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Small Indian Civet *Viverricula indica* (Photo: Kalyan Varma)

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Biogeography of Indonesian Mountain Weasel *Mustela lutreolina* and a newly discovered specimen

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Abstract

A previously undocumented specimen of Indonesian Mountain Weasel *Mustela lutreolina* from Java was previously ascribed, incorrectly, to Malay Weasel *M. nudipes*. The re-identification is based on a decisive cranial feature, and is consistent with known distributions of the two species. The addition of this specimen brings the total number of wild caught specimens in museums to 12. Using all known distribution data of *M. lutreolina*, we draw a tentative distribution map and hypothesise about its biogeographic history and population status.

Keywords: Sumatra, Java, cranial traits, conservation status, distribution, evolutionary history, last glacial maximum

Abstrak

Disini kami melaporkan tentang keberadaan suatu spesimen Musang Gunung Indonesia *Mustela lutreolina* dari Jawa. Sebelumnya, spesimen tersebut diklasifikasikan sebagai spesies lain, yaitu *M. nudipes*. Pengidentifikasian kami, didasarkan pada aspek-aspek tenkorak yang karakteristiknya untuk spesies tersebut. Klassifikasi juga sesuai dengan pengetahuan tentang distribusi dua spesies musang ini. Dengan masuknya spesimen baru, jumlah spesimen untuk *M. lutreolina* di dalam koleksi museum sakarang mencapai 12. Berdasarkan semua data tentang distribusi Musang Gunung Indonesia, kami menggambarkan peta distribusi dan membuat hipotesis tentang sejarah biogeografi spesies ini dan status populasinya.

Introduction

Assessing past or expected population trends of mammals is a commonly used method to determine their risk of extinction (IUCN 2006). Many mammals however, especially in tropical countries, are poorly known. Distribution ranges, ecology, and population trends are often inferred from a handful of sightings and/or specimen records, and assumptions about exploitation and habitat loss. Often more data are available on species distribution than would be revealed by a study of texts alone (e.g. Meijaard & Nijman 2003). It is especially important to review museum specimens and check with field workers about their knowledge of a particular species. One species in need of a reassessment is the Indonesian Mountain Weasel *Mustela lutreolina*. It was classified by the IUCN Red List as Endangered in 1996, based on the assumption that its distribution was small and fragmented (IUCN 1996), and this listing has not subsequently been changed. We reassess this status based on new specimen information, a new field record, and inference from biogeography.

Only 15 specimens of *M. lutreolina* have been collected, (including three zoo specimens; Table 1), at altitudes between 1,450 and 2,200 m a.s.l. A recent sighting was made at 3,000 m a.s.l. (Holden 2006). A message we have posted on the online Indonesian Nature Conservation newsletter (in Indonesian and English), which reaches about 2000 conservationists, NGOs, academics etc., asking for any records of the weasel, returned no report of anyone who had seen the species. Remarkably, no females are known among the specimens.

The additional specimen

The fifteenth specimen, previously ascribed to the Malay Weasel *M. nudipes*, is published here for the first time. The specimen, #48082, Museum für Naturkunde, Humboldt Universität zu Berlin, comes from the Ijang (= Jang, on original documentation) plateau, East Java (7°59′S, 113°40′E), 2,300 m a.s.l.

The skull is part of a batch of eight specimens (BZM 48080–48085 and 48089–48090) which share a batch number (1.9.36) in the museum's Katalog (=accessions register). There are no field tags on any of the skins in the batch, and by the first specimen (#48080, a Moonrat *Echinosorex gymnurus*) is written "auf Wünsch des Gebers, soll sein Namen auf den Objekten nicht verzeichnet sein" (= at the wish of the giver, his name should not be recorded on the specimens). The skull is annotated, in ink, with "♂ 48082 Jang Plateau, 2300 m, Ost Java, Jan 1935"; added in a later pen is "M[ustela] nudipes". Whatever the reason a donor might request anonymity, today the chief concern is that potentially the locality information might be in error. If, for example, the collector received the specimen from a local resident, the locality could reflect where the resident lived, rather than where the animal was collected. In this case, the skull's associated data seem reliable. The eight animals in the batch are recorded with various sites, dates and altitudes across Indonesia suggesting that the specific origins attributed to each are likely to be correct; in particular, altitudes are rarely given for historical specimens taken from markets or expatriate houses. The museum accessions register gives the collector as Paul Friedrich Franck, and some lettering, which looks as if it might well have been "P. F. Franck" has been scrubbed off the skull. The several skins in the batch have also had some of the original writing on the specimen tag (added by the museum) scratched out, in the space for collector name, indicating that the request for anonymity was for all specimens in the batch, rather than any particular one. The museum's card index to specimens gives no collector for the weasel, but for two Yellow-throated Martens *Martes flavigula* in the batch, also from the Ijang plateau (from 27 November 1935), "Dorries / Franck S.

Table 1. Known specimens and sight records of Mustela lutreolina.

Museum (specimen #)	**Island**	**Locality**	**Elevation m a.s.l.**	**Latitude S**	**Longitude E**	**Sex**	**Year collected**	**Remarks**
RMNH (7181)	Java	Ijang Plateau	2,200	7°59′	113°46′	Male	1932	van Bree & Boeadi 1978
RMNH (7182)	Java	Ijang Mt.	2,200	7°59′	113°46′	Male	1932	van Bree & Boeadi 1978
MZB (6749)	Java	Ijang Highlands	2,000	7°59′	113°46′	Male	1932	van Bree & Boeadi 1978
ZMB (48082)	Java	Ijang Plateau	2,300	7°59′	113°46′	Male	1935	*This study*
RMNH (14649)	Java	Kaligua Estate on Mt. Slamet	1,500	7°08′	109°07′	Unsexed	1929	Bartels 1937
MZB (278)	Java	Sukawana, Mt. Tankubanprahu	1,500	6°44′	107°36′	Male	1918	van Bree & Boeadi 1978
RMNH (26107)	Java	Tjiboeni, Bandoeng	1,400	7°11′	107°19′	Male	1932	Sody 1949, Becking 1989
MZB (8433)	Java	Cibodas	1,450	6°48′	106°56′	Male	1958	van Bree & Boeadi 1978
NHM (17.8.4.2)	Java	Cibodas	1,650	6°48′	106°56′	Male	1916	Holotype; Robinson & Thomas 1917
AMNH (106670)	Sumatra	Mount Dempo	1,800	4°01′	103°04′	Male	1936	Lunde & Musser 2003
MZB (6768)	Sumatra	Mount Dempo	1,800	4°01′	103°04′	Male	1941	van Bree & Boeadi 1978
RMNH (a)	Sumatra	Bengkulu District	unk.	3°20′	102°18′	Unsexed	1865	Jentink 1892 as *Mustela henrici* Westerman
MZB (12000)	unk.	unk.	unk.	unk.	unk.	Male	1977	van Bree & Boeadi 1978, Jakarta Zoo
MZB (12001)	unk.	unk.	unk.	unk.	unk.	Male	1977	van Bree & Boeadi 1978, Jakarta Zoo
Captive live animal	unk.	unk.	unk.	unk.	unk.	Unsexed	1980s	Schreiber et al. 1989, Centre for Tropical Biology, near Bogor
Field sighting	Sumatra	Mount Kerinci, Kerinci–Seblat National Park	3,000	2°09′	101°30′	Group of four	July 1995	Holden 2006
Unconfirmed								
Faeces seen in the field	Java	Lawu	3,000	7°37′	111°11′	Unsexed	1930s	Bartels 1937
Faeces seen in the field	Java	Slamet	2,000	7°14′	109°12′	Unsexed	1930s	Bartels 1937

Museum acronyms: MZB – Museum Zoologica Bogoriensis, Bogor, Indonesia; NHM – Natural History Museum, London, UK; RMNH – Nationaal Natuurhistorisch Museum, Naturalis, Leiden, the Netherlands; ZMB – Museum für Naturkunde, Humboldt Universität zu Berlin, Germany; AMNH – American Museum of Natural History, New York, USA. unk. – unknown.

G.” has been added to the card, with a modern ball-pen, in Dr R. Angermann’s distinctive hand. “S. G.” stands for collector and giver; Franck was a collector-naturalist (see, e.g., Franck 1934) who lived for some time in Bogor, West Java, from where access to the Jiang plateau would have been relatively easy. Dorries was a specimen dealer in Hamburg, who presumably routed the batch to the Berlin Museum (I. Thomas verbally 2006).

There were two reasons to check carefully that the identification of skull 48082 (hereafter "the Berlin specimen") is *M. nudipes*: first, an elevation of 2,300 m is outside the known range of this latter species (0–1,700 m; Duckworth *et al*. 2006), but is well within the range of *M. lutreolina* (1,400–3,000 m, Table 1). An altitude of 2,200 m is ascribed to two RMNH specimens (#7181 and 7182) from the same locality as the Berlin specimen. Secondly, although the type locality of Malay Weasel was originally given as Java (Desmarest 1822), this location was soon doubted (Vigors 1830), and no undoubted Javan records of *M. nudipes* were traced by Duckworth *et al*. (2006). However, *M. lutreolina* is well known to inhabit Java and, in fact, three of the 13 previously known specimens with locality data for *M. lutreolina* are from the Ijang area (Table 1).

Mustela lutreolina and *M. nudipes* are easily distinguished by their skins. The former is dark brown, the latter brightly coloured, usually orange, with a white head. The Berlin specimen does not have an associated skin and we therefore compared its skull with those of *M. lutreolina* and *M. nudipes* at the American Museum of Natural History, New York, and at the Natural History Museum, London.

The skull sizes of these two species are very similar, and the Berlin specimen size is well within the variation in both species (S. M. unpublished). There is, however, a good taxonomic character in the skull: *M. lutreolina* has a foramen in the medial part of the auditory bullae, mid-way along the anterior–posterior axis, at the point where the bullae attach to the skull (Abramov 2000). In most specimens of *M. nudipes* we examined (five out of eight) there is no such feature. In some (e.g. NHM 55.1595, AMNH 106065), there is a hint of one; but it is never clear cut and does not penetrate the bulla wall. In both *M. lutreolina* studied (AMNH 106670, and the holotype, NHM 17.8.4.2), as well as in the Berlin specimen, the foramen is well distinguished and penetrates the bulla wall (Fig. 1). On the basis of this cranial character the Berlin specimen is evidently a formerly unrecognised specimen of *M. lutreolina*. The geographical and altitudinal origin support this view.

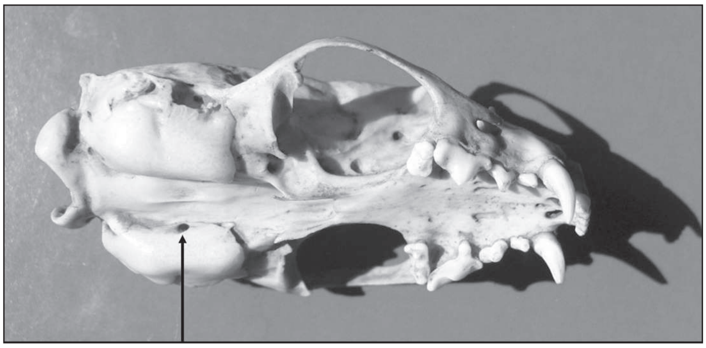

Fig. 1. The posterior margin of the Berlin specimen. The foramen is clearly seen in the middle of the bulla (arrow).

Biogeography

Available data allow some speculation on the evolution and biogeography of *M. lutreolina*, which lacks a fossil record. It is plausible that it arrived in Java and Sumatra during one of the more severe glacial periods, when land connections between those areas and mainland Asia might have supported suitable habitat. During the last glacial maximum, for instance, montane forest vegetation boundaries were lowered markedly in both Java and Sumatra (van der Kaars & Dam 1997, Stuijts *et al*. 1988). If *M. lutreolina* requires conditions found in montane areas, the lowering of the boundaries of montane vegetation types would have increased its dispersal opportunities from today's Asian mainland to the present range. Subsequently, the species would have been restricted to higher elevations during inter-glacial phases. Bininda-Emonds *et al*. (1999) estimated that the divergence between some of the South-east Asian *Mustela* species (*M. lutreolina*, *M. nudipes*, *M. sibirica* and *M. strigidorsa*) happened approximately 200,000 years ago. Marmi *et al*. (2004) suggested that *M. sibirica*, to which *M. lutreolina* appears most closely related (van Bree & Boeadi 1978), diverged from some other Eurasian species (*M. itatsi*, *M. lutreola*, *M. eversmannii* and *M. putorius*) between 700,000 and 400,000 years ago. *Mustela lutreolina* would then be a Late Pleistocene arrival on Java and Sumatra that had probably dispersed to the island during the penultimate or last glacial maximum (135 or 22 thousand years ago; van Bree & Boeadi 1978).

Javan records for *M. lutreolina* (Fig. 2) are well spread across the mountain areas of the island, but it remains unclear whether the species is restricted on Sumatra to the south, or has been overlooked in central and north Sumatra. Only three Sumatran specimens and one field sighting (Holden 2006) are known, and deducing a range restriction from this would be rash. Recent works have significantly extended the known ranges for other South-east Asian *Mustela* species (e.g. *M. kathiah*, Duckworth & Robichaud 2005; *M. nudipes*, Duckworth *et al*. 2006; *M. strigidorsa*, Abramov *et al*. in prep.). There does not seem to be an obvious mechanism for restricting species to southern Sumatran mountains. The Bukit Barisan mountain chain runs almost uninterrupted along the length of Sumatra. Only the area south of Lake Toba (Fig. 2) is lower and appears to be a faunal break for some species (Whitten *et al*. 1987). Further surveys in northern and central Sumatra are needed to define range limits of *M. lutreolina*.

