SMALL CARNIVORE CONSERVATION

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Malagasy civet *(Fossa fossana)* in the Ranomafana National Park, Madagascar - Photo: Mario Perschke

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We are particularly grateful to Walter Rasmussen for reading the manuscripts and improving the English style.

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The aim of this publication is to offer the members of the IUCN/SSC MV&PSG, and those who are concerned with mustelids, viverrids, and procyonids, brief papers, news items, abstracts, and titles of recent literature. All readers are invited to send material to:

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Mongooses in the Tsimbazaza Zoo and the Ranomafana National Park, Madagascar

Mario PERSCHKE

In September 1995, two Malagasy broad-striped mongooses (*Galidictis fasciata*) came into the botanical-zoological garden 'Tsimbazaza' in Antananarivo, the capital of Madagascar. The couple was caught in the eastern rain forest of Zahamena (north-east Madagascar). Clearly, this is the first time this species has been kept in a zoo (R. Wirth, pers. comm.). The richly contrastingly-coloured animals lived in a double-paned glass case in the vivarium, which was provided with tree branches, sleeping boxes, stones, and a floor covering of dried leaves. They were fed with pieces of beef and freshly killed one-day-old chicks (two chicks per mongoose). The male died after a short time, but the female was obviously healthy and I could observe and photograph her in October and November 1995. She was quite friendly, and was active during several parts of the day. Unfortunately, I heard that the female has also died.

Broad-striped mongoose, *Galidictis fasciata*, in Tsimbazaza Zoo. Photo: Mario Perschke.

The picture of the broad-striped mongoose from Tsimbazaza Zoo appeared in the German journal *Arbeitsplatz Zoo* (No. 3, 1995). It is probably the first time that a photograph of a living individual of this attractive species has been published (R. Wirth, pers. comm.).

In October and November 1995, there were also other species of mongooses living at Tsimbazaza Zoo: Malagasy ring-tailed mongoose, *Galidia elegans elegans* (1,1) caught near Anjozorobe, north-east of Antananarivo, also *Galidia elegans occidentalis* (1,1) caught near Morondava, western Madagascar, and Malagasy narrow-striped mongoose (*Mungotictis decemlineata decemlineata*) (2,3), also caught near Morondava. These were also kept in double-paned glass cases in the vivarium, each in two outer enclosures (modelled concrete structures with caves, tree branches, and small islands of plants). It seems that both species have been bred at the zoo for several years. Offspring of the ring-tailed mongoose were born at the end of last year, but were probably eaten by their parents.

Free-living ring-tailed mongooses, *Galidia elegans elegans*, and Malagasy civets, *Fossa fossana*, can both be observed well and easily in the Ranomafana National Park (south-east Madagascar, north-east of Fianarantsoa), which was founded in 1991. During the day, several ring-tailed mongooses stay in the surroundings of a small camp site, close to its entrance. With the beginning of darkness, up to two Malagasy civets appear, which are attracted by fried pieces of meat, offered by the Madagascan tour leaders. The animals have lost their shyness of humans, and even of large groups of tourists, and will come very close.

With a bit of luck, in the early morning hours you may even encounter the fossa, *Cryptoprocta ferox*, along one of the paths in the 41,600 ha-large rain forest reserve.

Egon-Kisch-Strasse, 55, 13059 Berlin, Germany

Narrow-striped mongoose, *Mungotictis decemlineata*, in Tsimbazaza Zoo. Photo: Mario Perschke.

Molecular techniques and small carnivore conservation

Isabelle SCHÖN and Huw I. GRIFFITHS

Introduction

Zoological research has been transformed with the advent of new molecular based techniques, particularly those incorporating the polymerase chain reaction (PCR)(Mullis & Faloona, 1987; Saiki *et al.*, 1985). However, the zoological community is very much divided between those who have first hand experience of the use and application of these techniques and those who are aware of their significance, but have a limited understanding of the ways in which they can be applied to conservation biology. The aim of the present article is to provide a basic level review on laboratory molecular techniques, to explain the terminology used, and to provide examples illustrating their application to conservation problems. The review is divided into three parts: providing a historical background, explaining some of the key DNA techniques used (chronologically, by order of first widespread use by zoologists), and some examples of their application.

The basic problem facing non-molecular biologists is understanding the simple principles behind DNA-based techniques, coupled with difficulties in knowing the technical jargon commonly employed. To many the basic terminology used in molecular work is completely incomprehensible, and provides an insurmountable barrier to appreciation of findings presented in research reports, journal papers, and even research proposals. We here assume the majority of readers are familiar with the basic structure of deoxyribonucleic acid (DNA). Those who are not, we refer to the various student textbooks available which offer detailed descriptions (e.g. Alberts *et al.*,1989; Watson *et al.*, 1987).

Historical background

Prior to the 1980s, the most sophisticated technique available to zoologists for genetic analyses was allozyme electrophoresis. This operates on the principle that variants of the same protein (allozymes) migrate at different rates across a starch gel when a current is applied. Although allozyme electrophoresis provides a certain amount of information at the alpha-taxonomic scale (especially at species level), it is of less use for intrapopulation studies because of the often limited degree of variation (polymorphism) involved. A more general limitation is the necessity to use fresh or frozen material. With DNA based molecular techniques the major advantages are that much more variation may be available, the sample need not be fresh and that only very limited quantities of DNA are required.

However, the first DNA based techniques were not quite so flexible. "Restriction fragment length polymorphisms" (RFLPs) and "DNA fingerprinting" were among the first available (all these terms will be fully described later). Both suffered to a degree in that they required fairly complex protocols and the information that they provided was often difficult to interpret. Since the late 1980s two key developments have enabled researchers other than specialized molecular biologists to use DNA techniques. The first was the advent of previously mentioned "polymerase chain reaction" (PCR), and the second was the development of so-called "universal (properly, "versatile") primers". Both techniques together enabled DNA analysis from poor quality specimens, with no prior sequence knowledge and, more importantly, no conventional "cloning". PCR and subsequent DNA sequence analysis have also made possible the DNA equivalent of allozyme electrophoresis, i.e. "microsatellites", and have facilitated the improved use of RFLPs for large scale screening programmes.

DNA techniques

DNA extraction

The majority of DNA techniques require a very small tissue/DNA sample that need not necessarily be of good quality. Nonetheless, steps should be taken to prevent sample degradation as much as possible, e.g. storing in 95% ethanol or a -20°C freezer. A range of non-lethal sampling regimes are possible and should always be considered. Ear punches or blood samples may be collected (e.g. from the tails of voles), but since mammalian red blood cells have no nucleus, the volume of sample must be larger than a corresponding sample taken from other vertebrate groups (birds, Amphibi), etc.).With DNA techniques it may not even be necessary to capture the animal. Hairs (from "sticky tape" traps) or even faecal remains (Taberlet & Bouvet, 1992) contain sufficient DNA for PCR based techniques. Finally, it is worth noting that large numbers of specimens are available in museums and other archival resources and these may also be used as sources of DNA. However, museums receive frequent requests for tissue specimens and will often require a research proposal before they are willing to release particularly important specimens. Specific technical problems are associated with so-called "ancient DNA", particularly when the sample is formaldehyde preserved, so that specialized extraction protocols are required.

Tissues selected as DNA source-material are processed to yield relatively pure DNA. Extraction must be undertaken with a certain amount of care, primarily to prevent cross-contamination

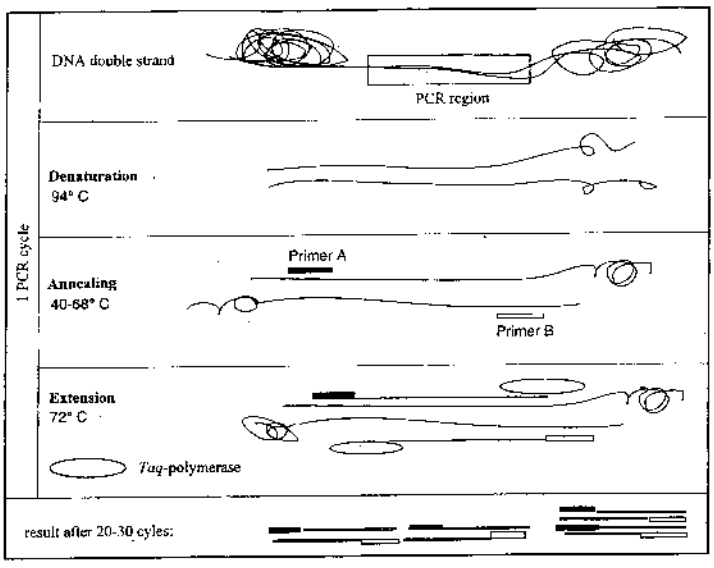

Fig. 1 Single steps of the "polymerase chain reaction" (PCR)(after Schön, 1995a)

of the samples. For instance, a recent "dinosaur" DNA sequence turned out to be contamination by the researcher (Zischler *et al.*, 1995). The extraction method varies depending on the source of the tissue sample analysed. Traditionally, DNA purification has involved proteinase digestion, followed by phenol/chloroform extraction to lyse cells, denature intracellular proteins, and free the DNA. DNA extraction in now better achieved through the use of simpler, safer techniques: silica (Höss & Pääbo, 1993), chelex (Walsh *et al.*,1991), commercial kits (Qiagen, Pharmacia) or simply by boiling an aliquot of tissue in buffer (Schön, 1995a).

In practice, different research aims are fulfilled by the examination of different DNA types: mitochondrial DNA (mt DNA), chloroplast DNA, and also various nuclear DNA regions that evolve at different rates (e.g. ribosomal or rDNA, and microsatellite DNA). The different scales at which these types of analyses operate are illustrated by Avise (1994). We will describe these in more detail later.

DNA-Fingerprinting

Perhaps the first DNA-based technique to attract widespread attention within the zoological community was "DNA fingerprinting", a technique developed by Jeffreys *et al.* (1985). The technique makes use of hypervariable parts of the nuclear genome, "minisatellites", which are multiple repeat units of DNA sequence. Minisatellite fragments are between 1 and 25 kilobases (kb=one thousand DNA bases) and highly polymorphic so that in theory, no two individuals (except identical twins) will produce the same DNA pattern. Their specificity and use in forensic work gave rise to their name. The technique is now considerably easier, and fingerprints have been obtained from a wide variety of species, but because minisatellites are so highly variable, their uses in conservation ecology have been limited outside of studies of paternity, mating system, and inheritance. Other limitations are that a relatively large and good quality DNA sample is required, and that it is difficult to apply the usual statistical analyses (such as testing for Hardy-Weinberg Equilibrium) because each DNA fragment is essentially anonymous (i.e. of unknown origin). As DNA fingerprinting is a multi-stage process, using techniques not applied to other types of DNA analysis, the methods are not discussed further here (but see review of Bruford *et al.*, 1992; Degnan, 1994).

PCR (Polymerase Chain Reaction)(Fig. 1)

PCR essentially mimics in vitro the process of DNA replication (DNA making a copy of itself). This process was first achieved in the laboratory by the use of polymerase enzymes to amplify bacterial DNA. Originally, this was a painfully slow and laborious process. To make multiple copies of a specific region of the DNA molecule (such as a gene selected at the start of the research programme), you had to use a chain of reactions at specific temperature conditions, each cycle of which would double the DNA content. The process itself involves three thermally assisted components, together termed a cycle. The first step is the "denaturing" step, in which the DNA double strand is separated into two single strands at a temperature between 93° and 95 C. This produces two single stranded DNA templates upon which the polymerase enzyme can act. For this purpose, it needs a small part of double stranded DNA to begin its polymerisation reaction. The second stage therefore is termed "annealing" in which a "primer", a short DNA fragment which is artificially synthesized binds to the DNA fragment in the reaction. The primer binds at this position, where its base sequence fits with the sequence of the DNA fragment. The reaction solution now consists of two templates with primers attached, in solution with appropriate salts, four free nucleotide bases (from which the new strand can be built) and the polymerase enzyme. Annealing takes place at a range of temperatures between 37° and 65°C. In practice, the optimum annealing temperature for each reaction must be sought by experimentation. The third stage is known as "extension". It is during this stage that the polymerase enzyme causes synthesis of a new, complementary DNA strand from the template and the free nucleotides. However, at the end of a single cycle such as this, there is only a doubling of the DNA content of the original reaction. For analytical purposes, this is insufficient, so the reaction cycle must be repeated 20 to 35 times, each with an associated doubling of DNA contents. After 35 cycles, the amount of original DNA has been copied by several order magnitude, and this abundance of DNA allows easier laboratory handling and treatments. However, the size of a typical PCR product would not normally exceed 2 kb, due to the polymerisation limit of the enzyme. If working with large sized DNA fragments, special conditions must be used e.g. cloning vectors and yacs (yeast artificial chromosomes) both of which are beyond the scope of this article. The major breakthrough in the harnessing of DNA analysis in routine laboratory studies came with the discovery of the enzyme *Taq*-polymerase. The enzyme itself is derived from a hot spring-dwelling bacterium *Thermus aquaticus*, and is now commercially available. The advantage of *Taq*-polymerase over the other types of polymerase enzymes available is its high resistance to elevated temperatures (in the "denaturing step" of the cycle) that would cause the others to denature and lose their function. Therefore, instead of adding a fresh amount of polymerase after each PCR-cycle, *Taq*-polymerase is included in the reaction mix from the beginning.

