) note, many of the named 'kinds' of badgers are merely localised phenotypes of 'family' groups, insignificant microgeographic variants or intergrades between races. A conservative taxonomic revision will likely show that they are synonyms.

Meles appears to have evolved in the temperate forests of Asia and to have spread westwards into Europe. Thorali's badger (*M. thorali*) is evidently ancestral to modern Asian and European populations (Kurtén, 1968). By the early Middle Pleistocene, fossil forms were very similar to modern specimens, both in Asia and Europe (Kurtén, 1968). One can envisage a scenario by which ancestral populations migrated across Asia and Europe, increasing in size in response to favourable interglacial conditions (as may have occurred in other species; Geist, 1971, 1987; Endler, 1977; Thurber & Peterson, 1991; Hewitt, 1993). Similar clinal variation occurs in head pattern, resulting in three distinct geographical groups (Long & Killingley, 1983). The increase in size would appear to have occurred across both space and time (Degerböl, 1933; Kurtén, 1965, 1967; Clutton-Brock, 1990; Grundbacher et al., 1990).

Norwegian populations apparently originated from Denmark, whilst those in Finland originated from the southeast (Kurtén, 1968). British populations presumably colonised *via* the now submerged late glacial forest tundra of the North Sea (Starkel, 1977; Griffiths, 1993). The origin of the Irish populations has been discussed in Lynch (1993) and Lynch & Hayden (1993), and there appears to be some evidence for human-aided colonisation of the island during post-glacial times (rather than colonisation *via* a landbridge as previously assumed).

It is of note that variation among badgers in the British Isles is as great as variation between these populations and populations in mainland Europe (Lynch, 1993; in prep.). This, together with the distinctiveness of the Japanese population, shows the relative importance of peripheral isolates as sources of novel morphotypes (and one assumes, genotypes). Further study of other island badger populations is of interest to general theories about the role of peripatric populations in macroevolution (Mayr, 1963; Bush, 1975; Frey, 1993).

Further systematic studies within the genus are likely to have implications for the conservation status of individual populations, and thus form a priority for badger research in Eurasia (Griffiths, *et al.*, 1993). There remains an urgent need for morphometric and genetic clarification of the taxonomic status of the endemic putative subspecies on Crete and Rhodes, in line with requirements for other basic research on these populations (Griffiths & Thomas, 1993). Should these populations, in particular, prove unique, all possible attempts should be made to ensure their survival.

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