Next to nothing is known about the natural history of Indonesian Mountain Weasel, and its conservation status was changed from Insufficiently Known (the precursor category for today's Data Deficient) to Endangered in 1996, with no new data or insight to support this designation. The scarcity of museum specimens is combined with a paucity of recent direct field sightings (quite possibly only that of Holden 2006).

Conservation

Indonesian Mountain Weasel was classified as endangered under the IUCN criteria B1 and B2c (IUCN 1996). This implies the Extent of Occurrence estimated to be less than 5,000 km² or the Area of Occupancy estimated to be less than 500 km² (criterion B) and the two following criteria:

1. Severely fragmented or known to exist at no more than five locations (B1).
2. Continuing decline, inferred, observed or projected, in area, extent and/or quality of habitat (B2c).

Relatively few biologists visit the altitudinal range of *M. lutreolina*, hampering assessment of its conservation status. Based on the altitude of museum specimens (Table 1), we calculated the 95% confidence interval for the altitudinal range of *M. lutreolina*

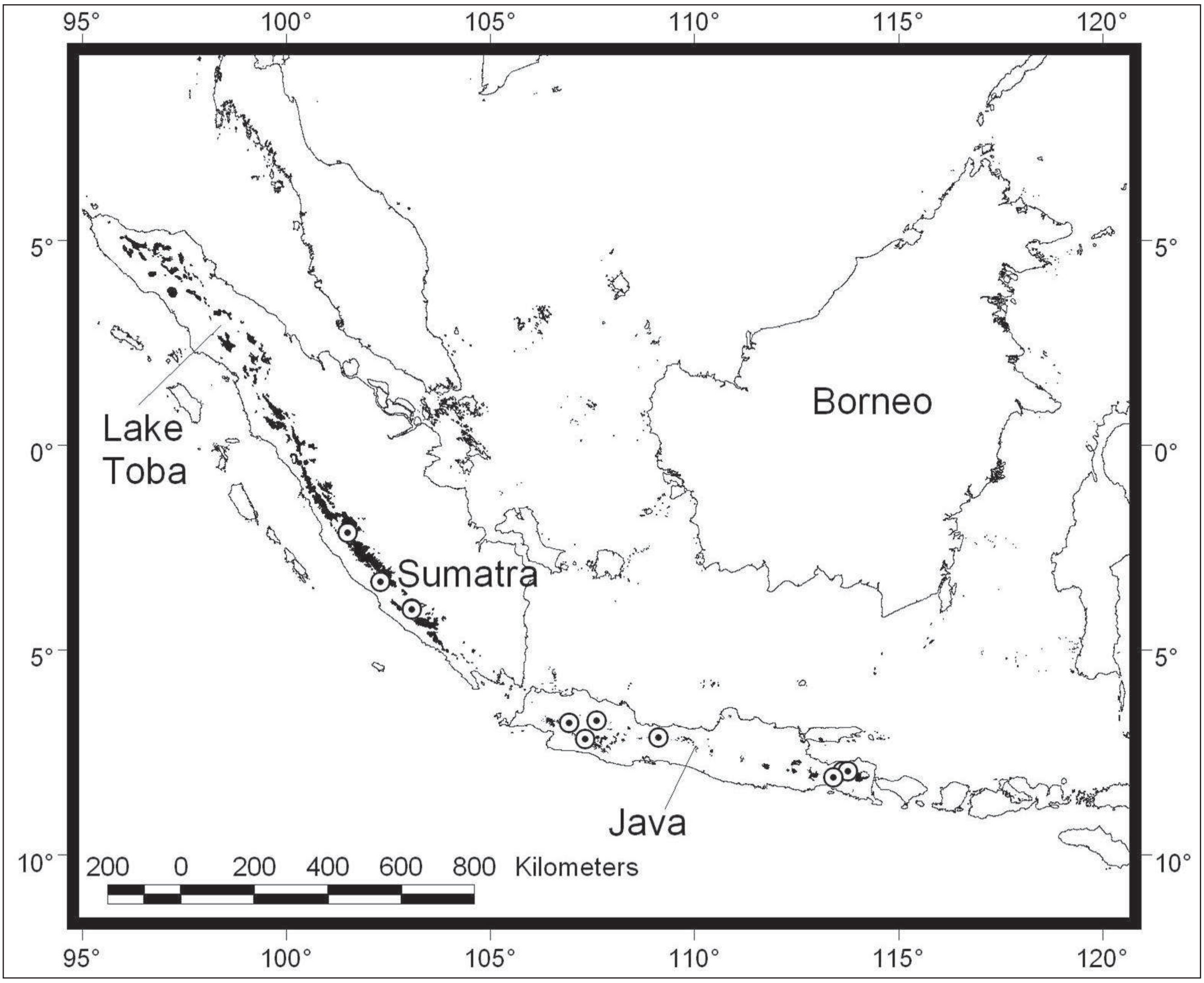

Fig. 2. Specimen localities or direct sightings of M. lutreolina *(circles). Black areas are areas on Java and Sumatra >1,000 m a.s.l.*

as 1,060–2,540 meters a.s.l. We therefore used an available 1,000 m contour map to create a tentative distribution map (Fig. 2).

The altitude data indicate that the geographic range of the Indonesian Mountain Weasel could be between 3,000 and 30,000 km^2, depending on whether only the mountains where the species was collected, or all areas > 1,000 m a.s.l. in Java and Sumatra, are included. On Java, even the maximum range is highly fragmented, but it is much less so in Sumatra, which has a north-west–south-east trending backbone with contiguous land over 1,000 m. There are too few habitat data to determine whether this weasel could inhabit all land over its minimum altitude, or whether only certain habitats are used.

Since the early 1990s montane forests on Java and Sumatra have been increasingly affected by deforestation. On Java, forest clearance on the volcanic slopes has reached its highest rates since the colonial period, mainly because of illegal logging in state forests and increased forest fires (Lavigne & Gunnell 2006). Conversion of montane forests, e.g. for coffee plantations, is rapidly increasing in southern Sumatra. Deforestation occurs at higher rates in state forests, including national parks, than in forests owned by communities (Kinnaird *et al*. 2003), indicating that protected area status is unlikely to reduce deforestation in the short term. It is unclear how dependent *M. lutreolina* is on forested habitats. Holden (2006) observed it above the tree line, and although other localities are lower, there is no specific information as to whether animals came from forest or open habitats. It is therefore unclear how the weasel is affected by deforestation.

Thus while *M. lutreolina* might justly be classified under criterion B1 if it was a Javan endemic, its Sumatran range is unlikely to be severely fragmented (Fig. 2) unless it has very precise microhabitat use (for which there is no suggestion). There are also no data that imply continuing decline in area, extent and/or quality of habitat. Thus criterion B2c is not met. Nor are there any data to imply any decline in population size that would classify the species as endangered under the IUCN population trend criteria for extinction risk. Although the extreme paucity of records of *M. lutreolina* might combine with a highly fragmented range and might therefore mean the species is rare, and field studies might prove it is declining, no data support this at the present moment, or even can be used to infer it. We therefore recommend the species status should be changed to Data Deficient until a study of actual habitat preferences and/or population status is carried out.

Conclusions

Mustela lutreolina is still very poorly known and may be under-detected because of lack of surveys at high altitudes. Although habitat in its altitudinal range is facing anthropogenic conversion, the significance of this to the weasel is unclear. Nearly 20 years ago the chief conservation recommendation for *M. lutreolina* by Schreiber *et al*. (1989) was for "field work...to locate populations...and to assess their conservation status and requirements". This remains an appropriate prioritisation today. Each part of the species's range, Java and Sumatra, was identified as a "Core area for mustelid and viverrid conservation" (and only seven such areas were identified globally) by Schreiber *et al*. (1989). In the intervening period ongoing forest loss and wildlife trade trends increase the urgency for accurate status information on the small carnivores of these two areas.

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Search for the Malabar Civet *Viverra civettina* in Karnataka and Kerala, India, 2006-2007

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Abstract

The Malabar Civet *Viverra civettina* is a critically endangered species endemic to the Western Ghats of India. Our study is the first long term conservation project to focus on the Malabar Civet and its current status. The study was conducted in the states of Kerala and Karnataka for the duration of one year, April 2006 to April 2007. Data relating to the species were sought through various methods. The initial stage of the study comprised of a reconnaissance survey along the coastal forests of the two states. During this period, interviews were conducted with local communities about their knowledge of Malabar Civet. Intensive camera trapping, faecal collection and night transects were then carried out in selected areas to seek the species. As yet there has been no proof of persistence, but the faeces remain to be analysed.

Keywords: Malabar coast, faecal samples, camera traps, local animal names, lowland semi-evergreen forest, plantations

Introduction

Many species of wildlife in India have been pushed to the brink of extinction. On current available information, the Malabar Civet *Viverra civettina* could be the latest casualty to join this list. The Malabar Civet is a small carnivore endemic to the Western Ghats, a hill range in south-western India. In 1978, IUCN listed the species as 'possibly extinct' (Rai & Kumar 1993), but it was rediscovered by the Zoological Survey of India in 1987 (Kurup 1987). The few historical records available of the species are all from coastal forests (Jerdon 1874, Pocock 1939, Prater 1971). The other species of civets found in southern India are the Small Indian Civet *Viverricula indica*, Common Palm Civet *Paradoxurus hermaphroditus* and Brown Palm Civet *P. jerdoni*, none of which is particularly similar to Malabar Civet in morphology or, presumably, ecology. In recent years two possible sightings of Malabar Civet have been published, one in Bhagavathy valley in Karnataka (Karanth 1986) and the other in Tiruvalla, Kerala (Kurup 1987), and continued presence was proven through two skin samples recovered from hunters in north Kerala (Rai & Kumar 1993, Ashraf *et al*. 1993). No photographic evidence of the species has been established so far, and there is no published proof of survival for over a decade. This does not necessarily mean that the species is extinct, considering its longstanding rarity and the short duration of previous surveys; but equally this possibility cannot be discounted. Therefore Wildlife Trust of India, with the support of the Ministry for Environment and Forests, India, initiated a two-year comprehensive survey titled "Conservation of the Malabar Civet". This report is based on the results of the survey conducted in the first year of this project (2006–2007).

Survey areas and period

The survey areas were determined by the past reports of the species's sightings and the origins of museum specimens. Accordingly, the lowland Western Ghats of Karnataka and Kerala were surveyed. Besides reserved forests, wildlife sanctuaries and national parks, the survey also covered plantations and private forests. Plantations surveyed included those of areca, coffee, coconut, cashew nut, rubber, and paddy. A. M. A. Nixon was based in Kerala from April 2006 to March 2007 and Siddharth Rao was based in Karnataka from June 2006 to April 2007 to carry out the survey.

Eleven districts in Kerala were surveyed, namely Ernakulam, Trivandram, Thrissur, Palakkad, Malappuram, Kozhikode, Kannur, Kasargode, Wayanad, Kollam, and Pathinamthitta. In Karnataka, coastal forests were given highest priority because historical reports of the species are from lowland forest tracts on the western aspect of the Western Ghats ranges. Most sites surveyed were either lowland evergreen or semi-evergreen forests, with the exception of the forests in higher elevations such as in Birnani in Kodagu (Coorg). Six districts of Karnataka were covered during the survey: Kodagu, Dakshina Kannada, Uttara Kannada, Udupi, Shimoga, and Chikmangalur (Fig. 1).

Survey methods

Rapid reconnaissance survey

The study began with a reconnaissance survey of forests in Karnataka and Kerala during the months of June–August 2006 and January–March 2006, respectively. Local people, especially hunters, were interviewed for the occurrence of the species. The aim of this survey was to identify areas where Malabar Civets potentially survive. Basic questionnaire surveys and informal interviews were conducted. The initial questions pertained to wildlife in general, such as what mammals the person observed in the surrounding forests. Subsequently, questions narrowed down to civets and other smaller mammals. Most people were not prompted or given hints about Malabar Civet unless the conversation strayed far from the subject. There is apparently no photo of a live Malabar Civet; and using line drawings of the species or photographs of other civets was confusing to many people. During interviews, therefore, people were encouraged to describe in detail each species they observed. This information was matched where possible to a particular species or group of species. For example in South India only two species of civets have ringed tails, the Small Indian Civet and the Malabar Civet. So any reference to a ring-tailed (with black and white bands) civet had to refer to one of these two animals.

The methodology used for the questionnaire survey was:

1. Respondents were initially asked to list the mammals that were found locally.

2. Details of individual species were then recorded, in relation to: size, shape, colour, behaviour, habitat preference, rarity in sighting the animal, presence or absence of scent gland, local name, and whether used for meat or other purposes.
3. People were then asked specific questions in relation to civets such as the different types of civets of which they were aware and details about them.
4. Respondents who did not provide any information apparently relating to Malabar Civet were given an oral description of the species and asked if they had any knowledge of it.
5. Respondents who described animals consistent with Malabar Civet based on the criteria given above were considered as respondents who 'recognised' the Malabar Civet.