The result of PCR is a highly concentrated, high purity solution of the amplified DNA fragment. Its size can be assayed by the migration of a small amount of the PCR product across an electrically charged gel. This process is very similar to that of allozyme electrophoresis, but the gel is made of agarose, not starch. Visualization of the DNA is achieved by staining with ethidium bromide solution which can be seen under UV light. Size can be assessed by comparison with a mixture of DNA fragments of known size (often known as a "ladder"). These are usually constructed on a logarithmic scale which gives higher accuracy to measurements of small fragments (see Fig. 3).

Primers

The specificity of DNA polymerisation reaction is largely a product of the primer decided on. Primers are usually short (15 to 25 basepairs long) and synthesized for specific purposes. The choice of primer will depend on the target DNA region. This itself will often be selected on the basis of availability of published sequences (either in research literature or in particular DNA sequence data bases). If, for example, the DNA fragment of interest lies within mitochondria, data bases can be searched for mitochondrial sequence that is likely to have a high degree of similarity (homology) with that under investigation. Once a suitable target region has been chosen, a short sequence of bases is selected for use as a primer. Primers are synthesized automatically, following a base "recipe". Ideally, there should be sufficient homology between DNA sequences available on the data base and that to be investigated to allow amplification to occur. Sufficient difference is also required so that the DNA samples can be compared and differences between them identified. If no appropriate DNA sequence data are available, it is also possible to use "random" primer for DNA amplification. These are very

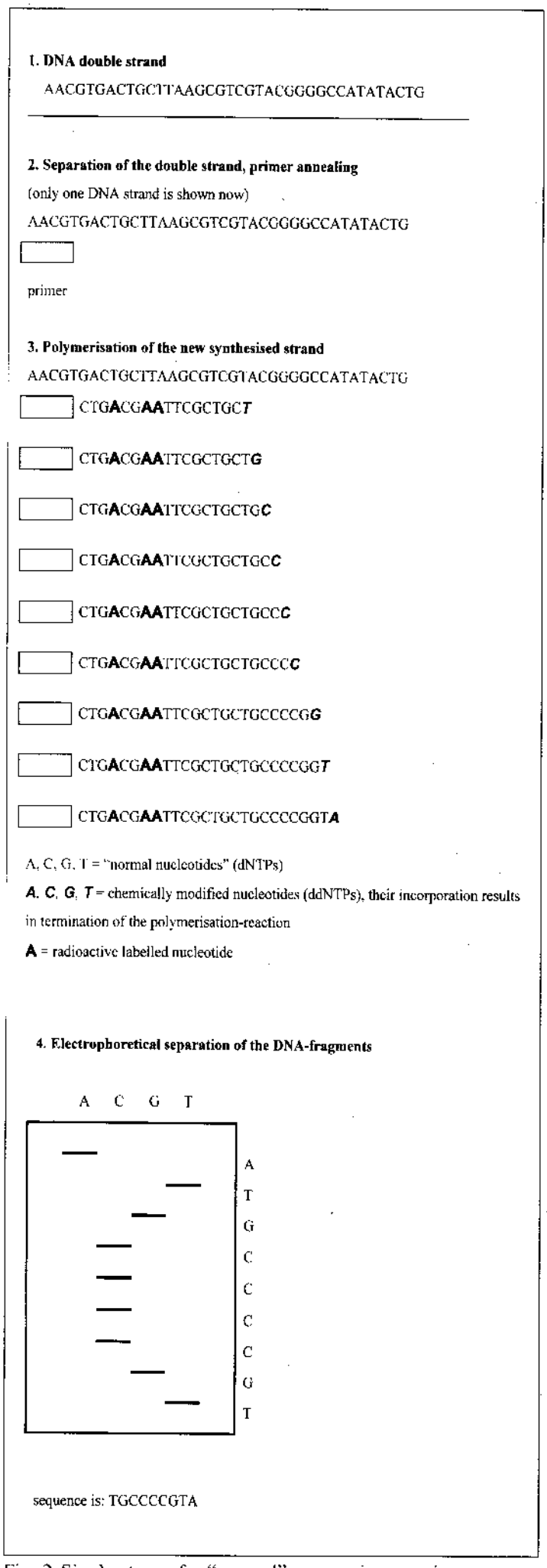

Fig. 2 Single steps of a "manual" sequencing reaction

short primers (10 to 15 basepairs long) which bind to random regions in the DNA. This procedure is known as "RAPD" (or verbally, "rapids") ("randomly amplified polymorphic DNA").

Sequencing (Fig. 2)

Sequencing is a very complex procedure which is now made considerably easier by the availability of automated sequencing machines. Unfortunately, such facilities are only available in the largest institutes and universities and are very expensive to install. In practice, most workers must still sequence "by hand". This is a time consuming procedure that can bring investigators into contact both with noxious chemical reagents and radioactive isotopes. In short, a sequencing reaction is quite similar to PCR, but the end result of sequencing is a photographic image of bands representing individual nucleotides in their order of assembly. (Some of the basic uses of DNA sequence analysis in ecological research are discussed by Butlin & Griffiths, 1995).

The first step in DNA sequencing is separating the double stranded PCR product. This can be done by various techniques e.g. incubating at a high temperature or magnetic separation using "magnetic, chemical labelled beads" to which one DNA strand will bind. In a second step, similar to the PCR cycle, a primer, the same as in the original reaction or one specifically designed for the purpose of sequencing, binds to the single stranded DNA. Also in this technique, a polymerase synthesises a complementary strand. It has a greater accuracy than the *Taq*-polymerase to ensure that only a small amount of sequence divergences arises due to mismatching. The great difference, compared to the reaction mix for PCR, is the mixture of nucleotides. In the sequencing reaction, equal sized measures of PCR products are incubated with different nucleotides individually (*i.e.* there are four different complementary reactions; one for each base). To visualise the reaction products at the end of the process, a radioactively-labelled nucleotide is included, which will provide an image on an X-ray film. Specific amounts of chemically modified nucleotides are also included, one being used in each one of the four separate reaction mixes. Every time one of these nucleotides is incorporated by the polymerase, the enzyme stops further polymerisation. As this happens randomly, the reaction ends with a mixture of DNA strands of different length, allowing their eventual visualisation electrophoretically. These mixtures rich in the four bases (G, A, T, C) are separated on acrylamide gels which have a resolution of single bases. After exposure of the gel to an X-ray film, a pattern of four lanes is revealed. Each lane represents one of the four bases with the presence of the base being indicated by a dark spot on the lane. Thus, the presence of Guanine will be shown by a dark spot in the guanine lane, but nothing in the other three. Therefore, by looking downwards at the pattern of spots on the lanes of the gel, it is possible to determine the DNA sequence from which they derive.

The process of sequencing needs to be done in "both directions", *i.e.* on both strands of the DNA, with the sequences running in opposite direction from one another. In the case of automatic sequencing, the four bases are labelled with fluorescent dyes, which are detected after gel electrophoresis by a laser in the machine. Eventually, this provides a printout indicating the position of the various bases within the sequence.

Sequence data analyses

DNA sequence information provides the "raw" data from which analyses are made. Such data consist of "chains of letters", which refer to the four bases in assembly order. It is necessary to

make a comparison of both strands (directions) from the same DNA sample. This helps to guard against errors in the sequencing process. Once this is done, it is possible to compare sequences between individuals, populations, and species. Specific algorithms allow computerised sequence analyses, which make the process much easier than the previous method in which sequences were compared by "eye and hand". In computer analyses the most commonly used package is "gcg" ("genetics computer group"), which is available, free of charge, from Daresbury, UK. The use of these programs allows the ready alignment of similar sequences and also the reversal of sequence orientation (if necessary). Data thus generated can be compared with previously published DNA sequences in various data bases. Newly generated sequence data should be submitted to a formal DNA data base such as Genebank (US National Academy of Sciences) or EMBL (European Molecular Biology Laboratory, Heidelberg, Germany).

Wright's F-statistics also can be applied to DNA sequence data, in a similar manner to that used for the analysis of information from allozyme studies.

Microsatellites

The analysis of microsatellites (also often confusingly referred to as VNTRs and SSR) is the most recent and most fashionable DNA technique that has been developed. Exactly as in an ordinary PCR reaction, a small region of the genome is amplified, but the region selected will contain highly polymorphic, short (typically dimeric) DNA repeats (e.g. ACACACACA). These microsatellites have such high mutation rate that they are useful for fine-scale studies of population differentiation and in studies of very closely related lineages. The advantages over allozymes are that often many more alleles are present, and that good quality specimen preservation is not required -museum preserved material or DNA from faeces will suffice. However, the problem associated with microsatellites is that new markers commonly have to be developed for each species under investigation, a process that may take from three months to one year.

What can molecular data tell us ?

Population size and subdivision

Allozymic techniques are weakest when examining divergence within species as the levels of variation observed within studied populations are often too low (i.e. beyond the limits of resolution of the analytical technique). This is precisely the type of problem to which molecular genetics data are ideally suited. The techniques actually utilised in phylogeny reconstruction are discussed by Swofford & Olsen (1990). A wide variety of species has thus far been investigated from different points of view. Byrne *et al.* (1990) describe various polymorphisms found amongst populations of woodmouse, *Apodemus sylvaticus*, and bank vole, *Clethrio glareolus*, in Ireland. Schön (1995 a,b) uses similar polymorphisms to examine the effects of habitat fragmentation on vole (*Microtus*) population substructures. Similarly, species regarded as being highly endangered have been " profiled" for their population variation, particularly when population sizes are restricted. Taylor *et al.* (1994) investigated the microsatellite variation within the northern hairy-nosed wombat, a species which has gone through a population bottle neck.

Similar studies have been undertaken upon species such as the European brown bear (Randi *et al.*, 1994), the black rhino (O'Ryan *et al.*, 1994), the Ethiopian wolf (Gotelli *et al.*, 1995), Spekes gazelle (Butler *et al.*, 1994), and humpback whales (Baker *et al.*, 1994).

Hybridization

Some of the most striking results to emerge from molecular studies are those in which apparently well known species have been found either to be hybrids between the taxa, or composites of several species of convergent appearance. The most well characterised of these cases is the now notorious dispute arising from Wayne & Jenks' (1991) study of the red wolf. Here, molecular data revealed the red wolf, a species that has attracted considerable attention and funding from the conservation community, was in fact a hybrid between the grey wolf and the coyote. The potential for hybridization to occur between related species either following human habitat change or the introduction of exotic or domesticated species, is also widely appreciated. Abernethy (1994) demonstrated extensive hybridization between red deer and the introduced sika deer (itself possibly a hybrid). Hughes & Carr (1993) reported a similar case amongst American white-tailed deer (*Odococilus virginianus* and *O. hemionus*). Recent DNA sequence analyses have revealed a prior hybridization event between American bison and cattle (Polziehn *et al.*, 1995).

Similar techniques are now currently being applied to investigate the introgressive hybridization between European polecat *Mustela putorius* and feral ferrets *M. p. furo* in Britain (Davison *et al.*, in prep.).

Phylogenetic reconstruction

Until recently it was commonly thought that the burst of mammalian radiations ca. 65 million years BP would prove a stumbling block to resolving mammalian phylogenetics from morphological features (all groups having been derived at approximately the same time [Gaur, 1993]). Molecular data are thus perceived as providing a robust means of reconstructing the evolutionary history of the various mammalian groups by the use of traits that are less prone to subjective interpretation and evolutionary convergence. Attempts to address the phylogeny of different mammalian groups have been made by many authors, e.g. Kuma & Miyata (1994, mammalian phylogeny), Cao *et al.* (1994, Eutheria), Vrana *et al.* (1994, higher level of arctoid groups), Masuda & Yoshida (1994, Mustelidae), Hoelzel *et al.* (1991), Milinkovitch *et al.* (1993, Cetacea), and Graur *et al.* (1996, Lagomorpha). At a lower phylogenetic level, Beltran *et al.* (1996) have looked at the relationships of lynx and relatives, showing the uniqueness of the pardel or Iberian lynx, *Lynx iberica*, in comparison to Canadian and European lynx. Veron & Catzeflis (1994) have similarly examined the relationships of the aberrant Malagasy viverrid *Cryptoprocta ferox*. Taberlet *et al.* (1994) compare the evolutionary histories of lineages of common shrew, *Sorex areneus*, by combining cytological and molecular approaches. In some cases, it has even been possible to investigate these types of relationships for extinct forms such as the Tasmanian wolf, by the extraction of DNA from museum material (Thomas *et al.*, 1989). A more detailed review of molecular techniques in phylogenetic work is given by Avise (1994). It is important to note however, that different DNA systems (e.g. mtDNA versus nuclear DNA) may give different phylogenetic results. For this reason, it is best to utilise two (or more) types of analysis in tandem.

Animal welfare implications

Aside from the advantages offered by molecular work from a purely scientific point-of-view, DNA technology has also

Fig. 3 Electrophoretic separation of DNA in a 1% agarose gel with ethidium bromide staining. "+" indicates smaller-sized PCR-fragments. A "ladder" (indicated by the letter M) was loaded into the last lane of the gel. The exact sizes of the different DNA fragments within the ladder are given in basepairs (bp)

some implications that are ethically beneficial. For example, the ability to use DNA from road-killed animals, and from material such as hair and faeces for analysis negates the need to trap. This obviously reduces any problems associated with animal handling, and removes any need to kill animals, or to use invasive tissue sampling techniques, both of which are undesirable if populations are threatened.

However, a word of warning is necessary here. Not all DNA techniques can be applied to samples such as these. For example, in the case of faeces, the large amounts of other DNA present contraindicates the use of mitrochondrial primers, although microsatellites, or species-specific primers, may prove useful.