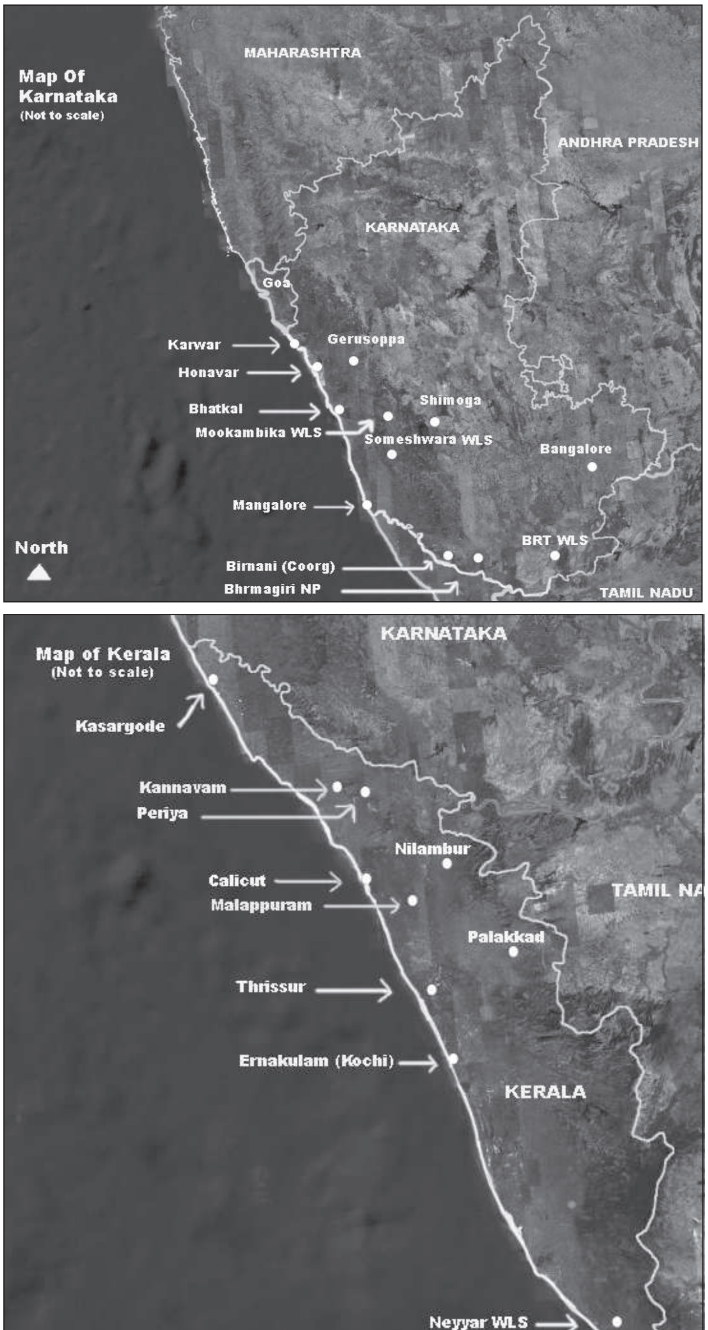

Figure 1. Maps of Karnataka (top) and Kerala (bottom) showing survey localities (map based on Google Earth).

Camera trapping

Based on the recommendations of the reconnaissance interviews, camera trapping was initiated in Someshwara Wildlife Sanctuary (Karnataka) and Kannavam Reserved Forest (Kerala). Three other sites (Biligirirangana Temple Wildlife Sanctuary, Karnataka, and Kallikandi and Periya Reserved Forests in Kerala) were surveyed later. Four thermal sensing (passive infrared) camera traps developed by Centre for Engineering Design and Technology (CEDT) at the Indian Institute of Science were used in each location. Camera traps were fixed to the trunk of trees at an approximate height of 2½ feet and tilted forward slightly; six feet in front of the lens a bait/lure was placed. Two lures imported from the USA, 'Saber Tooth' and 'Alley Cat', were trialled. 'Saber Tooth' attracted animals to the trap with 70% more success than 'Alley Cat' when comparing the two lures over a period of 40 camera trap nights each. After this, 'Saber Tooth' was used on a daily basis for all camera traps.

Traps were placed in relatively undisturbed natural habitat within protected areas or abandoned plantations, close to water (within 30 metres of a water source), at low- to mid-elevation (0–1000 meters), in areas with reports of sightings by local communities, trails used by animals, civetries or latrine sites of civets, and a minimum of 500 metres from the nearest other camera trap.

For the first 110 trap nights in Someshwara Wildlife Sanctuary, the camera traps were placed every evening at approximately 17h00 and removed the next day at approximately 07h00. For the remaining 230 trap nights the camera traps were left on during the day as a local hunter reported a sighting of Malabar Civet during the day. In Biligirirangana Temple Wildlife Sanctuary and Kerala it was not possible to operate camera traps by day, due to extensive movement of non-target species such as domestic cattle and dogs, as well as risk of theft of the equipment.

Faeces collection

Faecal samples of small carnivores, particularly civets, were collected and submitted to the National Centre for Biological Sciences (NCBS), Bangalore; results are awaited. A small portion of Malabar Civet skin from the specimen in Calicut University museum has been made available to NCBS for use in genetic analysis of faecal samples.

Night transects

Over 40 hours of night transects using spot lights were conducted in plantations and reserved forests in Kerala and Karnataka. This part of the survey was discontinued in Karnataka due to the volatile civil unrest in the region. A total of seven Small Indian Civets, four Brown Palm Civets, 28 Gaur *Bos gaurus*, three Jungle Cats *Felis chaus* and 16 Black-naped Hares *Lepus nigricollis* were sighted during these night transects.

Results and discussion

Reconnaissance survey results

In Kerala, the reconnaissance survey in 47 villages received responses from 87 people. Each interviewee was considered as an independent sample. Respondents from districts in central Kerala such as Ernakulam, Thrissur and Palakkad were not aware of the existence of a species fitting the description of Malabar Civet; they had no knowledge that such an animal existed in India. In

Camera-trap photographs of carnivores (clock-wise from top left): Brown Palm Civet, Small Indian Civet, Common Leopard (all from Someshwara Wildlife Sanctuary), and Common Palm Civet (from Biligirirangana Temple Wildlife Sanctuary).

contrast, 74% of respondents in Malappuram district (from 18 villages) claimed to have sighted the Malabar Civet, most popularly known as the '*Jawad*'. In Kannur district people from the Kuruchiyar tribe were interviewed and 90% of respondents recognised the Malabar Civet by the local name '*Kannan Chaandu'*. Therefore, Kannavam Reserved Forest (Kannur district) was chosen as the best location in Kerala for camera trapping. In sum, local knowledge apparently pertaining to Malabar Civet is extensive in Kerala especially among tribes living inside forests.

In Karnataka, 35 villages and towns were surveyed. Only five out of 100 people interviewed were knowledgeable about Malabar Civet. Four of these five were hunters from Udupi district.

One important finding is that pre-documented local names for Malabar Civet are not well known in Karnataka. Only two people interviewed, both in the vicinity of Someshwara Wildlife Sanctuary, gave a local name for Malabar Civet, '*Kallu suniga*', by which they also referred to the Stripe-necked Mongoose *Herpestes vitticollis*.

Earlier surveys indicated that names such as '*Jawadi*'/'*Jawadiyo*' and '*Kutri*' applied to Malabar Civet in parts of Karnataka (Rai & Kumar 1993), but the present survey found that '*Jawadi*' was used for Small Indian Civet in villages near Karwar. Experienced hunters (N = 20) in this area claimed to have trapped this animal and in size, shape, colour and behaviour, the described *'Jawadi'* fitted Small Indian Civet (Table 1). The name '*Kutri*' or '*Bal Kutri*' was not known by any people interviewed. The survey indicated Someshwara Wildlife Sanctuary and Reserved Forest as the best location in Karnataka for further studies: two out of five people recognised Malabar Civet. By contrast, in Reserved Forest along Periyambadi lake, Kodagu, only one respondent out of twenty evidently knew the animal. Other areas with the possibility of Malabar Civet in the state are Honnavar and Bhatkal Reserved Forest ranges, Uttara Kannada; Gerusoppa Reserved Forest, Uttara Kannada; Brahmagiri National Park, Kodagu; Agumbe Reserved Forest, Shimoga; and Mookambika Wildlife Sanctuary, Udupi. These areas were identified based on the habitat (predominantly lowland, evergreen forests) and proximity to areas with 'possible' sightings of the Malabar Civet.

Table 1. Questions asked about the Jawadi *and summation of responses from local hunters (N = 20) interviewed in Karnataka.*

Questions	**Responses**
Length (nose to tip of tail)	1½–3½ feet
Shape	Short legs, elongated snout
Colour	Greyish to brown. Prominent black bands on body and tail. More than six bands on tail.
Shoulder height	1–1½ feet
Behaviour	Nocturnal; eats crabs, fish, rats, frogs, insects, and fruit. Inhabits forests and paddy fields.

Table 2. Results of camera trapping survey in Karnataka and Kerala, 2006–2007.

Region & forest type	Period (dates)	Place / locality	Trap nights	Successful trap nights*	Mammal species photographed
Karnataka					
Someshwara Wildlife Sanctuary; Lowland Semi-evergreen forest	27 October 2006–25 March 2007	Bandimata, Onekabbe, Hanja, Kabinale	450	270	Red Muntjac *Muntiacus muntjak* Gaur *Bos gaurus* Leopard *Panthera pardus* Sambar *Cervus unicolor* Lion-tailed Macaque *Macaca silenus* Bonnet Macaque *M. radiata* Small Indian Civet Brown Palm Civet Indian Crested Porcupine *Hystrix indica* Oriental Small-clawed Otter *Aonyx cinerea* Indian Pangolin *Manis crassicaudata* Indian Chevrotain *Moschiola meminna* Murid rodents
Biligirirangana Temple Wildlife Sanctuary, Mixed deciduous forest	28 March–13 April 2007	Doddasampige	40	16	Red Muntjac Gaur Common Palm Civet Sambar Tiger *Panthera tigris* Asian Elephant *Elephas maximus*
Kerala					
Kannavam Reserved Forest, Semi-evergreen to evergreen	9 May–21 November 2006	Poovanthinkizhil; Nambuthiri thotam; Valiyavelicham; Chruvanchery; Chambukavu; Ammapaambu RF	321	11	Small Indian Civet EurasianWild Pig *Sus scrofa* Jungle Cat Black-naped Hare *Lepus nigricollis* Golden Jackal *Canis aureus*
Kallikandi Reserved Forest, Semi-evergreen to evergreen	23–30 November 2006	NAM College, Scrub forest area	33	4	Golden Jackal
Periya Reserved Forest, Semi-evergreen to evergreen	4–28 December 2006	Elapeedika; Seminary Villa; Periya-Nedumpoil road; Periya	176	8	Common Palm Civet Jungle Cat Red Muntjac Sambar Rodents
Kannavam Reserved Forest, Semi-evergreen to evergreen	9 January– 19 February 2007	Poovanthinkizhil; Nambuthiri thotam; Ammapaambu RF	64	0	None

Camera trapping

No trap picture of a Malabar Civet was obtained in a total of 1,084 camera trap nights in the study areas spread across Kerala and Karnataka, although many other mammal species were trapped, including other endemic species (Table 2). Of particular note was that Brown Palm Civets were frequently photo-trapped; this implies that the same camera would have been triggered by Malabar Civets, were they passing.

The west coast of Karnataka between Bhatkal and Karwar has some of the last lowland forests at the foothills of the Western Ghats. These areas were covered during the initial reconnaissance survey, but no information regarding the Malabar Civet was obtained from interviews with the villagers. Sustained camera trapping efforts were not possible in this area due to project constraints. However for a period of six days in March 2007, 24 camera trap nights were recorded in cashew plantations adjoining Mirjan Reserved Forests near Kundapur, Karnataka; two images of Brown Palm Civet were obtained.

Conclusion and plan of action for 2007–08

To further our understanding of the Malabar Civet and its current status there is a need to increase the intensity of camera trapping efforts, scat collection, and night surveys in the identified areas.

Equally important will be to have constant interactions with local communities living in these areas to gather information regarding possible sightings. Other methods of increasing information relating to the Malabar civet include creating awareness among forest department staff, local communities, field researchers, and members of the scientific community. These interventions will be kept in mind when implementing the second phase of this project; camera trapping efforts will be increased by using six more traps, giving a total of 14. The areas which will be given higher priority for camera trapping in the next phase of the survey will be around Honnavar, Karwar, Bhatkal, and Kumta in Karnataka and areas surrounding Nilambur, Neyyar, and Aralam in Kerala.

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OBITUARY

Dr. W. Chris WOZENCRAFT

(1954-2007)

It is with sincere regret we inform you that W. Chris Wozencraft died on 6 January 2007 at age 53, near Manistique, Michigan, USA. Chris was a native of Oklahoma and received a Ph.D. from the University of Kansas for his work on the phylogenetics of Viverridae. Chris's most recent position was Professor of Biology and Chair of the Division of Natural Sciences at Bethel College, Indiana. He had published many scientific articles, including the notable taxonomic review of the order Carnivora for the recent book *Mammal Species of the World*. Chris's research elicited the taxonomy and systematics of mammals, especially the Carnivora, with which he was especially familiar and with which his name will long be associated. Chris was an active member of the Small Carnivore Specialist Group, helping the group move forward in various ways, including maintaining the groups' membership directory. Last December, Chris was selected and accepted to serve as Chair of the Small Carnivore Specialist Group. Chris's contributions to the profession were monumental. His untimely death was most unfortunate; he will be deeply missed.

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Infant development and behaviour in the Fossa *Cryptoprocta ferox*

Jenni MUELLER[1,2], Alan SIRONEN[1] and Kristen E. LUKAS[1,2]

Abstract

The Fossa *Cryptoprocta ferox* is a solitary carnivore native to Madagascar, endangered in the wild and boasting only a small captive population. Preservation of the Fossa would benefit from further knowledge of the species's biology and behaviour, including an understanding of parturition and infant development. This topic has yet to be researched in the wild, whilst captive accounts are limited and anecdotal. We present a quantitative analysis of the early behavioural and physical development of two mother-reared and two hand-reared Fossas. All kits were easily sexed at an early age using visible differences in male and female genitalia. The development of the hand-reared kits paralleled what could be visually concluded from the mother-reared kits and what has been reported by other captive institutions, implying that the methods employed were successful. Behavioural data revealed that the mother-reared kits were more active than the adult female, with increased time spent locomoting and engaged in solitary and social play. They were first seen scent marking at 12 weeks of age, suggesting that behaviours necessary as adults may begin while sexually immature. Agonistic behaviour is common among juvenile carnivores but was not seen in the Fossa, possibly reflecting the small litter size and lack of resource competition. Our results provide the first quantitative look at captive Fossa infant development and hand-rearing techniques, further clarifying the biological and behavioural maturation of this enigmatic species. Studies such as this are necessary to manage captive individuals successfully, and they improve knowledge of a species difficult to study in the wild.

Keywords: captivity, hand-rear, nest box, scent marking

Faminitinana

Ny fosa, izay antsoina amin'ny teny ara-tsiansa hoe *Cryptoprocta ferox* dia biby mpihinan-kena mandeha irery, ary tsy fahita afa-tsy eto Madagasikara. Efa sokajiana ho an-dalam-paharinganana ny fosa hita eny amin'ny natiora ary ankoatra izay dia mbola tena vitsy dia vitsy ny isany any amin'ireo toeram-pihazonana biby eran-tany. Ny fahafantarana ny momba ny fiaim-pianany sy ny toetrany, anisan'izany ny fahalalàna bebe kokoa momba ny fiterahany sy ny fitomboany nanomboka tamin'ny fahakeliny dia mitondra voka-tsoa lehibe amin'ny fiarovana azy. Mbola betsaka tokoa ny fikarohana tokony hatao momba izany fahalalàna momba ny fosa izany raha ny any amin'ny natiora no jerena, ary ny zavatra fantatra momba ireo fosa izay hita any amin'ny toeram-pihazonana biby aza hatramin'izao dia mbola azo lazaina ho voafetra tokoa sady mionona amin'ny fitantaràna ankapobeny ihany. Eto isika dia haneho ny vokam-pikarohana iray izay misy antontan'isa mazava mampiseho indrindra ny fitomboana ara-toetoetra sy ara-batan'ny fosa roa izay nobeazin'ny reniny sy fosa roa nobeazin'olona narahina hatramin'ny fahakeliny. Tamin'ireo biby rehetra ireo dia mora tokoa ny namantatra ny lahy sy ny vavy hatramin'ny fahakeliny tamin'ny alalàn'ny fandinihina ny fahasamihafana miavaka eo amin'ny fitaovam-pananahany. Ny fitomboan'ireo nobeazin'olona dia tsy mifanalavitra akory amin'ny fitombon'ireo nobeazin'ny reniny sy izay volazan'ireo toeram-pihazonana fosa hafa ihany koa ka mahatonga haminavina fa mahomby ny fomba fanalehibiazana nampiasaina. Ireo fahalalàna azo momba ny toetrany indray dia naneho fa ireo fosa nobeazin-dreniny dia mavitrika kokoa nohon'ny fosa vavy efa lehibe¸ ka mampitombo kokoa ny fotoana laniny amin'ny fandehanana ary mavitrika kokoa amin'ny filalaovana irery na miaraka. Tazana namela maripofona voalohany izy ireo tamin'ny faha-12 herinandrony ka eritreretina fa mety efa miseho ny toetoetra maha-lehibe na dia mbola tsy maoty aza ny vatana. Ny toetra mitaraindraina dia fahita matetika amin'ireo biby mihinan-kena amin'ny fahakeliny nefa tsy mba fahita amin'ny fosa, ka izany angamba dia vokatry ny fahavitsian'ny zana-posa miaraka ateraky ny reniny ary koa ny tsy fisian'ny fifaninanana eo amin'ny fitadiavana sakafo. Ny vokatry ny fikarohana etoana dia nanome ny antontan'isa voalohany mikasika ny fitomboan'ny zana-posa nobeazin'olona sy ny tekinika fiompiana mahomby ka nitondra fanazavana bebe kokoa momba ny fiaim-piainana sy ny toetra maha-maoty ity biby sarom-pantarina ity. Ny fikarohana toy izao dia ilaina tokoa mba hitsinjovana ireo biby hazonina sady mampitombo ny fahalalàna momba ireo biby izay sarotra ianarana eny amin'ny natiora.

Introduction

The Fossa (Fosa) *Cryptoprocta ferox* is an endangered carnivore of the family Eupleridae (often previously placed in the Viverridae), endemic to Madagascar. It is the largest carnivore on Madagascar; adults reach up to 12 kg and 80 cm, with a tail of approximately the same length (Parker 1990). It has a beige to reddish-brown coat, with occasional melanistic individuals being reported in Eastern rainforest areas (Garbutt 1999). The gait is distinctive, using plantigrade-like locomotion when arboreal and digitigrade-like movement when terrestrial (Parker 1990). The ease of movement on both the ground and in the trees allows hunting of a wide variety of prey species. It is an opportunistic hunter, known for predating lemurs, but also taking other mammals, birds, reptiles, and insects (Dollar 1999).

Fossas are generally solitary, but populations still need a mechanism of intraspecific communication to create and maintain social organisation. Individuals have multiple scent glands for this purpose in the anal, genital, neck, and chest regions (Parker 1990). They scent mark throughout the year (Hornsey 1999). Many environmental and social factors affect marking behaviour (Moran & Sorensen 1986), and although the specific motivations behind Fossa scent marking are not known, it is probably used for territory association, individual identification, and mate attraction.

Breeding occurs in the spring and females seek out secluded sites such as hollow trees or termite mounds for parturition (Köhncke & Leonhardt 1986). Litters of 1–6 kits are born after a 90-day gestation (Sunquist 1998, Garbutt 1999). Kits typically weigh 50–150 g at birth, and although toothless and blind, they are born fully furred (Garbutt 1999). They do not reach adult weight or sexual maturity until 3–4 years of age and may stay with the mother for this entire period (Winkler 1996). This slow development correlates with estimated longevities of up to 20 years in captivity (Köhncke & Leonhardt 1986).

Current literature related to Fossa infants and maternal care is restricted to qualitative captive reports and brief care guidelines within the International Studbook/Husbandry Manual; there is no literature related to hand-rearing (Winkler 1996). Infancy is a significant time for behavioural development, as adult behaviour of an individual is partly determined by the environmental and social interactions experienced during early life (Carlstead 1996). If the physical and/or social environment of captivity varies from that of the wild, the behavioural development of the infant may be affected. Given that the early rearing of Fossa has never been documented in the wild, it is imperative that these events be examined in captivity to begin understanding the species's behavioural development.

Cleveland Metroparks Zoo (CMZ) has housed an adult male and female Fossa since 2002. The pair bred in 2004, providing opportunity to research the behavioural development of the infants and maternal care of the adult female as she raised her first litter. The study's objectives were to: (1) provide husbandry information for hand-rearing Fossa kits; (2) describe early development of kits; (3) determine how often Fossas use the nest box; (4) determine how behaviour differs between kits and mother; (5) approximate the onset of developmentally significant behaviours including weaning, scent marking and aggression; and (6) compare the adult female's pre- and post-partum levels of stereotypy.

This study is the first quantitative analysis of infant behaviour in this species and provides information related to behaviour, development, maternal care and hand-rearing. The results are applicable to captive management of the Fossa and may also contribute to understanding Fossa behavioural development in a natural setting.

Methods

Subjects

Subjects included one adult female and her four kits, two female and two male. The adult female has been housed at CMZ since July 2002 and was approximately five years of age at the onset of the study. She was fed daily either Dallas Crowne or chunk horsemeat with ¼ teaspoon of Osteo-Form (Vet-A-Mix®) calcium–phosphorus powder supplement. Two kits were mother-reared (MR; see Fig. 1) and were included in the behavioural study. Two kits were hand-reared (HR; see Fig. 2) and data pertaining to their growth and early development are included.

Housing and Husbandry

The adult female and MR (mother reared) kits were housed at CMZ Primate, Cat and Aquatics building in Cleveland, OH, USA. The exhibit consisted of two indoor enclosures (E1 and E2) connected via a 0.76 x 0.36 m opening and lit with skylights and high pressure sodium lamps. Each enclosure was approximately 50 m³ with a cement substrate and side walls and front glass viewing window. The rear walls consisted of welded wire above 1.5 m cement ledges. Each enclosure contained one or two rockwork ledges 1–1.5 m high and natural logs a minimum of 0.15 m diameter affixed both vertically and horizontally. Two wooden nest boxes (0.76 x 0.41 x 0.5 m) were located either on the ground or atop a rock ledge within each enclosure; these are suggested sites for female parturition (Winkler 1996). The boxes were bedded with straw and straw was also placed around the bottom edge of the ledges to protect the kits during a fall.

Fig. 1. Male and female mother-reared Fossa kits at approximately five months of age.

Fig. 2. Male and female hand-reared Fossa kits at approximately six weeks of age.

Plywood was placed over the exhibit glass following the birth of the kits to prevent zoo visitors from viewing the animals. This covering had a small window that could be opened for observers to collect data. The plywood was removed on 8 September 2004, but visitors were kept approximately 3 m from the exhibit glass using rope barriers for the remainder of the study. The kits initially reacted by investigating the glass and seemingly reacting to the movement on the public side; by the following day these reactions were not seen, and overall the removal of the plywood caused no observed differences in behaviour of the kits or the adult.

Data collection

To minimise disruption, behavioural data collection did not begin until the kits were six weeks old. Early developmental information was gathered via routine daily keeper observations. Quantitative behavioural data were then collected on the adult and MR kits from August to October 2004 for a total of 10 hours. The ethogram consisted of 13 solitary and seven social behaviours and was adapted from McCarthy *et al*. (2003). Data were collected using continuous 15-minute focal-animal observations, all taken between 10h00 and 17h00. Data were recorded using a Psion Walkabout© handheld computer equipped with a protocol written in The Observer® 4.1. Due to the small sample size, data are presented using summary statistics.

Results

Parturition

The kits were born in the nest box of enclosure E1 on 14 June 2004 and were first seen nursing on 16 June. On 17 June each was heard vocalising and seen locomoting within the nest box; they were estimated to be approximately 12–15 cm in length, had their eyes closed, and were a greyish colour. For the first two weeks the kits vocalised daily. The female spent most of the time inside the nest box, exiting only to feed, when she generally consumed all food outside.

On 30 June 2004 two kits were separately carried to the second nest box by the female and abandoned. Animal keepers removed the kits after each had been left for approximately one hour and they were subsequently hand-reared (HR). The kits were started on a diet of KMR® (PetAg®) formula (Table 1) and until 37 days old were kept in an incubator at 26⅔–28⅓ °C. The kits were sexed at 14 days as a male and female due to the presence of a prepuce and penis on the ventral abdomen of the male. Based upon this observation, the MR kits were visually sexed as a male and female.

Early development

The female HR kit opened her eyes at 18 days; the male opened one eye at 21 days and the other at 23 days. By 15 July they could walk short distances, and on 21 July they began to run and wrestle. By late July, at six weeks of age, the kits increased their locomotion and social interaction with climbing, running, more active wrestling, and were stalking each other to incite play bouts. At this age the kits also began grooming each other and cleaning themselves. Their teeth began erupting on 25 July (Table 2) and at two months of age they were first given lean ground beef with Vionate® (Rich Health®) vitamin/mineral powder and Herpcare™ (Mardel®) calcium carbonate powder in addition to the KMR. The kits at first only ate the meat when it was placed into their mouth, but after about one week they began to eat it on their own. On 23 September the kits also began to drink water. The diet of formula and meat was continued until the kits were six months old, at which time they were gradually weaned off the formula and fed meat twice per day. Weights were taken throughout the kits' development to track growth; the male and female kit developed at similar rates (Fig. 3).

Table 1. Formula regimen for hand-reared Fossa kits.

Date	Age	Amount (tbsp)	Frequency
1 Jul	2 weeks	1	Every 4 hours
21 Jul	5 weeks	1¼–1½	5x/day
2 Aug	6½ weeks	1¼–2	5x/day
14 Aug	8 weeks	1½–2*	5x/day
30 Dec	6½ months	n/a**	n/a

tbsp = tablespoon; *started on small amounts ground beef; **taken off KMR

Table 2. Early tooth development in the captive Fossas.

Date	Age	Event
25 Jul	5½ weeks	Upper/lower incisors erupt
7 Aug	7 weeks	Lower premolars can be felt
31 Aug	10 weeks	First upper molar erupts
13 Sep	12 weeks	Second upper molar erupts

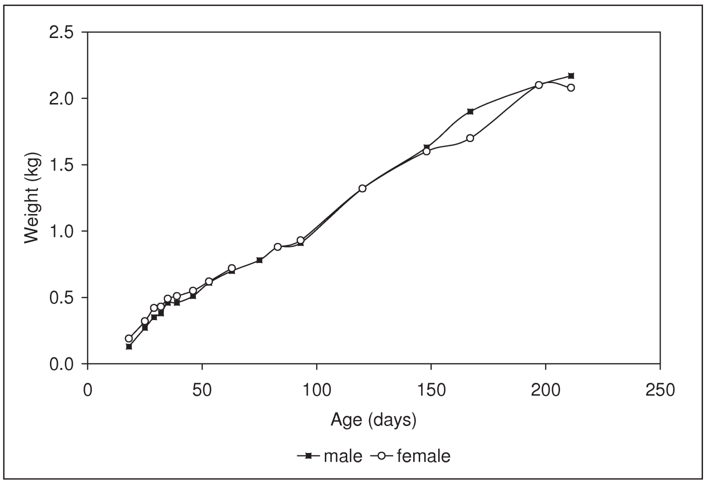

Fig. 3. Weight gain of hand-reared Fossa kits, July–December 2004.

The MR kits were first seen with their eyes open at 23 days of age. They were heard wrestling and vocalising within the nest box in mid July. At the same time, the female routinely removed the kits from the nest box for brief periods of time, during which they locomoted and played with each other. By the first week of August, at approximately seven weeks of age, they ventured out of the nest box on their own and were able to climb up and down the logs and rocks within the enclosure. The kits displayed bouts of playing behaviour and active investigation of the exhibit out of proximity of the adult female, but paused often to turn their heads briefly towards her. The kits typically remained close to each other. The mother seemed more willing to leave the kits as they became increasingly mobile, including spending time in the other enclosure and focusing her attention on the presence of food or a keeper. She visibly checked on them, however, every 1–2 minutes and continued to carry them back to the nest box before she slept.