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Columbian Weasel

Dave FAWCETT, Vladimir ROJAS DIAS and Hernán MONTERO

Introduction

The Colombian Weasel Project was initiated in 1993 to realise a recommendation in the the IUCN/SSC Action Plan for the Conservation of Mustelids and Viverrids (Schreiber *et al.*, 1989). This was to search for and study the ecological requirements of the Colombian weasel *Mustela felipei*.
[N.B. Unless otherwise stated, all sites mentioned are in Colombia. Abbreviations: RNP = Regional Natural Park; NNP = National Natural Park.]

Materials and methods

The project used wooden box live traps of dimensions 60 x 15 x 14 cm, based on the design used by Sleeman (1987) for *M. erminea hibernica*, which adapts the Whitlock mechanism used for *Mustela nivalis* by King (1973). Non-absorbent cotton wool was provided in the trap as insulating nest material. For the majority of the study, the traps were baited with sardines or tuna from a can. The vegetable oil in which they were preserved, which smelt particularly strongly, was applied to the trap entrance. Maize or wheat grain was also provided to sustain trapped small rodents (since some appeared to avoid eating the fish). An initial trial employed live five-day old chicks as bait, but none survived the cold of the first night, so this was not continued. Attempts were later made to use live small adult chickens as bait, but this too was soon abandoned, since the traps were not really of a suitable design to accomodate them. For a limited period near the end of the study, as an additional attractant to the sardines inside the trap, the gut contents of domestic rabbits were mashed and applied around the entrance area of each trap: an English gamekeepers' tactic employed successfully by King (1989).

The traps were set in transects at a spacing of approximately 100 metres, usually in forest, amongst or beside tree roots, logs, branches, rocks and banks of earth. (The exception to this was the last month of field effort, when traps were widely distributed around a farming area. Two to five traps were set - sometimes in gaps under buildings - at each farm previously visited by weasels). Several pieces of branch were often arranged as a "funnel" towards the trap entrance. Large leaves were placed on the roof of the trap to deflect rain. Traps were checked daily and left set at a given location for one week on average (varying from a couple of days to three weeks).

Results and discussion

Captures were dominated by small rodent species, which are of interest here particularly as potential prey for weasels. Our trapping efforts yielded only one weasel, a subadult male *Mustela frenata*, caught in Ucumarí RNP on 20 February 1994. The trap was baited with a dead 5-day old chick, and set between the Río Otún and a mule trail (2.5 km from El Cedral en route for La Pastora, altitude 2,300 m) on the ground under low thin tree branches. The immediate habitat appeared to be secondary growth forest, (with estimates of cover: canopy 0%, understorey 60%, herb layer 5%, fallen trees <5%, leaf litter and root mass 90%, bare soil 5% and woody stem densities: 4.5/m^2 of diameter <1 cm, 3.8/m^2 of diameter 1-3 cm, 0.3/m^2 of diameter 3-10 cm, 0.3/m^2 of diameter >10cm).

Table 1. Study sites

N°.	Site name	Co-ordinates	Department(s)	Approx. altitudes trapped (m ASL)
1	Ucumarí RNP	04° 42' N, 75° 31' W	Risaralda	2,050 - 2,550
2	Rio San Rafael in Tatamá NNP	05° 08' N, 76° 02' W	Risaralda	2,150 - 2,250
3	Alto de Galápagos	04° 51' N, 75° 12' W	Valle/Chocó	1,800 - 2,050
4	Cueva de los Guácharos NNP	01° 32' N, 76° 04' W	Huila	1,700 - 2,150
5	Farmland adjacent to site 4	01° 42' N, 76° 08' W	Huila	1,700 - 2,100

Table 2, Trapping effort and captures

Site	Dates	N° trap nights	N° capture events	Capture rate %	N° species
1	15/2/94 - 4/3/94	679	50	7.4	6
2	19/3/94 - 27/3/94	402	78	19.4	2
3	23/4/94 - 17/5/94	1,072	54	5.0	4
4	23/5/94 - 24/6/94	861	6	0.7	2
5	28/6/94 - 18/7/94	366	2	0.5	2
Total		3,380	190	5.6	11

Table 3: Species caught at each study site

Species caught	N° individuals (N° recapture events in brackets)				
	Site 1	Site 2	Site 3	Site 4	Site 5
Didelphis albiventris	2 (1)			1 (0)	
Mustela frenata	1 (1)				
Heteromys sp.			2 (0)		
Oryzomys albigularis	10 (1)	53 (15)	24 (20)		
Oryzomys minutus			1 *		
"Oryzomine" sp.	14 (1)				
Melanomys caliginosus				5 (0)	1 (0)
Aepeomys fuscatus		8 (2)	1 (0)		
Thomasomys aureus	3 (0)				
Thomasomys cineriventer			7 (0)		
Akodon affinis	13 (3)				
Rattus rattus					1 (0)
Total individuals	43	61	34	6	2
Total capture events	50	78	54	6	2

* captured by hand, so not included in trapping data

This weasel was restrained with an intramuscular injection of ketamine hydrochloride (100 mg/ml in Vetalar) at a dose of 25 mg/kg, for examination and the attachment of a radio tag (Biotrack SS-2 with a cable-tie collar, 3.5g). Measurements in mm were: total length 433, tail 175, hind foot 49, ear 19; body weight 250 g. Two ticks were removed from an ear and the back of the neck. The individually unique outline of the lightly coloured area on underside was traced directly onto a sheet of transparent acetate using a permanent marker pen. (A reference collection of these could be reliably used for individual identification should collars be shed or as an alternative to ear-tagging.)

As far as we were aware, radio tracking of this species was previously limited to three individuals in North America (King, 1989, cites DeVan, 1982 and Vispo pers. comm.). Tracking *Mustela frenata* was also intended to aid future tracking of *M. felipei* in similar habitat. The main aim was to try and identify hunting sites and den sites (through "homing"). Fixes were triangulated continuously (at intervals typically less than five minutes) during periods of tracking effort, which were maintained part-time, to enable trapping for *Mustela felipei* to continue. Following release at the point of capture, the weasel was tracked for three hours, first travelling rapidly to a half-hectare flat area of open wet meadow on the other side of the mule trail, dominated by herbaceous vegetation such as long grasses (there was low grazing pressure from a single horse), and surrounded by shrub-dominated scrub on three sides, and by forest up steeper slopes to the north. The weasel remained active in and around this open area (perhaps hunting) before entering an adjacent den, located 250 m from the point of capture, under an epiphyte-laden understorey tree with a very high density of thin, low branches protruding in all directions. This was growing on soil packed with large rocks, in a grove of similar trees and shrubs interspersed with patches of low scrub and herbaceous plants. This gave an overall impression of regrowth after previous clear-felling (almost coppice-like). During continuous daytime tracking the weasel's time was split between the same hunting area and den on the second day, but spent entirely in the den on the third day. On the fourth morning the weasel was tracked on a one-hour sortie in the opposite direction from the meadow, passing through a comparably sized area of mixed scrub, before crossing the mule track to riparian forest beside the Río Otún (approx ½ km upstream from the point of capture) and eventually returning to the den via the same route. A seven-minute sortie was made into the same scrub area mid-afternoon. Towards evening the weasel left the den and contact was lost as it headed beyond the meadow into the steep forested slopes below Cerro Buenavista. It was later tracked in that area, travelling constantly for over one hour (perhaps hunting or looking for alternative den site) but contact was lost despite overnight tracking. The weasel was briefly found back at the original den at the start of the fifth day, before disappearing up the slopes where it had been lost the night before.

The weasel was however recaptured on 26 February 1994, approx. 2 km south west of the original capture site, following the north bank of the Río Otún. (i.e. approx. ½ km along the path from El Cedral to La Pastora). The trap was baited with sardines, and set amongst large rocks 4 m from a small stream approximately 30 m into the forest between the path and the Río Otun. Estimates of habitat cover were: canopy 20%, understorey 40%, herb layer <5%, fallen trees 30%, leaf litter and root mass 80%, bare soil 5%, overhanging rock (moss-covered) 85%, and densities of woody stems: 2.5/m^2 of diameter <1 cm, 0/m^2 of diameter 1-3 cm, 0.3/m^2 of diameter 3-10 cm, 0/m^2 of diameter >10cm. The detectable range of the radio transmitter range was down to 60 m along line-of-sight (suggesting that the battery had failed - they do not store well). As we could only handle the weasel under anaesthesia once it became clear that the collar had been put on too tightly and the animal was in poor body condition. It did not recover from anaesthesia and later died.

After this an attempt was made to locate nest or latrine areas within the den site and find scats and other remains of prey e.g., fur or feathers used to line nest. No signs were found, despite extensive excavation, which suggested that it was not an established or well used den. Although some faeces had been deposited prominently on what appeared to be territorial "landmarks" such as rocks beside streams, it was not possible to identify any of these as weasel scats (they were often deformed by rain). Some elongated pellets found beside the Río Otún were identified as the faeces of the torrent duck *Merganetta armata.*

Inhabitants of areas adjoining study sites were asked which mammals they were familiar with. Almost all farm-dwelling people questioned had seen weasels, and usually thought of them as pests, since most encounters involved predation upon chickens or domestic guinea pigs (or in one case, a frog). The chickens were usually free-ranging, although a few people had night-cages on smooth bamboo legs, with small mesh chicken wire, designed to be inaccessible to weasels. It was not possible to substantiate many peoples' claims (unsolicited by us) that they could distinguish two kinds of weasels found locally, on the basis of size and/or colouration differences - usually one reddish-brown, one blackish-brown (all these could be accounted for by individual variation within *M.frenata* - see also below paragraph). Sometimes this included naming one of the "forms" *comadreja* and the other *chucurí* or *condumbí.* There was however, no apparent consistency in the combination of names with descriptions, perhaps because all three names are merely the word for weasel originating from a different language: the latter two coming from distinct indigenous linguistic families and the former coming from Castillian Spanish. No description was given of the main distinguishing features of *Mustela frenata* (the black tail tip) or *felipei* (the dark spot in the centre of the pale coloured chest/throat). Observation of these features had not been possible at a distance of 6 m during the one chance sighting we had of two weasels crossing our path, approximately 1km from El Cedral in RNP Ucumarí, shortly before dusk on 25 November 1993.

On close comparison of a specimen of *felipei* in the Universidad del Valle collection (Alberico, 1994) with our *Mustela frenata* specimen from Ucumarí RNP, the latter appeared darker all over the dorsum (whereas Izor and de la Torre, 1978, observed the opposite in specimens elsewhere), as well as on the head and upper neck (the dorsum of *felipei* was of a uniform colouration). This was due to the darker brown colour of the *frenata's* guard hairs, which contrasted strongly with paler duller brown underfur. The guard hairs of the *felipei* were much more rufous, as was the less contrasting underfur (both seemed more dense than in *frenata*). The venters of both specimens were mostly washed with a pale orange colour, being whiter towards the chin. It is possible that the *felipei* may have faded slightly since capture in 1988. A faded specimen of *M. africana* at the Escuela Politécnica Nacional in Quito was a lighter much redder brown above and yellowed below, although another caught in 1989 had maintained a very dark coffee (not rufous) brown dorsum and near-white venter. The interdigital webbing in the *felipei* seemed to be no more extensive than that in the *frenata.* As King (1989) points out, weasels in

general are good swimmers, whilst Alberico (1994) noted that hunting in water bodies by carnivore should not be taken as an indication of habitat restriction.

Following our visit to the Nutriovo chicken farm in La Suiza, outside RNP Ucumarí, its staff captured a male *Mustela frenata* in a sack on 11 March 1994, and took it to the local INDERENA centre, where it was examined and video filmed by Jorge Marulanda, Javier Bustos and Victor Avila, before being released alive. Measurements in mm were: total length 440, tail 125 (tip missing), hind foot 52; body weight 290 g. This individual was an adult, with testes descended and a high degree of scarring observed on the face.

One local inhabitant of the hamlet of Jerico (near Palestina, Huila), Alfredo Galindez, brought us a subadult male *Mustela frenata*. Measurements in mm were: total length 471, tail 203, hind foot 49, ear 23; body weight 265 g. He had caught it in a home-made trap of a style in widespread use. These traps are wooden boxes with a strong metal mesh cage on the back, in which a live chicken is housed as a highly attractive bait which weasels can see, hear and smell. Upon entering the wooden box to reach the chicken the weasel triggers a pivot on the roof of the trap, releasing the door which slides shut down channels in the box entrance. Safe behind the mesh, the chicken survives, whilst the weasel is liable to starve, (this was the unfortunate fate of the above mentioned individual, after feeding with raw egg failed to rescue it). Although many reports of weasels killed by this method or with dogs or guns were encountered, only a small number of skins seem to be kept (as curios or for sale for medicinal use e.g., for infertility) - three were found around Palestina, Huila, and one at Casanga, near Baeza, Ecuador - all *Mustela frenata*. Bodies were almost invariably discarded irretrievably - owing to their strong smell or superstition - even being burned to prevent their "return".

Small samples for DNA analysis were collected from three *Mustela frenata* skins (delivered to the Ministry of Environment collection in Bogotá), for comparison with *M. felipei* and *M. africana*. It has not however, yet been possible to secure material from these latter species for the research on mustelid molecular phylogenetics which is being carried out by Angus Davison. Anyone able to provide samples of these or any other poorly known mustelid species should contact him at: Department of Genetics, School of Biological Sciences, University of Leeds, Woodhouse Road, Leeds, LS2 9TJ, UK.