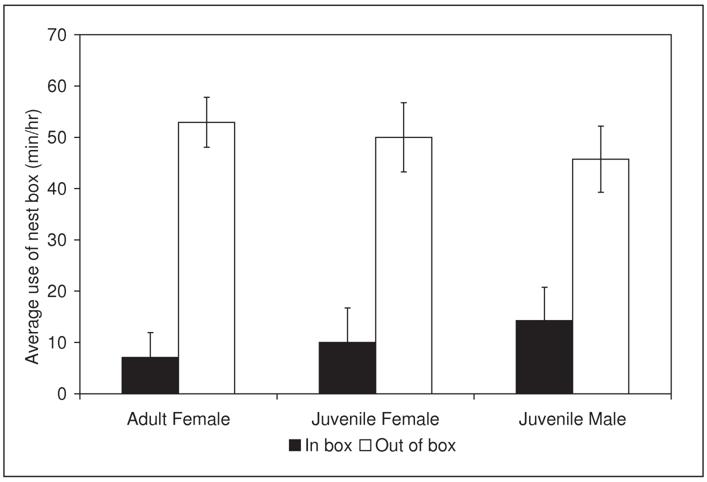

Fig. 4. Average use of the nest boxes by captive Fossas. Location determined by placement of subject's head and anterior limbs; includes nest box use in both enclosures.

Nest box usage

Nest boxes were used throughout the study. Each individual remained out of the boxes more than 75% of the time with no apparent differences between the three (Fig. 4).

Solitary behaviour

More than half the adult female's activity budget (Fig. 5a) was inactive behaviour (60.4%), including sleeping and resting. The majority of her active solitary behaviours consisted of self-grooming (5.9%) and locomotion (8.5%). The kits, however, showed more active behaviours and less inactivity. The juvenile female (Fig. 5b) spent larger amounts of time locomoting (12.6%) and investigating (1.5%) than the adult. The male's (Fig. 5c) investigatory behaviour was similar to that of the adult (0.7%), but his locomotion level was more than twice as high (17.7%). Additionally, only the kits displayed solitary play (male: 0.4%, female: 2.4%). The two females were not visible similar amounts of time (adult: 15.6%, juvenile: 13.6%), typically through being inside the nest box. The male, however, was out of view nearly three times as often as the females (40%). This probably related to his greater level of locomotion, as he often moved behind rocks and logs, so remaining out of view for various amounts of time.

Marking behaviour

Marking behaviour in the adult female was limited to two bouts of head/chin marking seen on two separate days: one lasted for 27.8 s, the other 4.0 s. Both kits were first seen marking on 8 September, at approximately 11 weeks of age. Each displayed two bouts of mount marking, or rubbing the genital region on an upright structure while in a standing posture; the female averaged 4.2 s per bout and the male 11.4 s. The kits were seen marking at later dates as well, though never more than once per observation; all occurrences were mount marks.

Stereotypic behaviour

During July keepers reported two occurrences of pacing in the adult female, and over the course of the study she was only seen pacing during one observation. She displayed 11 short bouts over 15 minutes, giving a rate of approximately 0.73/min; the total time pacing was 123.2 s.

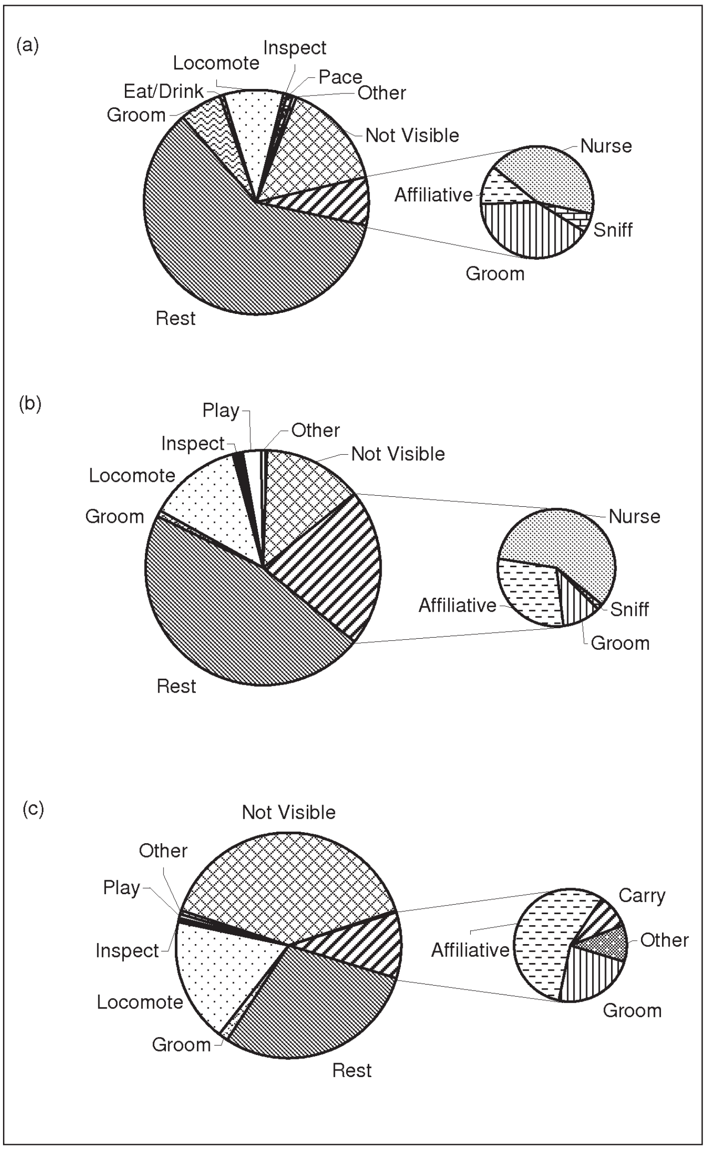

Fig. 5. Activity budgets of the adult female (a), juvenile female (b) and juvenile male (c) captive Fossas. Data are presented as percentages of total time exhibiting each behaviour.

Proximity

Proximate was defined as the subject being within 0.3 m of a conspecific and distant as being greater than 0.3 m from a conspecific. Unknown proximity usually indicated that one or more Fossa was not visible, which occurred most often with the adult female and never in the juvenile female. The adult was distant more often than proximate, though without a significant difference. The kits spent significantly more time proximate than distant (Fig. 6).

Social behaviour

Social behaviour (Fig. 5a) comprised only 6.9% of the adult female's activity budget. Grooming (2.8%) and nursing (3.0%) were the most common, with both sniffing and affiliative behaviour at less than 1%. The majority of these behaviours were initiated by her and directed toward the kits.

The juvenile female (Fig. 5b) showed the greatest amount of social behaviour (21.7%), more than half being nursing (12.7%). The male (Fig. 5c) was never seen nursing and had an overall social behaviour percentage much closer to that of the mother (9.5%).

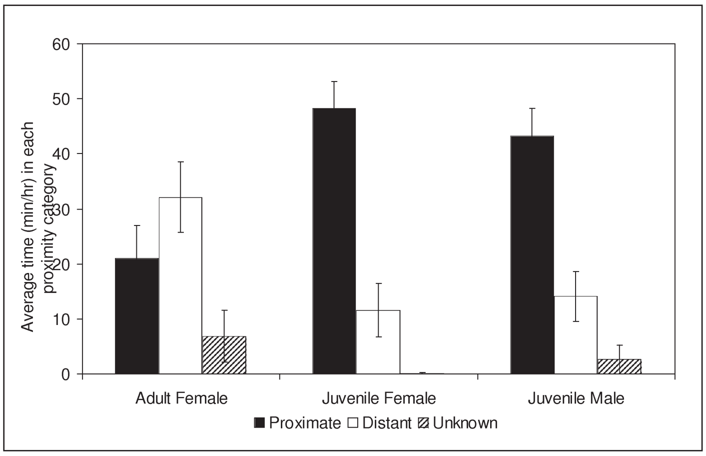

Fig. 6. Average time spent in each proximity category by captive Fossas. Proximate = subject being 0.3 m or less from another individual; Distant = subject being greater than 0.3 m from another individual; Unknown = subject's proximity could not be determined.

Both kits were seen being groomed by the mother and grooming each other, but only the juvenile female was seen grooming the mother, and only for a short period of time (<10 s). The kits also had much greater percentages of affiliative behaviour due to their bouts of social play.

Discussion

Early development

The female gave birth within the nest box, comparable to the secluded locations used in the wild (Hawkins 2003). The kits were smaller than the reported average value of 25 cm (Winkler 1996): this may be the result of our underestimating their size and/or an effect of the large litter size. Litters average 2–4 kits (Parker 1990, Sunquist 1998, Garbutt 1999) and larger litters may result in lowered average sizes of each individual. The kits were born blind, toothless and furred, as expected for this altricial species (Garbutt 1999). Their eyes opened at approximately the same age as that reported by other institutions (Albignac 1975, Köhncke & Leonhardt 1986, Winkler 1996). The coats were much lighter than typical adult coloration, which did not become fully apparent for 5–6 months.

Although adult Fossas rarely vocalise outside the mating season, daily vocalisation is common during the first few weeks of life (Winkler 1996). This is also a time during which the female rarely leaves the nest area, and this female exited solely to feed. After about one month the mother was more willing to leave the nest box and began transferring the kits between boxes. Similar behaviours of removing young from the original nesting area have been shown by captive Fossas and other mammals (Albignac 1975, Carlstead 1996), although the reason is unknown. Having the option to move the kits to a different nest box may have helped to decrease this stress and reiterates the necessity of allowing captive animals some control over their environment, especially when in new situations. It is also possible that the female was motivated by stressors such as ambient noises or keeper presence, as other carnivores will move young in reaction to environmental disturbances (Baker 1994).

Abnormal mothering behaviours such as rejection are not uncommon among captive mammals. Occurrences within the surrounding environment or even the birthing process itself can induce stress and affect the natural behaviour of the female, and inexperience with infants is associated with abandoning or harming young in multiple species (Carlstead 1996). Albignac (1975: 149) described a Fossa bringing her first litter of week-old kits out of the nest box and leaving them on the enclosure floor, seemingly acting in a 'nervous' way; after creating a partition between the female's exhibit and that of the male she became calmer and kept the kits within the nest box. Kopel (1998) noted that within the first week after birth a female left the nest box twice following a loud noise and proceeded to run and scent mark throughout the enclosure. Female Fossas with litters are clearly sensitive to environmental stressors (Winkler 1996) and their behaviour may also be affected by a lack of prior mothering experience; these factors may have contributed to the female in this study rejecting two of the kits.

Fossa kits are difficult to sex, because females have a penis-like os clitoridis visible when the labia are pulled back (Köhncke & Leonhardt 1986, Winkler 1996). The HR kits proved easy to sex: being a male and female, the anatomical differences could be compared easily (see Hornsey 1999). The male anatomy resembled a puppy's, with the penis enclosed within the prepuce and visible near the rear of the ventral abdomen; no os clitoridis was seen on the female. Hawkins *et al.* (2002) noted a 10-week old captive female lacking an os clitoridis and two female littermates with os clitorides much smaller than average measurements from wild juveniles aged 12–33 months. It is possible that some individuals do not show this feature, or that it is not yet visible in some newborn and young females due to differing rates of development. Female Fossa transient masculinisation is most prominent in individuals from one to two years old and the features diminish with adulthood (Hawkins *et al.* 2002). The difficulty associated with sexing juvenile Fossas may be eliminated if the kits are sexed earlier on.

Nest box usage

The nest box was an integral part of the reproductive husbandry, sheltering the mother and kits as does a nest site in the wild. Healthy development of young needs proper environments for adults (Baker 1994), so natural behaviour of a species should be foremost in designing enclosures for reproduction and parturition. The kits did not leave the nest box on their own until six weeks old. This corresponds to ages reported by Winkler (1996) and Garbutt (1999) for wild Fossas first leaving the den, and accounts of captive breeding have reported ages of 5–8 weeks (Albignac 1975, Winkler 1996, Kopel 1998, Hornsey 1999). Spending more time out of the nest boxes as the kits became increasingly active as they aged was expected, and the female rarely entered the box when the kits were not within. After data collection began at six weeks, the average percentage of time spent inside the box remained at a similar level for each individual, although the adult female's percentage of time inside the box decreased slightly during each month of data collection. This may be because she spent more time sleeping outside the nest box as the kits grew.

Solitary behaviour

Solitary behaviour differed between the kits and the mother. The adult female spent most of her time resting. Wild adult Fossas are generally inactive only 30% of the day, but low activity levels are normal for captive carnivores and previous studies have documented up to 85% inactivity in captive adult Fossas (McCarthy *et al.* 2003). The kits were much more active, with greater time spent locomoting and both showing some solitary play behaviour. Play and investigatory behaviour by the kits were not observed until the kits were approximately 10 weeks old. These behaviours increased during the third month in both individuals, correlating with their ongoing physical maturity: as they became more adept at walking, climbing and leaping throughout the enclosure, they could more easily explore the space and objects within it. This increased mobility also probably corresponded to the male's large amount of time not visible. He showed a high rate of locomotion and often moved into areas with little visibility, such as into the nest box or behind rocks or logs. Although related to times of high activity, his behaviour when in these areas could not be determined.

An interesting result was that the MR kits were never seen eating solid food, even when it was available. By six weeks of age the incisors of the HR kits had emerged and the molars could be felt through the gums; they began eating meat at two months and were fully weaned by six months. Winkler (1996) and Garbutt (1999) stated that meat is first eaten at 3–4 months of age, with full weaning occurring at 4–6 months. Other captive studies (e.g. Hornsey 1999) corroborated this. At the end of the study the MR kits were over four months old and still only observed nursing; it is likely that if they had not begun eating solid food, this behaviour would soon be evident.

Stereotypic behaviour in the adult female was rarely observed. Adult Fossas are prone to such behaviour, especially when in inadequate enclosures or when exhibit boundaries face exhibits housing other animals (Winkler 1996). The adult female displayed stereotypic behaviour since arrival at CMZ in July 2002, primarily as rapid pacing across the back ledge of the exhibit. From January to June 2004, before the birth of the kits, the female paced for approximately 20% of her overall activity budget (J. Mueller unpublished data). This behaviour ceased at the birth of the kits and was not seen again until the litter was almost one month old. During the duration of the study, the female paced only three times, a radical decrease from her previous rate. It is likely that the increased social interactions necessitated by the kits were a primary factor in this change. Social stimulation is considered the reason that housing compatible adult Fossas in pairs can eliminate stereotypic behaviour (Winkler 1996).

Marking

Marking in the Fossa is likely to have multiple functions, including mate attraction and the creation of territorial boundaries (Garbutt 1999). Both the adult male and female at CMZ marked their enclosures several times daily throughout the year (McCarthy *et al.* 2003, J. Mueller unpublished data), using either a genital rub on a vertical object, an anal rub across a flat substrate, or chin/chest rubbing on an object. During this study, the adult female was seen only chin marking, a common form of marking in viverrids (within which the Fossa was formerly included) and mustelids (Clapperton 1989). Both MR kits were first seen marking at about 12 weeks old. Throughout the remainder of the study they marked multiple times, using only the genital rub. Hornsey (1999) reported genital marking from a captive male kit aged thirteen-and-a-half weeks.

Scent marking when juvenile may reflect continuing behavioural development: young Fossas are unlikely to be motivated by territory or mate attraction, but these are future necessities, so animals begin to refine marking behaviour at an early age. The similarities between the two kits of different sex are not surprising: other species show similarities in male and female marking behaviour. Adult male and female Ferrets *Mustela* '*furo*' use anal drags and body rubbing with the same frequency (Clapperton 1989), and differences in individual Meerkats' *Suricata suricatta* marking behaviour are not sex-related (Moran & Sorensen 1986).

Proximity and social behaviour

The kits were proximate to another individual significantly more often than distant. The adult female averaged more than half her time distant, but this rarely included leaving the kits alone: generally she kept them within viewing distance, and if moving into another area of the enclosure returned every 30–60 seconds to check on them. Fossa kits cannot survive independently for at least six months (Sunquist 1998) and may even remain with their mother and littermates until sexually mature (Winkler 1996). Although adults are solitary in nature the species clearly has social tendencies when juvenile and subadult, so being housed together in captivity for extended periods of time may benefit behavioural development, learning and activity. Winkler (1996) stated that adult Fossas can be housed together if the exhibit is of sufficient size and intraspecific aggression is not displayed.

Social activity varied greatly between subjects, both in total percent of time and the division of specific behaviours. The adult female had the least social activity, of which the majority seen was nursing and grooming of kits. The mother provides vital opportunities to the kits, as her behaviour helps teach the young about sociality and environmental interaction (Carlstead 1996). Nursing, for example, provides not only nutrients but also the chance for the kits to learn that their behaviour (i.e. attempting to nurse) can affect the environment (i.e. cause the mother to allow them to nurse).

The juvenile female had more than twice the social behaviour of the male, largely explained by bouts of nursing lasting up to ten minutes. Her overall time spent being groomed and in social play resembled that of the male. The latter exhibited mostly affiliative behaviour (social play), including non-aggressive wrestling, chasing, pouncing etc., as was also described for Fossa kits by Albignac (1975) and Kopel (1998). As in most mammals, play can dispel energy, refine behaviours needed as adults, and reinforce social bonds (Carlstead 1996).

No aggressive behaviour was seen during the study. Young carnivores may display mild aggression toward littermates when competing for nursing opportunities or solid food, or establishing dominance. Additionally, adult Fossas are solitary and may display intraspecific aggression when housed together in captivity (Winkler 1996). Thus, it was expected that aggression would become more prominent as kits aged and increased their social interactions. The juvenile male and female, however, were never overtly aggressive towards one another. This may be due to the (post-abandonment) small size of the litter, meaning that resources such as food and space would rarely be limited. There was also no aggression seen from the adult female toward the kits, which was expected given that young may stay with their mother until sexually mature.

There are currently fewer than 80 Fossas registered in captivity (ISIS 2007). There were estimated to be fewer than 2500 mature individuals in the wild, hence the species is red-listed as Endangered by IUCN (Dollar 2000). The species has no natural predators, but the *in situ* population is continuing to decline through habitat loss and overhunting for illegal trade and livestock protection (Köhncke & Leonhardt 1986, Dollar 1999). Relatively little is known about the biology and behaviour of this species, and additional research both in the wild and in captivity could increase the successful propagation of the species. In captivity, encouraging natural behaviours is crucial for the physical and psychological health of the individuals but is difficult without comparative information from the wild (Carlstead 1996). This is the case for the Fossa, as small and fragmented populations along with its secretive behaviour hinder extensive behavioural research. Captivity therefore allows increased knowledge of this species. Long-term management of species relies on providing environments that promote successful reproduction (Kleiman 1994) and for captive Fossas this benefits from objective analyses of maternal care and infant development. Studies such as this can provide a better understanding of the behavioural and physical needs of the mother and infants which can improve husbandry guidelines and provide crucial information for properly housing and hand-rearing Fossas in captivity.

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Potential for sampling bias in diet studies of American Marten *Martes americana*

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Abstract

Numerous techniques have been used to estimate carnivore diets. When examining gastrointestinal tracts from carcasses of trapped animals, it is common to find intestinal contents paired with empty stomachs. In addition, trapping bias frequently results in unequal samples of groups to be compared (e.g. more juveniles than adults). We investigated the effect of unequal sample sizes on American Marten *Martes americana* diet by reducing sample size (by 50%) of one sampled group and repeating the statistical analyses. Comparison of ten constructed datasets showed that stomach and intestinal contents were similar, indicating that using either stomachs only, intestines only, or a combination of stomach and intestinal contents would not change test results. Ten identically designed stomach sample comparisons by sex and age class showed no differences in diets between groups, indicating that unequal sample sizes did not bias diet estimates.

Keywords: age class, food habits, sample size, sex class, USA

Introduction

Numerous techniques have been used to estimate carnivore diets including direct observations, following tracks to kill sites, scat collection, stable isotope analysis and carcass collection (Murie 1961, Weckwerth & Hawley 1962, Spencer & Zielinski 1983, Buskirk & MacDonald 1984, Hargis & McCullough 1984, Raine 1987, Nagorsen *et al*. 1989, 1991, Poole & Graf 1996, Ben-David *et al.* 1997, Simon *et al.* 1999, Bull 2000, Cumberland *et al.* 2001, Trites & Joy 2005). However, because many of these approaches are labour intensive or costly, sample sizes are often small. Carcasses collected during established trapping seasons can offer advantages when studying diet of carnivores including potentially large sample sizes and decreased time spent obtaining samples because trappers collect specimens (Buskirk & MacDonald 1984, Thompson & Colgan 1987). A limitation of this method is that sampling typically is restricted to the authorised period of harvest.

It is usually advantageous to design studies with equal sample sizes by groups to be compared (i.e., a balanced design; Zar 1999); however, this can be difficult in field studies. When examining gastrointestinal (GI) tracts from carcasses, it is common to find intestinal contents paired with empty stomachs because food spends more time in the intestine than in the stomach (Randall *et al.* 2000). In addition, trapping bias frequently results in unequal samples of groups to be compared (e.g., more males than females, more juveniles than adults; Strickland & Douglas 1987).

For American Marten, Nagorsen *et al.* (1989) suggested keeping stomach and intestinal contents separate for analysis because they may contain prey items from two different meals, adding an unwanted source of variation. However, diet analyses in previous American Marten studies were conducted on combined data sets consisting of contents of the stomach, intestine, or both stomach and intestine (Nagorsen *et al*. 1989, 1991, Poole & Graf 1996, Cumberland *et al.* 2001).

In this study, our objectives were to: 1) compare dietary contents of the stomach and the intestines in American Marten; and 2) estimate the effects of unequal sample sizes using diet comparisons between stomach and intestines and between sex and age classes.

Methods

The study was conducted in the Upper Peninsula of Michigan, USA (45°45′–46°49′N, 84°14′–89°30′W), located on the southern shore of Lake Superior and covering an area of 42,610 km².

Gastrointestinal (GI) tracts of trapped martens were collected by the Michigan Department of Natural Resources during the December trapping seasons from 2000 to 2004 and frozen until analysis. Sex, age, date, and location trapped were recorded for each marten. Only martens with complete information that were registered as harvested during the legal trapping season were used for analysis.

All martens harvested during 2000–2001 were used for analysis. Due to large numbers of carcasses and time constraints, not all carcasses were analysed during 2002–2004. In 2002 and 2003, more males were trapped than females; in these years, all females were sampled and an equal number of males were randomly selected for analysis. Because high numbers of both sexes were trapped in 2004, male and female martens from that year were randomly selected to equal numbers sampled during 2003.

Because stomachs and intestines of an individual marten may contain remains from different meals (Nagorsen *et al*. 1989), stomach and intestinal contents were kept separate and analysed separately. Contents of GI tracts from 2000–2001 were analysed for parasites prior to diet analysis (Veine 2004). Examined contents from GI tracts were placed in plastic bags, labelled, and frozen for diet analysis.

Gastrointestinal tracts from 2002–2004 were opened and scraped of their contents. We rinsed all marten gut contents with 75% ethyl alcohol, separated hair samples into labelled containers and air-dried hairs for identification (see Weingart 1973).

We made negative impressions of hairs sampled from each marten's GI tract (see Weingart 1973). We used a compound microscope at 40–400X magnification, hair identification guides (Adorjan & Kolenosky 1969, Moore *et al*. 1997, Andruskiw *et al*. 2003), and reference slides made from museum specimens to identify prey species.

We designated six prey groups for analysis based primarily on prey body mass: shrew, mice/vole, bird, chipmunk, squirrel, and grouse/hare. The shrew group included *Sorex* spp.

and Northern Short-tailed Shrews *Blarina brevicauda*. The mice/vole group consisted of North American Deer Mice *Peromyscus maniculatus* and Southern Red-backed Voles *Clethrionomys gapperi*. The bird group was all bird species excluding Ruffed Grouse *Bonasa umbellus*. The chipmunk group comprised Eastern Chipmunks *Tamias striatus*, and the squirrel group included American Red Squirrels *Tamiasciurus hudsonicus* and Eastern Grey Squirrels *Sciurus carolinensis*. Ruffed Grouse and Snowshoe Hares *Lepus americanus* comprised the grouse/hare group.

We compared the proportion of occurrence of prey groups within the stomach and within the intestines using a chi-square test. We calculated kilocalories (kcal) for prey groups using mean body mass of prey (Brewer 1991, Kurta 1995, Cumberland *et al*. 2001). We initially regressed body mass of prey against known calorific values of prey species reported by Cumberland *et al.* (2001). This regression line was forced through the origin as a body mass of 0 g has no calories. We then used this linear regression model to estimate calorific values (kcal) of prey species where calorific values were unknown.

We compared kilocalories of prey groups between stomachs and intestines using analysis of variance. To determine if unequal sample sizes of these groups (e.g., contents from stomach and contents from intestines) influenced results, we generated ten data sets where half the stomachs were removed randomly. A chi-square test was used to compare frequencies of prey groups in each of the ten generated data sets of 75 stomachs' contents with the original 151 intestinal contents.

We then conducted ten similarly designed analyses using male (n = 83) and female (n = 68) diets with half of the females (n = 34) randomly removed, and ten analyses using juvenile (n = 47) and adult (n = 104) diets with half of the juveniles (n = 23) randomly removed. Chi-square tests were used to compare each of the ten generated data sets of female contents with the original male contents, and each of the ten generated data sets of juvenile contents with the original adult contents. All analyses were conducted using STATISTIX 8 (Analytical Software 2003) with significance accepted when $P \leq 0.05$.

Results

We sampled 318 American Martens of which 151 contained food in both stomach and intestines that were used for analyses. Composition of the sample included 68 males and 83 females or 47 juveniles (<1 year old) and 104 adults (≥1 year old).

Proportions of prey groups in the stomachs and intestines of the 151 martens were similar ($\chi^2 = 2.13$, df = 5, $P = 0.83$; Fig. 1), as were comparisons when half the number of the stomach content samples were removed from analyses ($\chi^2 = 1.56$–4.80, df = 5, $P = 0.44$–0.91). Estimated kcal present in stomachs and intestines by prey group were also similar ($F = 0.00$–1.06, df = 1, $P = 0.30$–0.98).

Proportions of prey groups consumed by male and female martens were similar ($\chi^2 = 7.57$, df = 5, $P = 0.18$; Fig. 2), as were proportions of prey groups when half the number of female samples were removed from analyses ($\chi^2 = 2.87$–10.12, df = 5, $P = 0.07$–0.72). Proportions of prey groups consumed by juvenile and adult martens did not differ ($\chi^2 = 4.45$, df = 5, $P = 0.487$). Similarly, diet was comparable when half the number of juvenile samples were removed from analyses ($\chi^2 = 2.06$–5.06, df = 5, $P = 0.41$–0.84).