Opportunistic checking of museum specimen collections around Colombia and in Quito failed to reveal any further examples of *Mustela felipei* amongst specimens labelled as *frenata*. (Three of the five known specimens of *M. felipei* had originally been labelled *frenata* prior to knowledge of *felipei* existence).

Further exploration of Alto de Galápago, the site where Alberico (1994) reported *felipei* revealed that it is in fact at the headwaters of some streams, Quebrada Cristalina and Quebrada Pacífico, which drain northwards and southwards respectively . The flow of one branch of the latter seemed to have been affected by its diversion on construction of the road. Alto de Galápago is situated in the Serranía de los Paraguas mountain range, just to the south of where this leaves Tatamá NNP. In 1994 measures were initiated to develop protection along the full length of the Serranía, banning further felling or settlement of forest above 1,800 m ASL and developing sustainable management in surrounding zones. Action and Management Plans were being formulated by Municipal Committees, Autonomous Regional Corporations, the Environment Ministry and the Biopacífico programme.

Santa Marta, the holotypic locality of *Mustela felipei*, lies just outside Puracé NNP, at 2,700 m ASL in a steep-sided forested valley where the Río Magdelena leaves the park from the Páramo de las Papas. Weasels are frequently seen around Laguna San Rafael, in the north of the park, hunting rabbits in páramo habitat (high moorland in which *M. frenata* but not yet *felipei*, is known to occur elsewhere in the Andes). A trail passing through Santa Marta into the park from Quinchana, is an excursion from San Agustin, one of the main tourist sites in the country. This currently presents little pressure and could encourage protection of the forests and spectacular landscape currently lying outside the park. A proposal had already been made to extend the boundaries to include more of Río Claros basin. Further unprotected forest extends below the Páramo de la Soledad for about 50 km (equivalent to ¾ the length of Puracé NNP) from Santa Marta eastwards along the range of mountains where the eastern cordillera joins the central, to Cueva de los Guácharos NNP, where a specimen of *Mustela felipei* found under the adminstrative headquarters cabin was captured with a blanket by INDERENA staff in 1983 and preserved in alcohol in Unifem collection in Bogotá). A survey of this forest might identify a potentially important stronghold for *felipei*.

Baeza (0° 25' S, 77° 55' W, province of Napo, Ecuador), from which the American Museum of Natural History has a 1923 specimen of *Mustela felipei*, lies just outside two huge Ecological Reserves, Cayambe-Coca (which extends to the north) and Antisana (which extends to the west), both of which contain habitat of an appropriate altitude range for *felipei*. The area also has potential for comparative study of this species with its nearest relative, *M. africana*, which Dr Luis Albuja (pers. comm.) of the Escuela Politécnica Nacional in Quito captured in 1989 at Huaticocha, 1,200 m ASL, near Sumaco to the south east. This is yet closer to Baeza than the previous record of *M. africana* from the Jatun Yacu, a tributary of the Río Napo.

Further protected areas within potential geographical and altitudinal range of *felipei* include the Colombian NNPs of Sumapaz and Chingaza in the Eastern Cordillera, Nevado de Huila and Las Hermosas in the Central Cordillera, and , Caramanta, Las Orquideas, Paramillo, Munchique and Los Farallones de Cali in the Western Cordillera (a proposal has been made to conserve habitat between the latter two as a "biological corridor" to maintain viable wildlife populations), and NGO-run Nature Reserves such as La Planada in the Nudo de los Pastos range. Additional National Parks of potential interest in Ecuador include Podocarpus and Sangay, which are already the subjects of Andean mammal conservation programmes (carnivores and mountain tapirs respectively). There also remain considerable areas of forest of appropriate altitude outside protected areas, and of course we still have no evidence that *felipei* cannot also survive in farming areas, as *frenata* clearly does, despite persecution.

Concluding remarks

The fact that we failed to trap *Mustela felipei* should not in itself be seen as an indication of rarity. After all, through our own trapping efforts we only encountered one individual of the widespread, common species *M. frenata*. Although we remain uncer-

tain of the species' status it seems preferable to continue to focus efforts on attempts to study this animal in the field (if it is endangered we need to identify its habitat needs for protection) rather than to divert resources into captive breeding (Schreiber *et al.*, 1989) on the assumption that it is endangered.

Future trapping effort might benefit from penetrating into the deepest identifiable areas of virgin forest or, contrarily, from exploiting the attraction of domestic animal prey in surrounding farming areas, and a modified trap design could be used to accomodate live bait. The latter is being tested by Elizabeth Mesa Gonzalez, a student at the Universidad Nacional in Bogotá, who is currently attempting a trapping and radio tracking study of the diet and habitat use of *Mustela frenata* in and around Tambito Reserve (1,500 - 2, 700 m ASL, near PNN Munchique), where *M. felipei* may well co-occur.

A search for local reports (and especially skins) throughout the potential range of the species, could lead to new distributional discoveries. This is one aim of a conservation awareness poster "Lesser known mammals of the cloud forest" currently being developed by Dave Fawcett and Paul Robinson of the MV&PSG.

Credits

Field work was carried out by Dave Fawcett and Justin Farthing (UK) and Vladimir Rojas Dias and Hernán Montero (Universidad del Valle, Colombia), further assisted by Alonso Flores, Dan Lafoley, Adriana Almeida, María Adelaida Fernández and Valeria Pizarro.

We thank the many people, who helped us with logistical support, hospitality and interest, particularly Michael Alberico and Roland Wirth who provided all of these. Space limits mention of the others, who shall be listed in our Full Report of the project. Field work was kindly permitted by INDERENA, Colombian Minsitry of Agriculture Ministry, and (in Risaralda) by CARDER.

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Recent publications

Badgers

Ferris, C. 1995. *Beneath the dark hill.* Swann Hill, Shrewsbury. 182 pp. £16.95.

Amidst the ever mounting tide of natural history books, and a new badger book every couple of months, two will stand out. The new revised version of Michael Clark's *Badgers* (Whittet) gives a valuable new insight into issues such as the Great TB Debate. And Chris Ferris will need no introduction to readers of her four badger books. Her latest evocative epic returns to the badger persecution problems of Kent and elsewhere in England, but is also a voyage of discovery in the shadow of the dark Hill Dydor, in the Lothians of Scotland. It records a comparative study of badger/otter behavioural ecology, with observations elsewhere in Scotland. Many penetrating notes are made within a historical perspective of past and present distribution of both species as well as persecution of pine marten, fox, and wildcat. Probably all were widespread before systematic destruction began linked to sporting interests. And the present modest recovery and distribution has more to do with human factors than with natural population regulators such as den availability or food supply. Many odd facts emerge however, including introductions of badgers and foxes even from abroad. And the scattered low density of badgers is linked to acid tolerant earthworm prey which are relatively 'unavailable' as compared to typical English species (*Lumbricus rubellus* rather than *L. terrestris*, a surface feeder). Clan size is hence smaller too.

The various forms of human persecution are documented, and ongoing, although both species are supposedly 'legally protected'. These include considerable 'predation' by road traffic, snares, gassing, lamping, etc. The latter 'sport' decimates badgers in some areas rather than badger digging, and eel fyke nets or lobster creels take many an otter. Laws are one thing, enforcement another. And the pointless culling of badgers over TB in cattle continues.

The beauty of Chris Ferris' books however lies in her mastery of poetic description of ecological cameo entities, from protracted patient observation. A 'seeing eye' and 'attuned ear' hence enrich portraits of fishing badgers, wrens, robins, and thrush. The battle between barn and tawny owl. Mating and birth of roe deer. The exultant spring displays of oystercatcher and clamour of winter geese against a sunset tapestry of hills. All are evocative of the delight of discovery by a 'sassenach' of northern wildlife and wild places.

(M. Hancox)

Field observations of Wolverine (*Gulo gulo luscus*) in eastern Talkeetna Mountains, south-central Alaska

Jeff CAIN

A field study on wolverine demography and ecology conducted by the Alaskan Dept. of Fish and Game and the National Park Servive has continued in south-central Alaska since autumn 1991. I was fortunate to work on the project and observed wolverines, occasionally at close range.

The remote study area of 4,1000 km^2 lies between 62°8.30'-62°49.35'N and 147°12'-147°9.30'W in the eastern Talkeetna Mountains. This splendid wilderness region provides favourable wolverine habitat. The vast taiga forest and willow shrub, abundant river drainage, and high alpine tundra supports a healthy subarctic environment. Moose (*Alces alces*), caribou (*Rangifer caribou*), brown bears (*Ursus arctos horribilis*), black bears (*Ursus americanus*), wolves (*Canis lupus*), lynx (*Lynx canadensis*), red fox (*Vulpes vulpes*), marten (*Martes americana*), ground squirrels (*Spermophilus parryii*), and microtine rodents are relatively numerous in the area. The winters are long, cold and dry, and the summers cool and wet.

Wolverines travel quickly, covering great distances and are, consequently, difficult to find. The wolverines in the project were located primarily by either following trails in fresh snow or by radio-tracking individuals from fixed-winged aircraft. Wolverines were most often observed above the treeline between 900 and 1,400 metres and were active in broad daylight. Kill sites were monitored for wolverine activity, as were accumulations of tracks around snow or rock holes, these indicating possible den sites.

Red foxes were seen close to wolverines on two occasions. In mid April a wolverine was foraging down a willow-covered gully. Following behind came a red fox that appeared interested in the mustelid's movements. The wolverine then suddenly turned back up the trail, sending the fox scampering over a ridge. The other sighting involved a female wolverine that was scavenging from an old moose carcass. A red fox trotted into view and circled the vicinity cautiously. The fox decided to wait its turn and curled up nearby, while the unconcerned wolverine continued feeding. In both of these observations, it was clear that wolverines dominated foxes.

Wolverines are renownd scavengers and are adapted superbly for this trade. However, they can also be effective hunters. A successful ptarmigan kill was noted on a frozen lake, north of the Oshetna River. From a dense willow patch, wolverine tracks were found with wing marks on either side. The winding trail ended in a circular area of hard packed snow, and nothing remained of the ptarmigan apart from a few chewed feathers. The wolverine had captured the bird amongst willow shrub, and carried it alive across the lake to an area free of drifting snow.

Porcupines primarily inhabit the spruce zone. However, I did observe individuals high on the alpine tundra. With their needle-sharp defence these formidable rodents can seriously injure attacking predators. For example, a radio-collared male wolverine was found to have porcupine (*Erethizon doratum*) quills embedded in his throat, mouth, and forehead. The wolverine was fortunate not to have been blinded. Fieldwork in the Yukon Territory, Canada, also revealed porcupine quills in many of the wolverine carcasses taken by trappers.

Wolverine
Artwork: Jeff Cain

Golden eagles (*Aquila chrysaetos*) often patrolled the skies, or fed on scattered carrion. On one such occasion, we watched a golden eagle tearing away at a caribou carcass. In the distance, a small female wolverine bounded through the snow towards the kill site. As the wolverine approached, it lunged aggressively at the eagle, which only just managed to escape. The wolverine then sniffed around the area, and urinated near the carcass before starting to feed. Snow-tracking in the Jokkmokk area of northern Sweden led to a golden eagle that had been killed and partly eaten by a wolverine. In an earlier study, north of the Talkeetnas, within a white spruce area we found where a wolverine had dug up a cache that contained a golden eagle.

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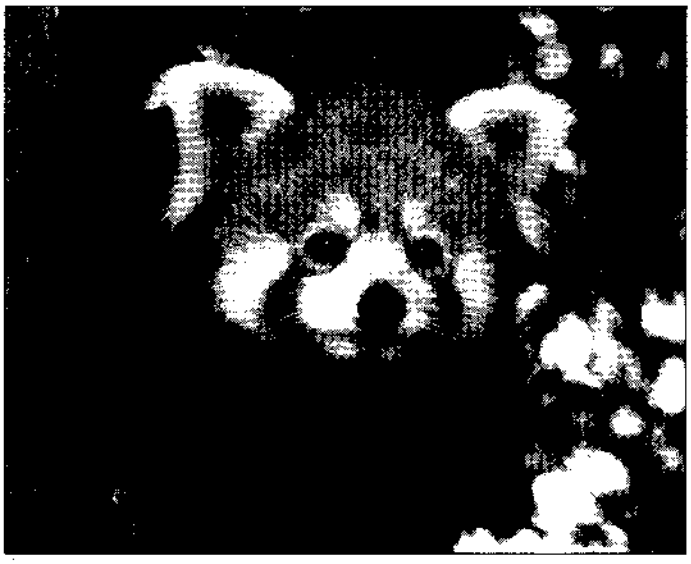
Red Panda News



Red Panda Captive Management News

Appreciation is conveyed to the contributors of the following articles:

EEP News

The red panda EEP was officially organised in 1986, but has been coordinated unofficially since the International Studbook was established in 1977. In order to provide EEP participants with detailed analysis of the red panda population in their region, it was decided to produce a separate EEP studbook, beginning in 1995. It will appear every second year alternating with the production of the International Studbook.

Demographic trends in the EEP red panda population indicate that if it continues to grow at current rates it will number 400 individuals in 10 years. This is twice the envisioned carrying capacity. This increase is due to both an increased birthrate and decreased infant mortality achieved since the introduction of husbandry and management guidelines.