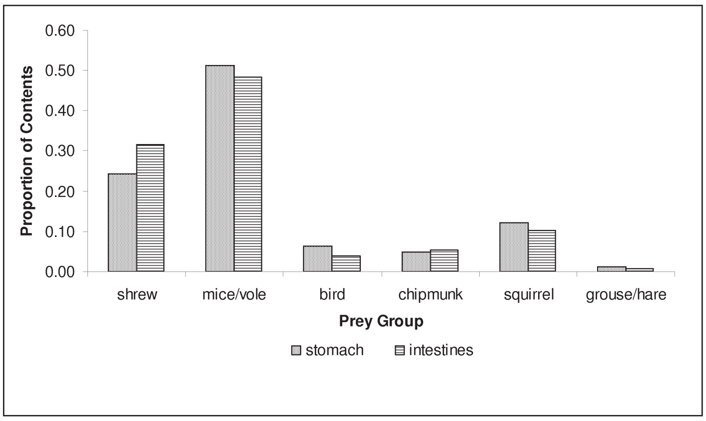

Fig. 1. Proportion of prey groups in the gastrointestinal tracts of 151 trapped American Martens, Upper Peninsula of Michigan, USA, Decembers of 2000 to 2004.

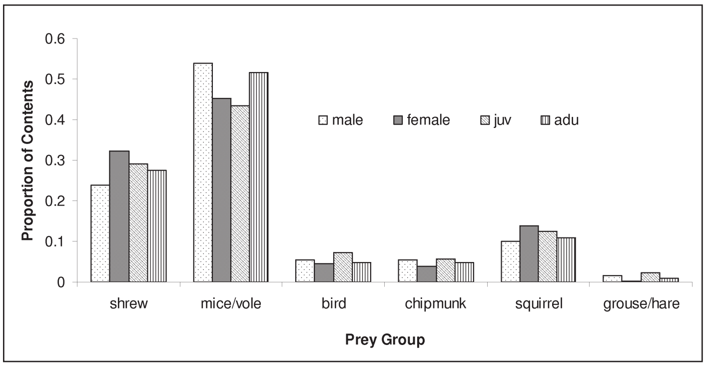

Fig. 2. Proportion of prey groups in male (n = 83), female (n = 68), juvenile (n = 47), and adult (n = 104) American Marten gastrointestinal tracts, Upper Peninsula of Michigan, USA, Decembers of 2000 to 2004.

Discussion

Often, collecting samples for research is opportunistic. However, small sample sizes increase the probability of variability due to sampling error (Trites & Joy 2005). Diversity of individuals sampled (e.g., by sex or age class) must also be considered (Trites & Joy 2005). Larger sample sizes can increase power of test results and investigator confidence in interpretation of data.

In this study, the stomach generally was the organ without prey items. Traps typically used to capture martens in Michigan are body-gripping and foot-holding traps. Body-gripping traps kill captured animals quickly, preventing further digestion and passage of contents through the GI tract. In contrast, foot-holding traps leave the marten alive until the trapper returns to collect the animal. The time between trapping and collection may be enough for the trapped marten to partially or completely empty its GI tract.

Our data did not support the contention of Nagorsen *et al*. (1989) that stomach and intestinal food contents of American Martens need to be kept separate to avoid potential bias of some martens having multiple meals represented in analyses. Martens in Michigan's Upper Peninsula during early winter used a small number of prey species which may explain in part the similarity in diet between organ contents. Regardless, there was no difference in dietary content when analysing the contents of stomach or intestines. Therefore, at least in our study area, all marten specimens (e.g., stomach, intestine) may be included in a diet study which will markedly increase sample size.

This method of sampling may not be appropriate for studies conducted under different conditions. As animals consume more food, digestive transit (the speed at which prey travels through the stomach) increases (Randall *et al*. 2000), which will influence GI contents. Also, relative abundance of prey species and number of prey species available can influence diet contents. For example, if martens are sampled in a location where more types of prey are available, the probability of the number of species present in the entire GI tract being greater than the number of species present in the stomach or intestines increases. Under this scenario, the probability of organ contents differing also increases.

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On some weasels *Mustela* from eastern Asia

Colin GROVES

Abstract

Comparisons of pelage and skull features validate *Mustela russelliana* Thomas, 1911, *Mustela tonkinensis* Björkegren, 1942, and *Mustela aistoodonniva*lis Wu & Kao, 1991, as species under a phylogenetic species concept. *Mustela russelliana* is the world's smallest species of the order Carnivora. All are known from only few specimens and tiny geographic ranges.

Keywords: morphology, *Mustela aistoodonnivalis, Mustela kathiah, Mustela nivalis, Mustela russelliana, Mustela tonkinensis*, systematics, taxonomy

对比四川伶鼬 *Mustela russelliana* Thomas, 1911, *Mustela tonkinensis* Björkegren, 1942, 和缺齿伶鼬 *Mustela aistoodonnivalis* Wu & Kao, 1991 的皮毛和头骨特征，证实牠们为亲缘种。食肉目动物中以四川伶鼬的体型最小。这些物种已知的分布区狭小，亦只有少数标本。

In the autumn of 1909, the Duke of Bedford organised a collecting trip to western China (Gansu and Sichuan) under his employee Malcolm Anderson. The several new mammals which resulted from this trip were announced in a preliminary presentation by the leading British mammalogist of the time, Oldfield Thomas of the British Museum (Natural History). They included a new species of weasel, *Mustela russelliana*, diagnosed as follows:

> "Size excessively small. Colour nearly as in *M. kathiah*. Tail not tufted" (Thomas 1911a).

Later the same year (Thomas 1911b), the description was elaborated, stressing the extremely small size ("about that of the very smallest known weasel – the American *M. rixosa* Bangs"), the sharp contrast between upper and lower parts ("as in *M. kathiah* and the stoats, not as in *M. nivalis*"), the "beautiful pinkish buff" of the underside, turning into white in the interramal region, and the tail shorter than in *M. kathiah*. (Some of the other characters mentioned are individually variable, so are not diagnostic). The type (and only) locality is Tatsienlu (now Lucheng, 30°03′N, 102°01′E, 4,480 m a.s.l.), in Sichuan. The description ends on a sycophantic note:

> "The combination *Mustela bedfordi* being already in use, I have given to this striking new species a designation based on the family name of the donor of the present magnificent accession to the National Collection of Mammalia".

Allen (1938) was one of the few to examine the type series or even mention the species, which he accepted as valid. He mentioned its similarity in size to the Pygmy Weasel, which he called *M. rixosa pygmaea* and of which he had earlier described some specimens from Siberia and Mongolia, but "the tail is much longer in proportion, and all the series have the throat white, but the remaining under parts contrastingly pale orange buff".

Ellerman & Morrison Scott's (1951) influential checklist set the tone for the whole of mammalian taxonomy for the next quarter-century—indeed, its legacy of wholesale lumping of species is still with us. In this compilation, the Sichuan weasel was relegated to the status of subspecies as *M. nivalis russelliana*. The best way to ensure that a taxon gets forgotten or overlooked is to reduce it to the status of subspecies; unsurprisingly, *russelliana* dropped off the radar for the remainder of the century and beyond, to the extent that when in 1991 a further new species was described from China, *russelliana* was mentioned, but, being supposedly a mere subspecies of *Mustela nivalis*, not specially compared with the new species.

The "further new species" was the magnificently named *Mustela aistoodonnivalis* Wu & Kao, 1991, dubbed the Lackedteeth Pygmy Weasel by its describers, based on four specimens from the Qinling Range, central China: three from Mt Taibai (1,950–2,750 m a.s.l.), in Zhouzhi County, approx. 34°N, 108°E, and one from 2,400 m a.s.l. in Zhashui County, approx. 34°N, 109°E. I am unaware of any other specimens of this species. The specimens are presumably held in the collections of Northwestern University, Xian, China. It was diagnosed as follows (English abstract from Chinese paper):

> "External features of the new species are very similar to *M. nivalis*. The tail is very long…exceeding one third of the length of body and head. The summer fur of the back, tail and head is dark brown, no dark markings on face or head. Under the lip, chin and throat, the fur is white but the chest and belly are a pale yellow with some irregular and rusty-red spots. The backs of front legs are brown, and the hind limbs are similarly brown but the inner lateral parts are white hairs with brown spots. The palms and soles have shorter hair. The second lower molar (M_2) is absent" (Wu & Kao 1991: 93–94).

As far as the Palaearctic and Continental ranges are concerned, the reputed subspecies of *Mustela nivalis* are continuously distributed with the exception of *russelliana* and the Vietnamese *tonkinensis* (Abramov & Baryshnikov 2000). In 2006, I examined the type series of *russelliana* in the Natural History Museum, London, and compared it with other Asian representatives of *M. nivalis* (particularly *tonkinensis*), with *M. kathiah*, to which Thomas (1911a, 1911b) likened it, and with the description of *M. aistoodonnivalis*; I have not seen the original specimens (Tables 1, 2). *Mustela kathiah* is itself closely related to *M. nivalis*, and belongs (together with *M. subpalmata* and *M. altaica*) in the subgenus *Gale* Wagner, 1841 (see Abramov 2000).

Examination of the four (sic) specimens in the type series (see colour plate on page 25) shows that *M. russelliana* is on average the smallest of all *nivalis*-group weasels and is longer-tailed than any but *M. n. numidica* from Morocco and the Azores. It is exceptionally dark in colour, a rich almost maroon brown, with a

Table 1. Measurements of Mustela russelliana *and related taxa.*

No.	Sex	Locality	Head and body length, HB (mm)	Tail length (mm)	Hindfoot length , Hf (mm)	Ear length (mm)	Tail % HB	Tail cf. Hf
M. tonkinensis								
63.0148		Sa Pa	200	90	29	-	45.0	3.1
M. russelliana								
11.2.1.86	F	Lucheng	133	54	22	11	40.6	2.5
11.2.1.85	M	Lucheng	138	54	24	12	39.1	2.3
11.2.1.87	F	Lucheng	128	50	22.5	11	39.1	2.2
11.2.1.84	M	Lucheng	135	54	23	12	40.0	2.3
M. aistoodonnivalis								
84069	F	Mt Tabai	146	60	22	11	41.1	2.7
81029	F	Mt Tabai	150	57	23	15	38.0	2.5
84013	M	Mt Tabai	160	62	27	12	38.8	2.3
81037	yF	Qinling	[131]	[50]	[22]	[8]	38.2	2.3
M. cf. nivalis								
14.11.1.14	F	Alzamay	145	23	19	11	15.9	1.2
14.5.10.68	M	Zharkent	175	25	25	10	14.3	1.0
1938.8.8.8	M	N.Korea	180	34	16	10	18.8	2.1
longest-tailed	n=14	Azores + Morocco	223-266	89-116			41.5	-
smallest	n=24	N.E. Siberia	138-180					
M. kathiah								
16.3.25.58	F	Darjiling	207	131	36	7	63.3	3.6
33.4.1.249	M	Chapa	235	155	35	18	66.0	4.4
33.4.1.248	M	Chapa	280	174	46	25	62.1	3.8
1895.519	y	Lucheng	[174]	[80]	[27]	-	46.0	3.0
43.160	M	Naga Hills	[165]	[80]	[32]	[10]	48.5	2.5

y = young; *M. tonkinensis* is in NRM, the *M. russelliana*, *M.* cf. *nivalis* and *M. kathiah* specimens are in BMNH; measurements of immature specimens are in square brackets; measurements of specimens of *Mustela aistoodonnivalis* are taken from Wu & Kao (1991) and ranges of samples from the Azores, Morocco and north-east Siberia from Abramov & Baryshnikov (2000).

beautiful golden-toned underside, quickly becoming whitish on the upper throat and interramal region. Hands and feet are dark like the rest of the upper side; the palms and soles are hairy. There is no white spot between eye and ear.

Among the other Asian *M.* cf. *nivalis*, those closest in distribution to the Chinese and Vietnamese weasels are creamy-white on the underside, and most are lighter on the upper side (one from Qostanay, Kazakhstan, is extremely pale), although some Siberian specimens of *M. n. nivalis* are nearly as dark as *M. russelliana*. The pelage of *M. kathiah* is much more similar to *M. russelliana*. The underside is creamy gold or golden, but unlike the latter the throat is also golden, not white, although it can be paler than the venter, only the interramal region being white; and the underside of the paws is not hairy, and not white.

The skull of *M. russelliana* resembles *M. kathiah* in many respects (Figs 1–2). Notably, the postorbital constriction is sharply marked and deep relative to the width of the brain case, though not necessarily relative to the size of the skull as a whole (see Abramov & Baryshnikov 2000, Fig. 2). The zygomatic arches are straight as in *M. kathiah*, not outwardly bowed as in *M. nivalis*. The post-palatal notch is V-shaped as in *M. kathiah*, not widely U-shaped as in *M. nivalis*. Unlike either *M. kathiah* or *M. nivalis*,

Fig. 1. Skulls from below. Left to right: M. aistoodonnivalis *(holotype),* M. tonkinensis *(NRS A.63.0148),* M. nivalis *(NRS MN 19/62, Sweden). The rostrum is more constricted anteriorly in* M. aistoodonnivalis*. The zygomatic arches are more bowed in* M. tonkinensis *and particularly in* M. nivalis*. Basioccipital widens posteriorly in M. tonkinensis, but is parallel-sided in the others. Post-palatine notch is U-shaped in* M. tonkinensis *and* M. nivalis*, V-shaped in* M. aistoodonnivalis*. Photos: left, Wang Yingxiang; others, Annika Felton.*

Table 2. Comparisons of Mustela russelliana *and related taxa.*

Morphological character	***M. tonkinensis***	***M. cf. nivalis***	***M. russelliana***	***M. aistoodonnivalis***	***M. kathiah***
Dorsum	dark brown	brown	rich maroon-brown	"deep brown"	rich maroon-brown
Pattern	V (*vulgaris*)	N or V	N (*nivalis*)	N	N
Venter	white, yellowish tinge	white or yellow-tinged	pale yellow to rust-red	pale yellow to red	bright golden
Throat, interramal	white as venter	white as venter	white, contrasting	white, contrasting	white (throat only)
White spot between eye and ear	yes	no	no	no	no
White spot below ear	indistinct	clear	no	no	no
Lower molars	1	usually 2	1	1	2
Postorbital constriction	deep	less	deep	deep	deep
Basioccipital	widens posteriorly	parallel-sided	widens posteriorly	widens posteriorly	parallel-sided
Rostrum	very short, square	short, square	narrowing anteriorly	narrowing anteriorly	square
Zygomata	bowed	less	straight	straight	straight
Temporal fossa	width nearly = length	width > length	width < length	width < length	width < length
Sagittal crest	no	maybe	no?	no	maybe
Post-palatine notch	U-shaped	U-shaped	V-shaped	V-shaped	V-shaped
Head + body length, HB, M (mm)	200	152-310	136-138	160	235-280
Tail as % HB	45	17-31	39.1-40.6	38.0-41.1	62.1-66.0
Condylobasal length, Cbl, M (mm)	36.2	29.8-46.1	29.9	31	48.0-51.4

M–male

however, the basioccipital widens posteriorly rather than being parallel-sided, and the rostrum narrows anteriorly instead of being blunt and square.