Another trend is a female sex bias in the EEP population. Analysis indicates that infant mortality is higher in males. Additionally, peak fertility seems to occur earlier (2-8 years in males as opposed to 5-12 years in females). These data mean the generation length for males is 5.3; considerably lower than that of females at 6.7. In addition, the negative effect of inbreeding on reproductive value is more marked in males than females. The female population also enjoys a more stable age distribution than the males. All of these need further investigation.

The genetic variation of the EEP population is good; twenty four of the possible 26 founders are represented. The representation of these founders in the descendant population could be improved by transfers and exchanges with other regions. A Genedrop analysis indicates that the EEP red pandas contain 94% of naturally occurring variation. The mean inbreeding coefficient of .02 is fairly low. However, this can be expected to rise in the future as fewer unrelated animals will become available to form new breeding pairs. This in turn could have a deleterious effect on the reproductive performance of red pandas worldwide.

The Red Panda EEP Committee membership has expanded in two ways: First, by incorporating the JMSG programmes of the UK, and secondly by the increased number of EEP zoos holding red pandas. The present committee consists of:

Peter Bircher, Marwell Zoo	United Kingdom Sub Group
Paul Vogt, Krefeld Zoo	Germany
Kuno Bleijenberg, Botterdam Zoo	Benelux
Leif Blomqvist, Helsinki Zoo	Scandinavia
Jose Cobo, Madrid Zoo	Iberia
Pierre Gay, Doue la Fontaine	Italy and France
Vacant	Central Europe

JAZG News

The Japanese region holds 182 red pandas at 39 institutions per the 1994 studbook. The JAZG representative has indicated a desire to relocate the 17 red pandas of the *Ailurus f. fulgens* subspecies to other regions, thereby focusing their efforts on the Chinese subspecies, *A. f. styani*. Currently this subspecies is held at two institutions.

ASMP News

The Australasian Species Management Program for the red panda includes Southern Hemisphere zoos (currently South Africa) in its region as these institutions share the same breeding season. The first approved captive management plan for the Nepalese Red Panda has just been published by the Australasian Regional Association of Zoological Parks and Aquaria (ARAZPA):

As the smallest region in the International Studbook with a current population of 29 animals, the ASMP's founder representation is only 21 out of a possible 26 founders.

However, in other terms of measure it has done well. In genetic diversity, it has retained 95% of the wild genes. The mean inbreeding coefficient is .012, half the global average, although like other regions, this figure is set to rise.

Perhaps the most notable variation in ASMP red panda data is the lower infant mortality; 32.8% of births against a global average of 40.6% This does not appear to be due to the longevity of the region, as the first births in Australia occurred in 1977, the same year as the International Studbook data began. However, small sample size may be a contributing factor.

Research Projects

HUSBANDRY

Training regimes developed at Knoxville Zoo, USA are now in use at Columbus Zoo, among other SSP zoos, to habituate red pandas to keeper contact. This contact permits the taking of weights, measurements and various other procedures without the stress of capture. The training program at Columbus has been completely successful with their male following several months of gradually increased contact, but has developed more slowly with the female.

DISTEMPER

Preliminary results from the European Canine Distemper Vaccine Project are encouraging. The Webster vaccine from Australia produced sera titer antibodies in 8 of the 9 red pandas tested. Websters is in the process of developing a special inactivated vaccine for use on all non-domestic carnivores which uses a smaller volume and is hopefully more effective.

A quantity of killed freeze-dried Distemper Vaccine has been offered by Solvay-Duphar Ltd., Southampton, UK, for use with red pandas. Whilst this experimental batch is now twelve months past expiry date, the manufacturers state that, being a freeze-dried product that has been stored in ideal conditions, it is still capable of stimulating a good immune response. The IRPMG plan to use some of the vaccine in red pandas at the Darjeeling Zoo where the possibility of distemper is high due to domestic dogs having access to the zoo. The feasibility of vaccinating the local dog population is also being considered as an additional protection.

REPRODUCTION

The UK is planning a research project to investigate the use of genome resource banking and artificial methods of reproduction, with the red panda being used as a role model for the use of such techniques in the conservation of small mammals. Several institutions have expressed interest in such a project, and further information is expected in subsequent reports.

Two projects, one at Lisbon Zoo, and another at Adelaide Zoo, are assessing faecal progestin levels using RIA (radioimmunoassay by solid phase technique). They are both designed to detect ovulation and gestation in the red panda. The Lisbon project is being conducted by Dr. Rui Marques Leitao of "Estacao Zootecnica Nacional". The Adelaide project is being conducted by Andrew Spanner of Sydney University.

An ELISA test for the detection of faecal progestin levels in mammals (including the red panda) is being developed in Australia. The ELISA test is not necessarily species specific. Once developed, it would produce the same results as RIA, but in a simpler fashion, enabling many zoo labs to do their own fertility testing.

International Red Panda Management Group Meeting

Dublin, Ireland, 29-30 September 1995

PARTICIPANTS

IRPMG Members: Angela Glatston (Chair, Rotterdam Zoo), Carol Bach (Taronga Zoo, Sydney), Peter Bircher (Marwell Zoo, UK), Takashi Miyake (Shizuoka Zoo, Japan), Frank Princee (Stichting NOD), Miles Roberts (National Zoo, USA).

S.C. Sharma (Central Zoo Authority, India)

OBSERVERS

Bengt Holst (Copenhagen), Leif Blomqvist (Helsinki Zoo), Fletcher Morgan (Himalayan RESCU, UK), Sian Waters (Bristol, UK), U. Minnanheminda (Thailand), Sean McKeown (Fota, Ireland), Debebe Dessalegne (Wildlife Information Network, UK).

DISCUSSION

IRPMG members gave an overall picture of red panda activities in each region. As a result of standardised husbandry practices, the captive population has experienced net increases so that the carrying capacity may be reached in the very near future. All agreed that future goals of the red panda program are to be focused beyond captive breeding, and on in-situ conservation. The brightest prospect for such efforts at this time is northeast India. Effectively, this excludes the *styani* subspecies in the medium-term in favour of *A.f.fulgens*. However, outcomes should benefit both groups by establishing a proven structure for conservation activities.

IRPMG support of the captive breeding program in India developed into a Red Panda Workshop in Darjeeling in April 1995, initiated by the Central Zoo Authority, India. In addition to providing some technical population management training for local zoo and wildlife staff, much attention was drawn to local conservation. Three Himalayan zoos wish to form a captive breeding nucleus, and the Forestry Department is interested in restocking red pandas, as one of several species, into protected habitat.

The prospect of reintroduction has attracted a great deal of attention to the red panda program. Preliminary fieldwork in Singalila National Park in West Bengal indicates that suitable habitat exists. The decline of red panda in local forests is attributed to their past removal for pets and the "zoo trade". Forests are now well monitored. But both the need and efficacy of any restocking cannot be determined until a great deal more field data on existing red panda populations and their habitats accumulates. This research is valuable in and of itself, whether or not it ultimately results in reintroduction.

OBJECTIVES

- Provide financial support for continuation of fieldwork towards the production of a comprehensive management and conservation program for red pandas and red panda habitat in India as well as Nepal and Bhutan.
- Arrange further technical training as necessary for veterinarians, directors, curators, keepers, etc., from the three Himalayan zoos (Darjeeling, Sikkim, and Arunachal Pradesh) both inside and outside of India.
- Establish with the Indian coordinator a captive breeding masterplan to include the number of pairs needed for the core population in India and an exchange strategy to achieve these levels.
- Support the development of an education project covering the schools and villages in the Darjeeling area near Singalila in cooperation with the Zoo Outreach Organisation.

Functional roles were assigned to individual IRPMG members. Additional meetings are necessary to maintain momentum and facilitate communication. A red panda fund is planned to centralise financial support.

Reported by Carol Bach

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Dental and skull abnormalities in the Stone marten *Martes foina* (Erxleben, 1777) from Slovenia

B. KRYSTUFEK and S. POLAK

The dentition of mammals is typically highly differentiated (heterodont) and replaced only once during an animal's lifetime (dilophodont). The number of teeth is constant and frequently diagnostic of genera or families. Any damage to, or losses from such a stable and integrated dental complement will necessarily result in an inbalance, and frequently also in the reduced fitness of an individual. Anyhow, tooth loss, either through congenital or traumatic causes occurs within many natural mammalian populations, but generally at low frequencies.

The dental complement of the stone marten is the same as for the genus *Martes* itself: i 3/3 c 1/1 pm 4/4 m 1/2 = 38 (Miller, 1912). Deviations from this in a sample of 43 stone martens from Poland were studied by Wolsan *et al.* (1985). They found no extra teeth, although oligotonties, particularly those expressed in a deficiency of the first lower premolar, were quite common. There were also no dental abnormalities observed among Polish stone martens.

We collected skulls during a survey of the two marten species in Slovenia. An unusually high frequency of missing teeth and other malformations was evident at first sight, with some of these anomalies being so severe that they must have reduced the survival abilities of the affected animals. Thus, we believe that our results may contribute to a better understanding of the life history of the stone marten, a highly adaptable and successful European mammal.

Material and methods

We examined 106 skulls, collected from different regions of Slovenia, mainly between 1983 and 1994. To allow statistical comparisons, material was pooled into reasonably large samples.

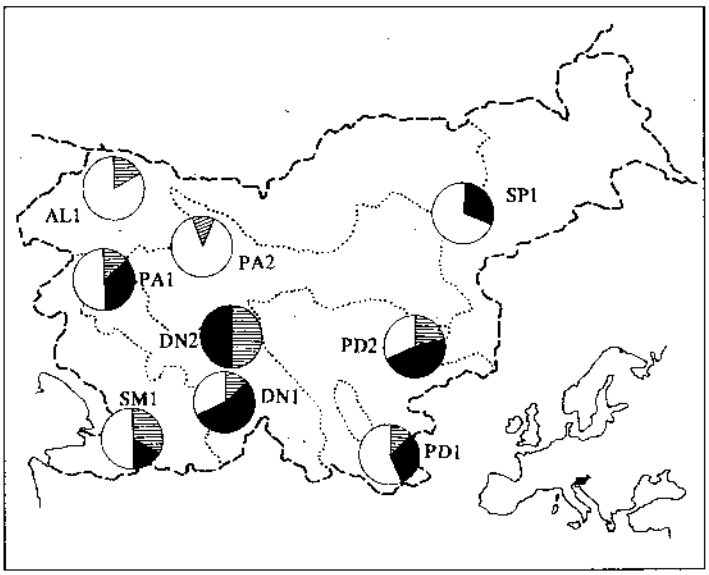

Fig. 1. Geographic variation in frequency of absence of first lower premolar (pm1) in nine *Martes foina* samples from Slovenia. Percentage of uni- and bilateral pm1 oligodonties are proportional to shaded and black areas. See text for details of sampling sites, localities, and phytogeographic regions.

Sample areas were kept as small as possible and restricted to particular phytogeographic regions (as defined by Wraber, 1970), these being considered to roughly indicate environmental homogeneity. The abbreviations for these regions as used in sample designations and also in Fig. 1 are: AL - Alpine; PA - pre-Alpine; SM - Submediterranean; DN - Dinaric; PD - pre-Dinaric; SP - Subpannonian.

Skulls were cleaned by boiling and subsequent maceration. They are stored in the collections of the authors; their initials are given with their collection numbers in the subsequent text. Dentition was observed macroscopically and, when necessary, also viewed under a stereomicroscope. Four growth groups (GG) were recognised, based mainly on the degree of development of the sagittal crest (Heptener & Naumov, 1967).

Sample designations and their contents are listed below. Geographic locations are shown in Fig. 1. Abbreviations for sexes are (M) for males, (F) for females, and (?) for gender unknown. Sample AL1: Kranjska gora; Martuljek; Srednji vrh (3M, 4F); sample PA1: Tolmin, Volce (8?); sample PA2: Kranj; Skofja Loka; Spodnja Idrija; Ziri (6M, 1F, 1?); sample SM1: Dekani; Strunjan; Dutovlje; Sezana (3M, 5?); sample DN1: Cerknica; Planina (10M, 23F, 2?); sample DN2: Borovnica; Ljubljanski vrh; Sodrazica; Ribnica; Taborska jama (6M, 1F, 2?); sample PD1: Bela krajina (4M, 3F, 2?); sample PD2: Gorjanci; Otocec; Mirna pec; Kostanjevica na Krki (1M, 8?); sample SP1: Slovenska Bistrica (5M, 3F, 2?). Four further specimens (1M, 3?) were not ascribed to any of the above samples.

In the subsequent text and figures, teeth of the upper jaw are designated by capitals, and those from the mandible by small letters; e.g. PM1 and pm1 are the first premolars in the upper and lower jaw, respectively.

Results and discussion

Congenital deficiency of the first lower premolar (pm1)

Only those cases in which a pm1 deficiency was presumably congenital we considered here i.e. where there was no sign of its prior presence, e.g. by traces of an obliterated alveolus.

The deficiency of pm1 is the most common form of dental deviation in stone martens from Slovenia. In approximately one half of the specimens this small tooth was missing, at least on one side (Table 1). Bilateral oligodonties were more than twice as frequent as unilateral ones; the difference being significant (X^2=4.44, p<0.001). In the case of unilateral oligodonty, the tooth was missing on the right side in seven cases, and on the left side in nine cases; this difference was not significant. Oligodonty was more common in females with 50.0% of specimens being oligodontic (N=34) against 39.4% occurrence in males (N=33); however, the difference was not significant. Wolsan *et al.* (1985) recorded a much lower occurrence of pm1 absence from 43 stone martens from Poland, i.e. 20.5%. Unilateral oligodonties prevailed in Polish material, being evident in 75% of the specimens affected.

Table 1. Incidence of oligodonty of the first lower premolar (pm1) in *Martes foina* from Slovenia according to geographic samples. See Fig. 1 for sample acronyms.

Sample	(N)	Unilateral		Bilateral		Total	
		N	%	N	%	N	%
AL1	(7)	1	(14.3)			1	(14.3)
PA1	(8)	1	(12.5)	3	(37.5)	4	(50.0)
PA2	(9)	1	(11.1)	·		1	(11.1)
SM1	(6)	2	(33.3)	1	(16.7)	3	(50.0)
DN1	(35)	4	(11.4)	19	(54.3)	23	(65.7)
DN2	(6)	3	(50.0)	3	(50.0)	6	(100.0)
PD1	(9)	1	(11.1)	3	(33.3)	4	(44.4)
PD2	(9)	2	(22.2)	4	(44.4)	6	(66.7)
SP	(10)	1	(25.0)			1	(25.0)
Remaining	(4)	1	(25.0)			1	(25.0)
Total	(103)	16	(15.5)	36	(35.5)	52	(50.5)

Since the teeth, and particularly the smallest ones, can be lost during the course of an animal's life, and with subsequent obliteration of the alveoli, the frequency of oligodonties ascribed to congenital deficiencies may be overestimated in older age groups. Wolsan *et al.* (1985), who studied oligodonties according to age groups, found the frequency of missing pm1 to be mainly constant during the life of stone martens, but with a great increase in the oldest age group. However, small sample size (their oldest age cohort included only three animals) made making definite conclusions very difficult. In our material a decrease in the occurrence of the missing pm1 is evident with advanced age (Table 2), so is suggesting that specimens with complete dentitions are "fitter" than those missing teeth. Pairwise comparisons, however, did not demonstrate statistical significance in these differences.

Table 2. Incidence of oligodonty of the first lower premolar (pm1) in *Martes foina* from Slovenia according to growth groups (see text for explanation). Growth groups follow Heptner & Naumov (1967)

Growth group	(N)	Unilateral		Bilateral		Total	
		N	%	N	%	N	%
II	(54)	9	(16.7)	20	(37.0)	29	(53.7)
III	(30)	4	(13.3)	9	(30.0)	13	(43.3)
IV	(16)	2	(12.5)	4	(25.0)	6	(37.5)

The occurrence of pm1 oligodonty varied between 11.1% (sample PA2) and 100% (DN2) in different geographic samples. The following pairwise comparisons were statistically significant ($p<0.05$): AL1-DN1 ($X^2=5.71$), AL1-DN2 ($X^2=6.43$), PA2-DN1 ($X^2=6.55$), and PA2-DN2 ($X^2=7.71$). A high incidence of pm1 oligodonty seems to be centered in the Dinaric Alps, then decreasing gradually towards their periphery (samples PA1, SM1, PD1, and PD2). Northern Slovenia, on the other hand, is characterised by a low incidence of the pm1 deficiency. Different frequencies of pm1 occurrences were found in regions with similar environments (e.g. AL1 against samples DN1 and DN2 from the Dinaric Alps), as were populations from contrastingly different phytogeographic regions (e.g. SM1 vs. DN2) characterised by similar degrees of pm1 oligodonty. This makes the explanation of pm1 frequencies by environmentally based selective forces unlikely. It is therefore more probable that this oligodonty is due to some genetic difference.

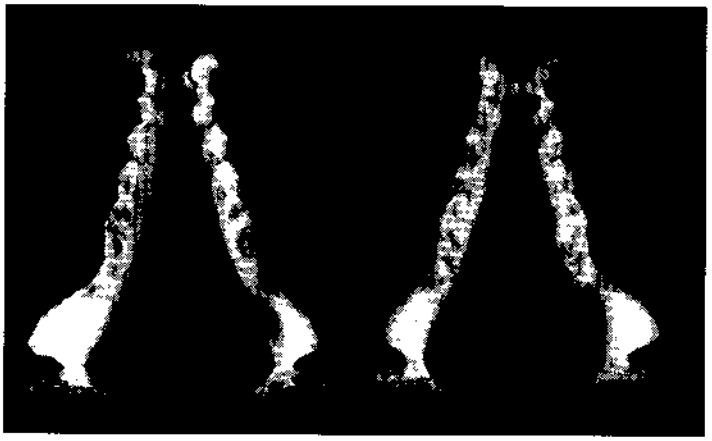

Fig. 2. Lower toothrow of stone marten from Slovenia. Left = complete dentition; right = set with bilaterally loss of pm1.

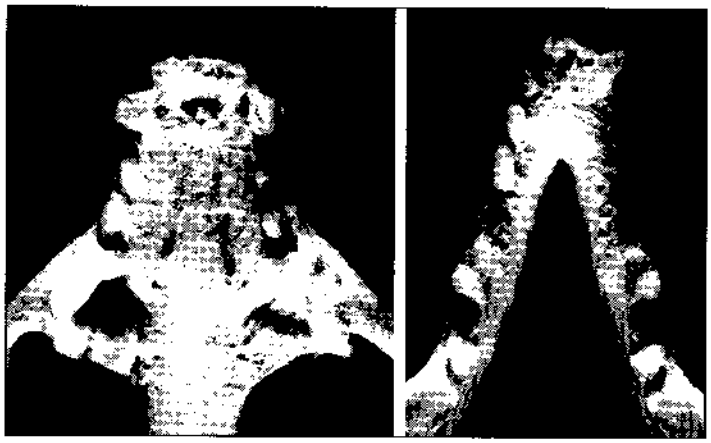

Fig. 3. Upper (left) and lower (right) dentition of a very old stone marten (5637 BK) from Slovenia. Note heavy traumatic injuries.

Other congenital oligodonties

Only four cases of a missing first upper premolar (PM1) were recognised among 103 scored crania (i.e. 3.9%): on the right side of an unsexed animal from sample DN2, on the left side of an unsexed specimen from sample PD2, on the left side of an unsexed marten from sample DN1, and a bilateral deficiency in a female, also from sample DN1. All specimens were subadult (GG II), and all lacked the first lower premolar, either unilaterally (specimen PD2) or bilaterally (the remaining three).

One unsexed specimen (GG III) from sample PA1 lacked the right second lower molar, but this deficiency could be also due to traumatic tooth loss.

Several other cases of oligodonty were associated with badly deformed skulls. In such cases, missing teeth more likely resulted from mechanical injuries rather than any congenital cause.

Traumatic tooth losses

Included here are specimens which had evidently lost one or more teeth during their lifetime, either from mechanical injuries or other unknown causes. Of 95 skulls, 13 (13.7%) showed traumatic dental injuries. In total, 39 teeth were missing (the number of incidences is shown in brackets): i1 (3), i2 (4), i3 (3), c (3), pm1 (4), pm2 (3), pm3 (3), pm4 (4), I1 (4), I2 (2), I3 (3),

PM1 (1), PM4 (1), and M1 (1). Most frequently lost were incisors and lower premolars, i.e. teeth not critical to the hunting success of martens. The essential part of the dentition (canines, carnassials, and M1) was rarely affected.

Traumatic effects were more common in the dentition of older animals. Of 13 specimens, 5 each came from GGIII and GGIV, and only 3 from GG II. As could be expected, the incidence of injuries accumulates with age (Fig. 3). There were no differences in this respect between sexes. Affected specimens occurred in all samples except PD1 and SM1.

Abnormal tooth wear

Specimen No. 3520 BK (Fig. 4), an unsexed subadult (GG II) from sample PD1. All incisors, all canines and both pm2 (pm1 are missing on both sides) are severely worn, and their pulp cavities are open. Other teeth are not much affected. Injuries are particularly severe on the right side of the mandible which is partly worn out, together with i3. As the teeth are so much lowered, malocclusion resulted: this is particularly evident in the area of the right canines. The exact history of this specimen is unknown, but it was presumably shot in the wild.

Specimen No. 9586 BK, a subadult female (GG II) from sample SP1. Both PM3 and left pm4 are much worn, with open pulp cavities being visible. The pulp cavities of the upper premolars are opened labially, suggesting that this part was not worn out by possible malocclusion with pm3 and pm4. The reason for such an anomalous pattern of over-wear is unclear, but the specimen was killed in the wild.

Specimen No. 3.2/11 SP, an adult female (GG III) from sample DN2. Both upper canines and the first two left incisors are much worn, but the left I3 is of normal length. Corresponding teeth on the lower jaw (left canine and all incisors) are broken. There are also other traces of traumatic injuries in the skull. The animal was killed in the wild.

Traumatic abnormalities in skulls and teeth

Specimen No. 5252 BK, an unsexed adult (GG IV) from sample PD2, killed in the wild. Only the right upper canine is functional, whilst the left one never erupted; its alveolus is open and the apex of the canine is clearly visible. At first sight the skull showed no trace of traumatic injury, but careful examination revealed a nasal asymmetry, the left one being slightly shorter and shifted backwards. This suggests an old mechanical injury which most probably inhibited the eruption of the canine. All the remaining teeth, including the opposing lower canine, are normal.

Specimen No. 9589 BK (Fig. 5), an unsexed subadult (GG II) from sample SP1, shot in the wild. The rostrum is abnormally developed, with the right side being more affected. This is evident in a shorter right premaxillary bone, a shorter right nasal bone, and by an asymmetric nasoincisive incisure. The right incisors and the incisive foramen are shifted slightly backwards. Both second premolars are also affected, the anterior part of the left premolar being slightly inclined mesially, whilst the opposite is evident in the left premolar, which has a labially orientated anterior part. Neither upper canine had erupted: their alveoli are open and the apex of each canine is clearly visible.

Rostral deformations should be ascribed to traumatic injury with subsequent repair. All upper premolars are compressed more than is usual in this species (see relations between pm3 and pm4 in Fig. 5) indicating that a very strong force squeezed the entire rostrum. It is worth noting that the mandible with dentition shows no trace of any previous deformation. Both lower canines are also normally developed.

Specimen No. 4854 BK (Fig. 6), an unsexed subadult (GG II) from sample DN2, which was found dead. In the upper tooth row, left I3, both canines and both PM1 are missing, with still-visible traces of bone repair. The situation with the incisors is most unusual. The left I1 and I2 are shifted anteriorly and slightly towards the right. The left I1 thus lies in front of the right I1.

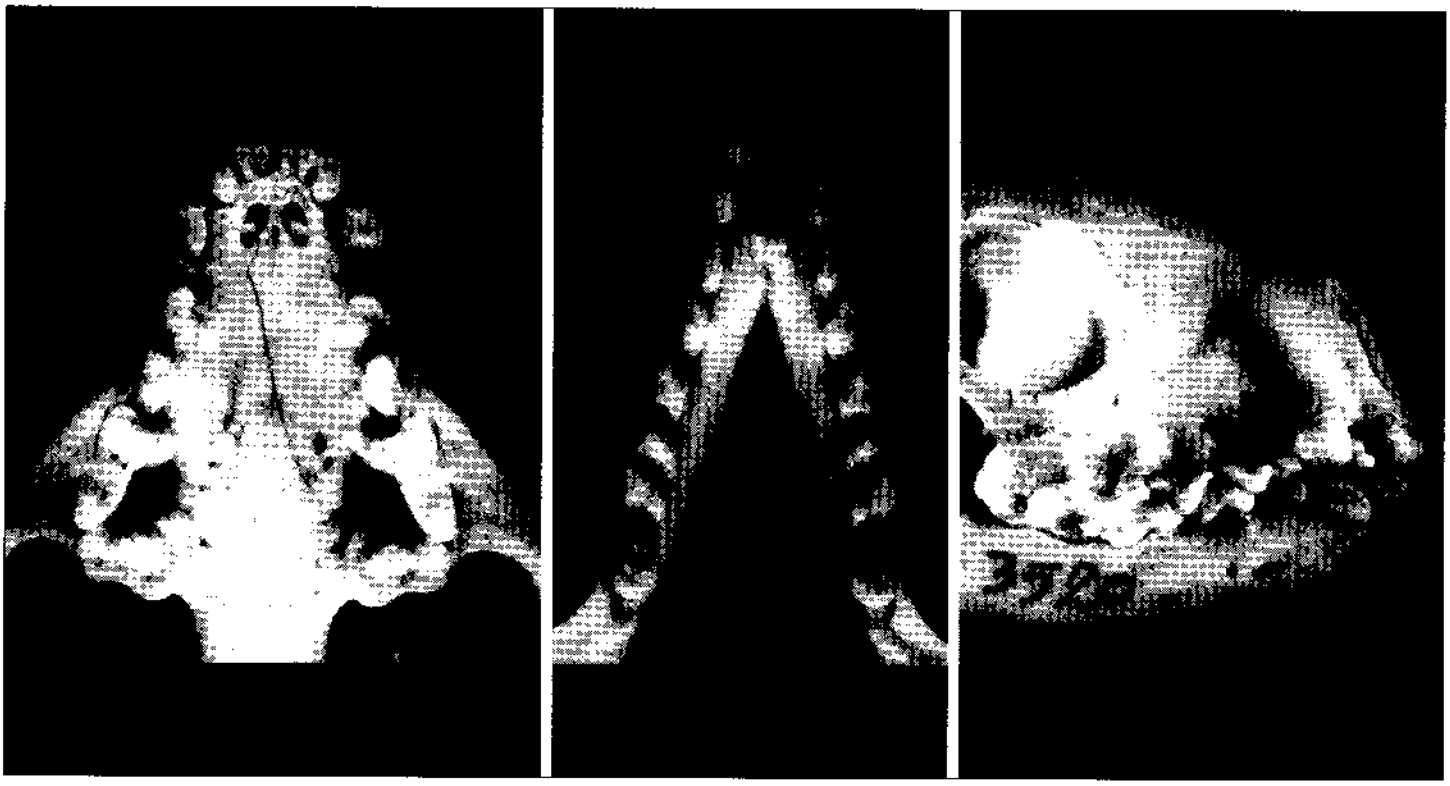

Fig. 4. Upper (left) and lower (middle) dentition of stone marten 3520 BK to show abnormal tooth wear. Right: the same specimen in lateral view to show malocclusion. See text for explanation.