As far as can be told from the description, and from photographs of the holotype skull kindly supplied by Professor Wang Ying-xiang, the skull features of *M. aistoodonnivalis* are exactly the same as in *M. russelliana*. Strikingly, all of the type series of *M. russelliana* lack M_2, the feature from which *M. aistoodonnivalis* takes its name; this feature does occur in *M. nivalis*, but is uncommon (and it also occurs in other species of *Mustela*, outside the *M. nivalis* group), so it cannot be considered diagnostic of these two Chinese species. Its presence at high frequency (perhaps fixed?) is noteworthy, and is a further indication that the two are very close: in fact, only the greater size of *M. aistoodonnivalis* seems to separate them. A number of other mammalian taxa or species-groups are likewise distributed between the Qinling range and the mountains of Sichuan, including the Giant Panda *Ailuropoda melanoleuca*, Golden Snub-nosed Monkey *Rhinopithecus*

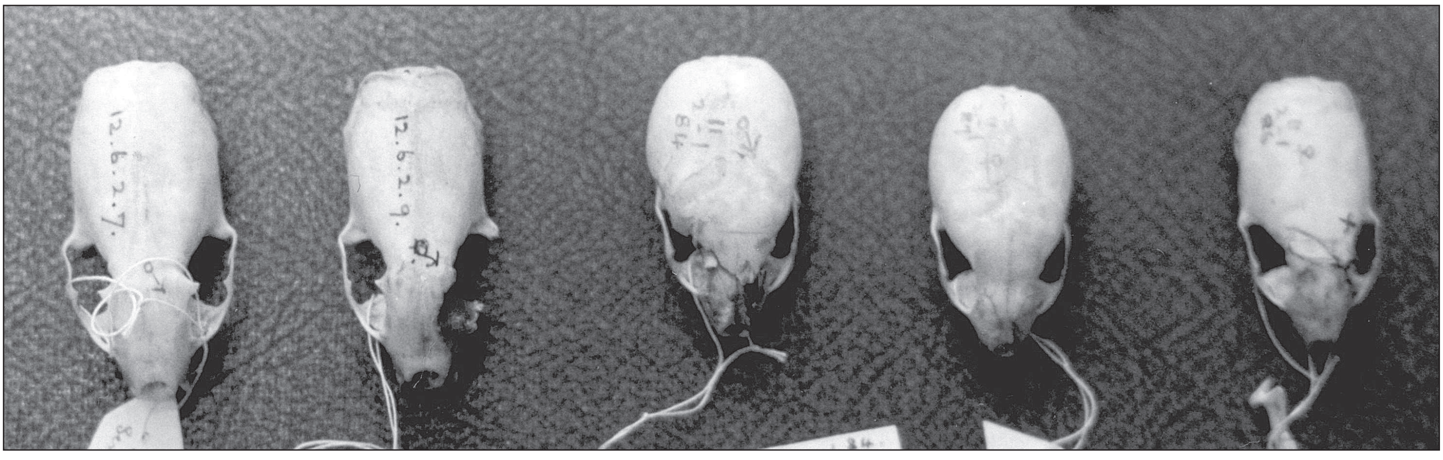

Fig. 2. Skulls from above. Left: two M. nivalis *(BMNH 12.6.2.7, -9, from Djarkent, Kazakhstan); right, three* M. russelliana *(BMNH 11.12.1.84, -7, -6 [holotype]). Notice the much deeper, more angulated, postorbital region constriction in* M. russelliana*, the short, anteriorly narrowing rostrum, and the straight zygomatic arches, so that the temporal fossa in dorsal view is long and narrow. Photo: Colin Groves.*

Fig. 3. Left hemimandibles, buccal view. Left, holotype of M. tonkinensis*; right,* M. nivalis *from Sweden, to show the absence of* M_2 *in the former, and its presence in the latter. Photo: Annika Felton.*

roxellana and takin *Budorcas* spp. (I take takin to be three or four distinct species, not the one as commonly held).

The holotype and only known specimen of *M. tonkinensis*, in the Naturhistoriska Riksmuseet, Stockholm, is said by the describer, Björkegren (1942), to have been collected at Chapa (now Sa Pa, 22°21′N, 103°52′E). The precise origin has been discussed by Abramov (2006), who concludes that it was most likely Mi Ti, at 22°15′N, 103°54′E. After a detailed description, Abramov (2006) concludes that it is a southern isolate of *M. nivalis*, and bears a particular similarity to an undescribed form on Taiwan. The pelage features do not really fall outside the range of *M. nivalis*, except for the presence of a white spot between eye and ear, while the white spot below the ear, so clearly marked in most other *M. nivalis*, is very poorly represented. The skull, however, is more different. Photographs of the skull (Fig. 3), kindly made on my behalf by Ms Annika Felton, of the Australian National University, show that it has a sharp, deep postorbital constriction and a posteriorly widening basioccipital, as in *M. russelliana*, but the rostrum and post-palatal notch are as in *M. nivalis*, and the zygomatic form is intermediate. Remarkably, M_2 is absent.

I have elsewhere made detailed arguments in favour of the phylogenetic species concept, under which any population that is diagnosably distinct from others must be recognised as a species (see, for example, Groves 2001), and thus objectively the Tonkin Weasel ranks as a distinct species.

Conclusions

1. *Mustela russelliana* is the world's smallest weasel—indeed, it is the smallest species of the order Carnivora.
2. *M. russelliana* and *M. aistoodonnivalis* are sister species, differing (apparently) only in size.
3. Their closest relative is not *M. nivalis* but *M. kathiah*.
4. Geographic diversity within *M. nivalis* has been clarified by Abramov & Baryshnikov (2000), but many (most?) of the subspecies recognised by them may well be diagnosably distinct, hence would rank as distinct species under a phylogenetic species concept.
5. I hypothesise that *Mustela tonkinensis*, distributed at the south-eastern margin of the subgenus *Gale*, is a primitive species, standing close to the point of separation of the *nivalis* and *kathiah* groups.

Acknowledgements

I am very grateful to Annika and Adam Felton for going to considerable trouble to photograph weasels, including the type of *Mustela tonkinensis*, for me in the Naturhistoriska Riksmuseet, Stockholm; to Paula Jenkins and Daphne Hills for facilitating my 2006 visit to the Mammal Section of the Natural History Museum, London; and to Alexei Abramov for very helpful comments on this paper.

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Plate. Skins of Mustela russelliana *and related taxa.*
Top to bottom:
M. tonkinensis (holotype, NRS A.63.0148)
Four skins of *M. russelliana* (BMNH 11.2.1.86 [holotype], -84, -87, -85)
M. mosanensis (BM 1938.8.8.8, Chosin, north Korea).
M. nivalis (BM 14.5.10.68, Djarkent, Kazakhstan)
M. nivalis (BM 14.11.1.14, Alzamai, Yenisei, Russia)
M. heptneri (BM 1938.4.14.16, Qostanay, Kazakhstan)
M. stoliczkana (BM 75.3.30.8, Yarkand, China)
The status of *mosanensis*, *heptneri* and *stoliczkana* as full species or as subspecies of *M. nivalis* remains to be determined under a phylogenetic species concept.
Photos: top, Annika Felton; others, Colin Groves.

Field observations of Yellow-throated Martens *Martes flavigula* feeding on flowers in Meghalaya, North-east India

R. NANDINI[1] and T. KARTHIK[2]

The Yellow-throated Marten *Martes flavigula* is a wide-ranging carnivore distributed from Pakistan and Afghanistan in the west to the Russian Far East and Indonesia in the east (Corbett & Hill 1992). In India, the species is reported to occur in the foothills of the Himalaya across Himachal Pradesh, Uttar Pradesh and east into Sikkim (Hussain 1999), Assam (Choudhury 1997a), Arunachal Pradesh (Choudhury 1997b), West Bengal (Choudhury 1999), Nagaland (Choudhury 2000), and Manipur (Ramakantha 1994). In Meghalaya, it is reported to occur in the Garo hills as well as in Balpakram National Park (Kumar *et al*. 2002). Little is known of the ecology of the species, a trend that is true for most non-Holarctic species of carnivores (e.g. Grassman *et al*. 2005).

This short note is based on observations made during a visit to Balpakram National Park, Meghalaya. The park (220 km²; Khan *et al.* 1997) is located in the south Garo Hills district and the elevation ranges from 200 m to 1,027 m. The habitat comprises of tropical moist deciduous and tropical evergreen forests (Haridasan & Rao 1985). On 11 March 2007, we were walking along a trail close to Mahadeo *aking* (village) Inspection Bungalow at Balpakram, when we saw two Yellow-throated Martens on a *Cynometra polyandra* (Roxb.) tree at 06h20. The tree was approximately 20 m off the road on a declivity and was in full bloom. The two animals seemed to be feeding on the flowers, and moved along branches between a height of 8 and 15 m. The martens foraged for about 10 minutes till the presence of passers-by on the trail caused them to look up and move down the tree into the undergrowth.

We walked further along and as we were approximately 100 m further down the trail we again saw two Yellow-throated Martens running after each other on the ground through an Areca-nut *Areca catechu* plantation. The martens stopped for a while and sat on a broken tree stump at the edge of the Areca-nut plantation, and after a few minutes climbed another tree of the same species, *C. polyandra*, also in full bloom. The two martens foraged on the tree, walking around in both the lower and upper reaches of the canopy and feeding on flowers. The martens stayed on this tree for approximately 10 minutes, till a strong gust of wind and a light rain caused the tree to sway. The martens ran down and we did not see them after this. The surrounding habitat was an Areca-nut plantation interspersed with few remnant native forest trees, and the area nearby had been cleared for *jhum* (shifting cultivation). Both the trees were mid-storey trees approximately 17–20 m high.

Yellow-throated Martens are known to be dietary generalists similar to other martens (Ramakantha 1994, Ruggiero *et al*. 1994, Ewer 1998, Parr & Duckworth 2007). They are known to eat rodents, small mammals, birds, reptiles, fruits and honey (Ramakantha 1994), and Pocock (1941) reported "a fondness for" the nectar of flowers. Martens are known to take advantage of seasonal variation and locally available resources (Ewer 1998). A similar plasticity has also been observed with another omnivorous carnivore in tropical forests, the Brown Palm Civet *Paradoxurus jerdoni* (Mudappa 2001). During our observations, we noted that the martens visited two flowering trees of the same species consecutively. The tree species was very distinctive due to its profuse flowering, and we noted that the two trees visited were the closer together of three visible flowering *C. polyandra* trees on the slope. We suggest from our observation that the martens intentionally capitalised on this opportunity to forage on this species. However, further studies on resource tracking based on availability and use of resources need to be conducted before conclusions can be made.

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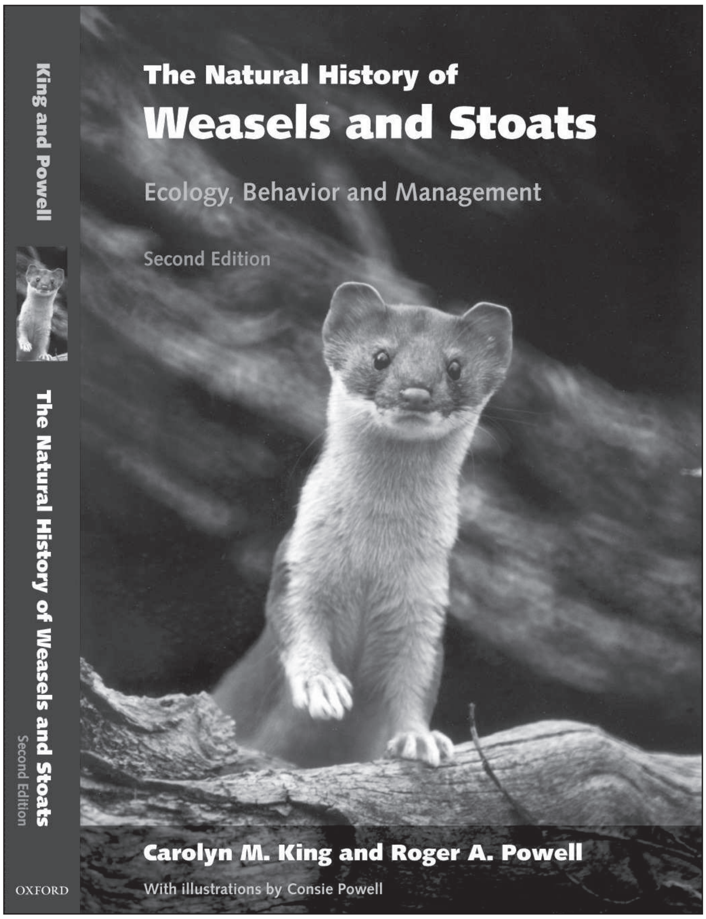

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American marten *Martes americana* (Photo: Andrea Hales, U. S. National Park Service)

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