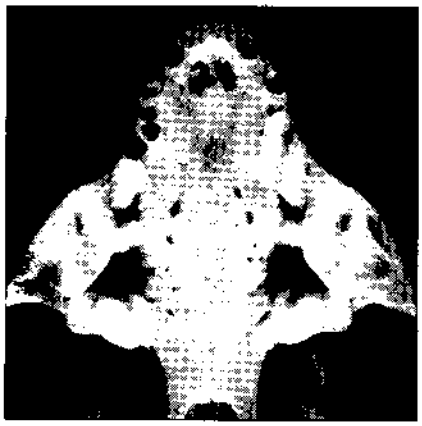

Fig. 5.
Upper dentition of stone marten 9589 BK. See text for explanation.

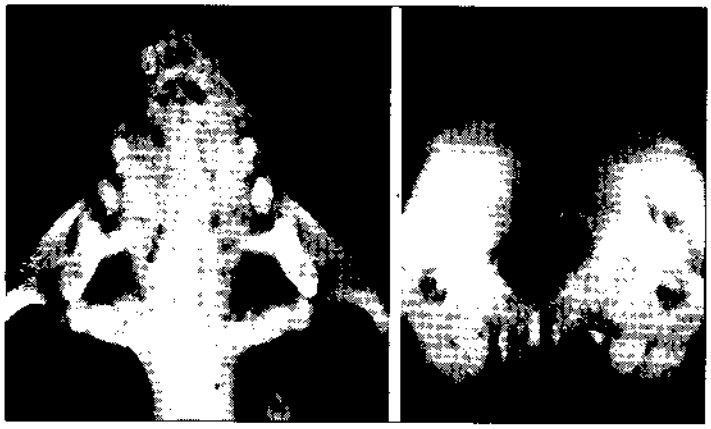

Fig. 6.
Rostral part of stone marten 4854 BK in ventral (left) and frontal (right) view. See text for explantion.

Traces of mechanical injury are also evident in the region of the nasals, which otherwise already fused with the maxillaries and premaxillaries, and in an asymmetry of the nasoincisive incisure. The animal was apparently injured when the cranium was still cartilaginous. The mandible is normally developed, and its toothrow complete (except for the bilaterally absent pm1).

Specimen No. 3267 BK (Fig. 7), an unsexed young subadult GG II) from sample PD2. This animal was killed by a car, resulting in damage to the braincase. The rostrum is much shortened (Fig. 7) and turned in the sagittal plane towards the right. The toothrow is badly deformed, with only the two posterior premolars (PM3 and PM4) being unaffected. The right PM1 and PM2 were lost, and their alveoli are still not completely closed. On the left side the PM1 and PM2 are present, but the second premolar is badly deformed. The left upper canine is turned forwards, and the nasals are much shorter than usual. The mandible is of normal length, and its teeth are not much deformed, although both pm1 are missing. The occlusion, which is perfect in the carnassials, is disturbed in the more anterior teeth. When the jaws are closed the upper incisors touch the pm2 whilst the lower incisors protrude forwards. Judging by the length of mandible, the rostrum is shortened by approximately 20% (Fig. 8). The reason for this is not clear, and we cannot exclude the possibility of congenital shortening of the rostrum.

Such a shortening, resulting in the condition known as "Mopschädel" is quite common in domestic mammals, and is sometimes even considered as a sign of domestication (Klatt, 1927; Herre & Röhrs, 1973). Hutterer & Weber (1983) also report it in a free living shrew, *Crocidura russula*.

There are several features common to all four cases described above: (i) only the rostrum is affected and not the mandible, (ii) malformations supposedly resulted from some mechanical injury in very young animals when the rostrum was still not ossified, and (iii) when the region around upper canines was traumatically affected this presumably inhibited their eruption.

Conclusions

Of 104 stone martens examined from Slovenia, only 41 (i.e. 39.4%) had a complete dental complement of 38 teeth. In the remaining animals, at least one tooth was missing, either congenitally, or traumatically, or both. Amongst affected martens, 9 (i. e.

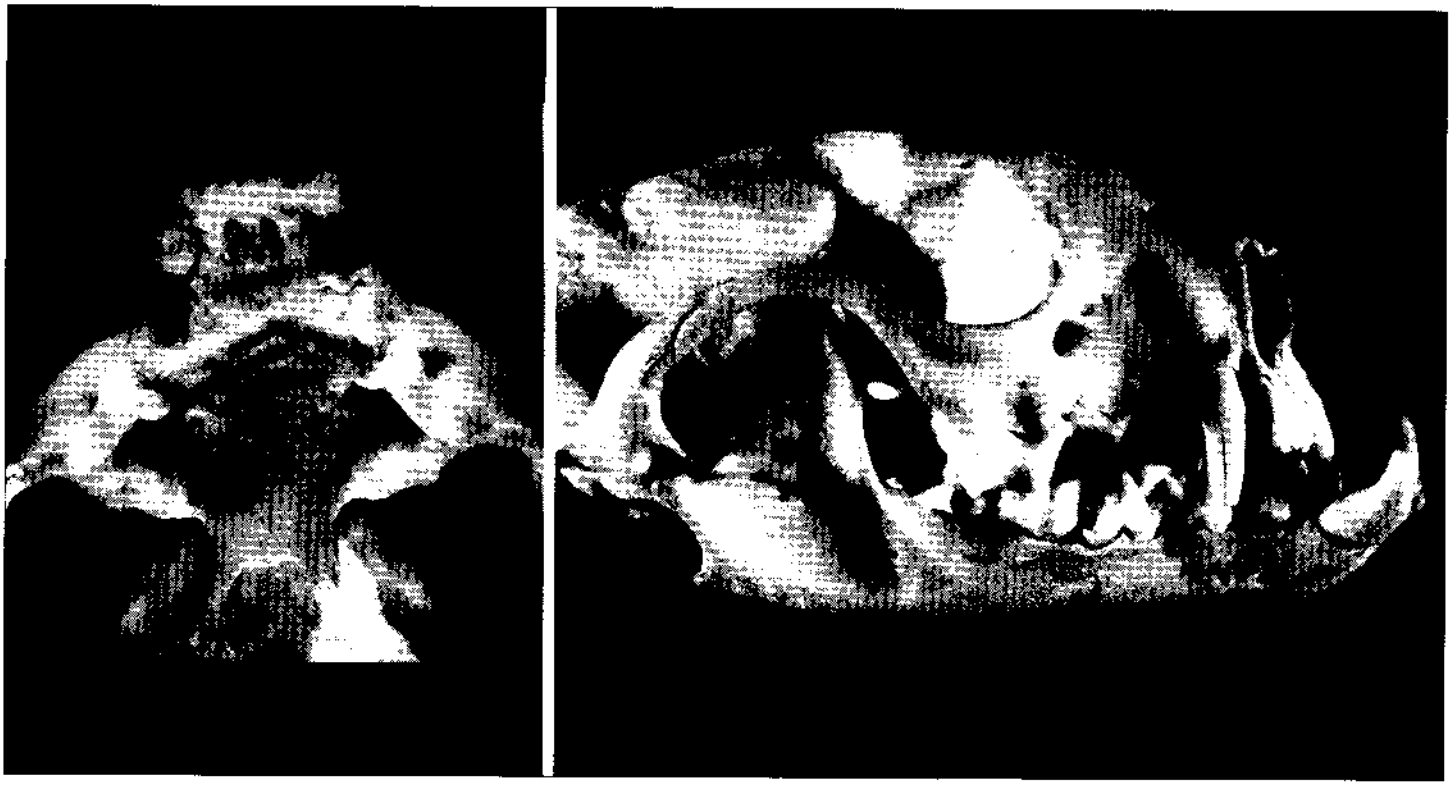

Fig. 7. Rostral part of stone marten 3267 BK in ventral (left) and lateral (right) view. See text for explanation.

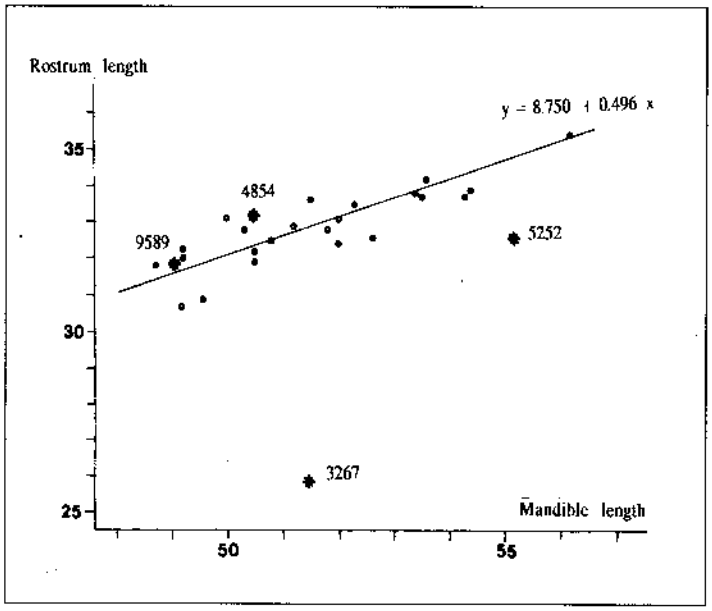

Fig. 8. Plot of rostrum length (measured from M3 to premaxillary) against mandible length (from articular process to symphysis) in young/subadult stone martens (Growth group II) from Slovenia. Dots -normally developed speciems; crosses -specimens having injured rostrum (with collection numbers). Regression was calculated for unaffected specimens only. Dimensions are in mm.

8.7%) had such severe abnormalities that their hunting success and consequently their survival were presumably reduced. One of these specimens was very old and its malformations were most probably due to advanced age. The remainder were subadult (6 specimens) or adult (2). Specimens with severely injured skulls and dentition are under-represented in older age-groups, which does suggest competitive inferiority.

The frequency of malformation is much higher in stone martens from Slovenia than in a representative sample of 220 skulls of the pine marten, *Martes martes*, from Poland (Wolsan, 1984). Besides, none of the skulls reported on by Wolsan (1984) was as badly injured as was the case in some of the specimens amongst our material.

The first lower premolar is not a functional part of the dentition. In the stone marten it is reduced in size in comparison with the pine marten, and this could be an important reason for its frequent deletion (Wolsan *et al.*, 1985). Our results suggest that even such minor deficiencies in the dental complement could result in competitive inferiority in the specimens affected. Does this mean, however, that any deviation from the standard dentition necessarily affects the vital function of the animal? Due to the small sample sizes it is not possible to demonstrate statistically significant differences in pm1 deletions between different growth groups. More data, and from different parts of the species' geographic range, are needed for the proper evaluation of the functional and evolutionary significance of pm1 reduction in the stone marten.

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Mapping the species distribution of sub-saharan African mammals

At the University of Copenhagen we have recently initiated an attempt to map the species-richness and endemism values of sub-saharan Africa at the scale of 1 degree square. We believe that this is an important task at the present time as the world is debating the values of 'biodiversity' and so far as we are aware there are no clear maps of the biodiversity priority areas in continental Africa which are based on the computerised analysis of species distributional data. This seems to represent an obvious barrier to the setting of conservation priorities, and to understanding why certain areas are so important for particular species-assemblages. It is also something that we believe we can do something about by compiling the existing distributional data and undertaking some relatively simple analyses on already existing computer programmes.

This attempt to map African biodiversity for mammals will be made through the Centre of Tropical Biodiversity in Copenhagen, in collaboration with as wide a network of collaborating agencies and individuals as will be prepared to join in this task. The methodology and project phases that we envisage are as follows:

- produce species-lists of African mammals from Wilson & Reeder (1993.
- gather species distribution data for the ca. 960 species which live in sub-Saharan Africa
- input species range and locality data onto the specialised biodiversity analysis programme WorldMap which has been developed at The Natural History Museum in the UK
- check draft species-distribution and locality maps with recognised experts in the field
- finalise the data-base on the computer and analyse the patterns in terms of species-richness and endemism for all mammals of subsets of them (families, forest species, phylogenetic relics)
- publish an overview of the biodiversity distribution of African mammals, and specialist papers as appropriate.
- promote the results within the scientific, conservation and development worlds

So far, a species-list of African mammals has been compiled from Wilson & Reeder. This is available for collaborators in this project to have and to verify. We are now writing to ask whether you would be prepared to help with this endeavour, especially with the *small African carnivores*. At this stage the most important things seem to us to be to collect:

- copies of any publications which you or colleagues have produced which contain species distribution maps for African mammals
- Lists of those references which you know to contain reliable species-distribution or species-location maps for any African mammal species
- names and contact details of other people who you think that we should be contacting about this project

We would like to assure you that any information and data that you provide will under no circumstances be duplicated, or transferred from us to other persons. Please contact: **Dr. Neil Burgess, Coordinator, Danish Centre for Tropical Biodiversity, Zoological Museum University of Copenhagen, Universitetsparken 15, DK 2100, Copenhagen, Denmark**

Coati studies underway in Tikal National Park

Since June 1994 we have been studying the White-nosed coati (*Nasua narica*) in Tikal National Park, Guatemala. The studies composing "Proyecto Pizote" constitute our doctoral dissertation research at the University of Florida: SDB in Wildlife Ecology and Conservation, and GAB in Zoology. We are focusing on coati behavioral ecology and population genetics, and reproductive biology, respectively.

Until very recently, coatis had been studied intensively only on Barro Colorado Island (BCI), Panama, where a series of investigations have been conducted in the last four decades (Kaufmann, 1962; Russell, 1979; Gompper, 1994). Their findings form the basis of our current knowledge of Central American procyonids, but this isolated population may not even be representative of the species. In contrast to BCI, Tikal is part of a large and relatively intact ecosystem, with a full complement of large predators. This national park also has unusually high densities of fruit trees -perhaps due to ancient Mayan cultivation -which may influence coati ecology in a variety of ways. It therefore presents an ideal opportunity for comparative studies with BCI, as well as many new avenues for research.

To date we have captured 79 coatis: 17 adult males, 31 adult females, and 31 immature animals. Recaptures are routinely made, and blood samples and a battery of morphological measurements are obtained from all captured animals; fecal and urine samples are also obtained from these and from free-ranging coatis whenever possible. Thirty-four adults have been radiocollared, including 20 females distributed among four bands. We have habituated two of these bands and several males to our presence in order to conduct behavioral observations.

Already some exciting differences between Tikal and BCI have emerged. Our two habituated bands contain 76 and 150 members, by far the largest coati bands ever documented anywhere. Preliminary radiotelemetry data indicate that the bands have correspondingly large home ranges. During most of the year the males occupy much smaller areas than the bands, but during the mating season they travel with the bands, battling fiercely for access to the females; more than one male has been observed copulating with the females of a given band in a single mating season. Radiotelemetry and observations reveal that bands are frequently accompanied by males at other times of year as well. Genetic analyses are planned to clarify the relationships among the males and band members.

Morphological data and observations indicate that coatis in Tikal display reproductive patterns similar in most ways to that found on BCI and suggested elsewhere. Mating takes place within a highly synchronous period in the middle of the dry season, parturition occurs some two-and-a-half months later -about one month before the wet season -and the young first emerge from the nest as the rains begin. But, in a phenomenon not previously reported, a second breeding may occur if the first fails to produce young or the young do not survive. Serum and fecal hormonal analyses will be conducted to characterize the reproductive cycle. A wide variety of dietary and phenological data are also being collected to examine environmental influences on this cycle, as well as on other aspects of coati ecology.

We are also extremely interested in the region's mustelids, especially the tayra (*Eira barbara*). During a pilot study conducted in 1992, we trapped and radiocollared an adult male Gray-headed tayra (*E. b. senex*) in Tikal, but due to equipment failure, we were not able to collect much data. We hope to pursue tayra studies in the future at another location, as the species is only rarely seen in Tikal.

We would like to hear from anyone with an interest in these species, particularly our colleagues in Costa Rica and Colombia, whose recent coati studies were mentioned in the October 1994 issue of this newsletter. At the present time, the only reliable way to communicate with us is by fax:

Susan D. Booth-Binczik & Gerald A. Binczik
University of Florida, Gainesville, FL, USA
Fax (in Guatemala): 502-9-500-077 •

European Marbled polecat in need of conservation action

The European marbled polecat *Vormela peregusna peregusna* is listed as a Priority Species in need of conservation action in both the *Action plan for mustelids and viverrids* (Schreiber *et al.*, 1989) and *Small carnivore assessment & management plan (CAMP)* (Wirth *et al.*, 1993). It is also listed in the *IUCN red list of threatened animals* and in regional red data books for the former USSR and Bulgaria.

There has been a resurgence of conservation interest in the marbled polecat and the steppe ecosystem which it inhabits. The cause of decline in this subspecies of the marbled polecat is not known with certainty but the steppe habitat in the Balkans and Ukraine is continuously under threat from intensive agriculture. It has been suggested that the ecological pressures facing the marbled polecat may be similar to that of the Black-footed ferret *Mustela nigripes* which became extinct in the wild due to conversion of its North American prairie habitat (Schreiber *et al.*, 1989).

Historically the range of *V. p. peregusna* was extensive. It is now thought only to occur in the Ukraine, Moldavia, Bulgaria, Romania, former Yugoslavia (Serbia, Macedonia), and possibly still in eastern Greece. The present distribution is not continuous with the two larger fragmented populations to the 'north' and 'south' divided by an 800 km corridor.

Recommended conservation action includes field studies to determine the population status and the distribution and ecology of the European marbled polecat (including data on its association with social rodents and the Steppe polecat *Mustela eversmanni*). Equally important is a taxonomic investigation of

Vormela to identify the validity of the European (and other) subspecies.

The IUCN/SSC Mustelid, Viverrid & Procyonid Specialist Group (MVPSG) has been approached to assist with a number of conservation efforts for the European marbled polecat in Bulgaria and Romania. The MVPSG has agreed to investigate the development of conservation programmes in these and other countries with a view of providing a regional conservation strategy. It is hoped that any conservation effort can be integrated in an ecosystem approach to focus on the southern steppe regions, though we as a group responsible for the conservation of small carnivores will still highlight the European marbled polecat as a flagship species.

Paul Robinson has been asked to co-ordinate the "Vormela Project". The main task ahead is to identify current conservation and research activity in the European marbled polecat or in the marbled polecat generally. It is important to develop a network of conservationists/researchers with relevant expertise who are interested in supporting this programme. Additionally, it is equally important to communicate with other conservation organisations involved with other taxa and/or habitat management in the region. Such an approach will hopefully prevent the possibility of duplication of efforts and the waste of valuable resources. The next stage would be to initiate a working group to oversee conservation activities and to impliment a regional conservation strategy for *V. p. peregusna*, and to disseminate information to others on the conservation of the European marbled polecat.

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The MVPSG requests the assistance of its members who have relevant expertise and knowledge of *Vormela peregusna* or who can assist in other ways. Please contact:

Paul Robinson, 41 Moss Lane, Hesketh Bank, Preston PR4 6AA, UK.
✆ ++ 44 (0)1772 816470; fax ++ 44 (0)1704 506556
e-mail: pr8@student.open.ac.uk.

Abstract

Carnivores in a Central African rainforest

Ray, J. C. 1966. Resource use patterns among mongooses and other carnivores in a Central African rainforest. Ph.D dissertation, University of Florida, Gainesville, FL. 251 pp.

Two years of research in the Dzangha-Sangha Reserve/ Dzanga-Ndoki National park in the Central African Republic provided ecological data on an assemblage of eight sympatric Carnivora (including three herpestids, three viverrids, and two felids) and their resources.

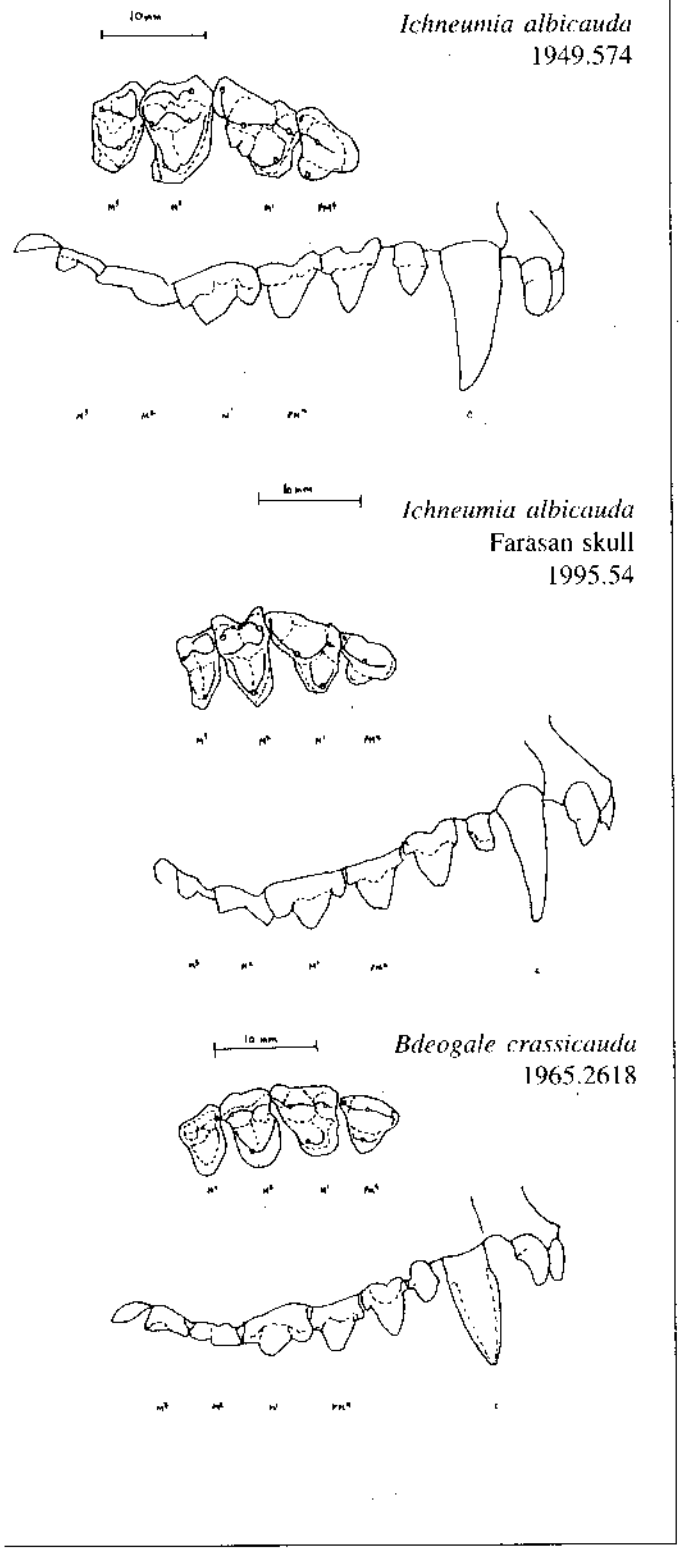
The 28 km^2 study area was a mosaic of habitats, including logged and unlogged forests, which demonstrated distinct differences in community composition of large (> 10 cm DBH) and small (< 10 cm) trees, stem density (for both trees and lianas), basal area, species and family diversity, and vegetation structure (analysed for both understory [0-10 m] and canopy cover). Small mammal trapping resulted in the capture of 1,957 individuals of 15 species, 13 of which were rodents and two shrews. The species composition of the rodent community indicated a relatively undisturbed habitat.

In primary forest, the ratio of *Hylomyscus*: *Praomys* was high, *Deomys* was abundant, and species characteristic of savannah edge habitats were absent. Highest levels of rodent abundance and diversity were attained in secondary forest; detailed analyses of trap-sites where rodent species were captures demonstrated that dense understory was important for most species. Repeated sampling during three seasons over two years also yielded important differences in population levels of all species in this highly seasonal forest. Although seasonality in breeding activity was evident, inter-year differences in population densities were even more significant. Radio-tracking of five long-nosed mongooses (*Herpestes [Xenogale] naso*) and one marsh mongoose (*Atilax paludinosus*) revealed clear separation in activity, habitat use, and movement patterns.

A detailed analysis of predation on small mammals by *Herpestes naso* and other carnivores indicated a highly diverse prey base, including 16 species of shrews. Analyses of selective predation on rodent species for which population densities could be estimated indicated a tendency for small carnivores to select species inhabiting areas with relatively dense understories or large amounts of fallen timber. Interestingly, not only was the incidence of predation on shrews unusually high (as judged by an extensive literature survey), but monthly frequencies of rodent remains in the scats closely mirrored shrew frequencies. Of the 1,066 carnivore scats collected, 666 (62%) were identified using seven techniques, including the analysis of bile acid patterns via thin-layer chromotography.

Detailed identification of mammalian, arthropod, herpetofauna, fish, fruit, and bird contents in scats revealed clear dietary separation between most of the eight species in the community. Those species that experienced a relatively high degree of overlap in the diet were the most likely to exhibit differing habitat use or activity patterns. The diets of all species were diverse, but two species (*Atilax paludinosus* and *Civettictis civetta*) were relatively specialized by virtue of their restricted use of habitat. Arthropods dominated the scats of all species except the two felids (*Profelis aurata* and *Panthera pardus*), which were specialists on mammalian prey. It is suggested that the maintenance of this highly diverse carnivore community was facilitated by the breadth of the resource base, marked degree of microhabitat heterogeneity, and high levels of abundance, or high rates of renewability in some prey groups.

Correction



In number 13 (October 1995) we made a mistake. In Fig 3 of D. J. Simmons' paper (p. 4) the drawing of *Ichneumia albicauda* Farasan skull) was shown twice and *Bdeogale crassicauda* not at all! Please note the correct illustration.

Mr. David J. Simmons has informed us that he is currently available for work and would appreciate any offers of employment. He can be reached at: 15 Orchard drive, The Sands, Durham DH1 1LA, UK. Tel. 0191 3861570.

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