Small Carnivore Conservation

The Journal of the IUCN/SSC
Small Carnivore Specialist Group

Volume 36 April 2007

IUCN
The World Conservation Union

Altai Weasel *Mustela altaica* (Photo: Marc Foggin)

The production and distribution of this issue has been sponsored by:
Royal Zoological Society of Antwerp, Antwerp, Belgium
Columbus Zoo, Powell, Ohio, USA
Wildlife Conservation Society/Living Institutions,
New York, NY, USA

Small Carnivore Conservation continues

From the Editor-in-Chief

Dear readers,
I am sure you are all aware, Harry Van Rompaey, former Editor-in-Chief of *Small Carnivore Conservation* (SCC), recently passed away (see obituary, page 2). Harry initiated this journal, formerly titled Mustelid and Viverrid Conservation, almost 20 years ago and ensured its continued success throughout this period. Harry's tireless efforts not only to keep SCC alive, but his overall ambitions to aid the conservation of small carnivores worldwide, should not be taken lightly. As Roland Wirth had written in the previous issue of SCC "It won't be easy for anyone to step into your shoes, Harry!" I think this could not have been more appropriately stated. On behalf of the editorial staff of SCC, I dedicate this issue in the memory of Harry Van Rompaey.

In my, until now, impartial opinion, SCC is one of the best journals published of any specialist group within the IUCN/Species Survival Commission. Undoubtedly, this recent transition in oversight of SCC will bring about both constancy and change. Constancy in that our intent is to maintain SCC as a leading journal in the dissemination of sound scientific and conservation-related information on Ailuridae, Herpestidae, Mustelidae, Procyonidae and Viverridae. Change in that we envision growth of SCC in both geographic coverage and breadth of topics published.

As you may have noticed from reviewing the inside front cover, this issue of SCC also reflects a number of changes in the editorial staff. To start with, I would like to briefly introduce myself to each of you. I am presently employed as a wildlife biologist with the US National Park Service. Although I have worked with numerous wildlife species and continue to do so, my greatest interest and satisfaction has always been while studying carnivores, particularly small carnivores. My professional work with small carnivores began in the late 1980s and has revolved primarily around American Martens, Fishers, and Northern Raccoons, in addition to some work with Short-tailed Weasels, Long-tailed Weasels, Striped Skunks, and American Badgers. My current small carnivore research programme emphasises American Martens and Fishers.

I personally want to thank each of the previous members of the Editorial Board for their respective contributions to SCC over the years. I particularly would like to acknowledge the continued efforts of William Duckworth, who has ensured that publication of SCC continued during this difficult transition. Will has kindly agreed to continue as Associate Editor for SCC for which I am grateful. I also would like to acknowledge each new or continuing member of the current Editorial Board: Alexei Abramov, Philippe Gaubert, Angela Glatston, Frank Hawkins, Barney Long, Divya Mudappa, Scott Roberton, Jan Schipper, and Roland Wirth. These individuals have graciously offered their time, expertise and enthusiasm to the continuation of SCC. I look forward to working with each of you as well as all other members of the Small Carnivore Specialist Group (SCSG) to ensure the long-term success of this journal.

Another recent change is that we have developed information for authors wishing to contribute manuscripts to SCC. A summarised version of this can be found on the inside back cover of this issue. Complete guidelines can be obtained by emailing any member of the editorial staff. We will ultimately include an electronic version of these guidelines on the SCSG website. For questions about manuscripts not addressed in these guidelines, please contact me or William Duckworth.

The scope of SCC was well described in the October 2004 Editorial (Number 31). Attributes of SCC mentioned in this previous editorial I would like to reiterate are that the journal is: 1) to be complimentary to the many international mammalogical and conservation journals, 2) to provide rapid publication of all manuscripts, particularly 'breaking news' items in which findings are likely to be relevant years later, 3) to provide syntheses of current knowledge on the status and distribution of many of the small carnivores, and 4) to further enhance reader's awareness of other small carnivore research through compilation of recent literature and reviews of published books or monographs.

Although I still have much to learn regarding numerous aspects of SCC, as well as many of the species we work with, I am excited and pleased to have this opportunity to serve as the Editor-in-Chief. My goal is to maintain the same high-quality content this journal has enjoyed in past issues. With the enthusiasm, efforts, and support provided by the present editorial staff, I am confident of the future success of SCC.

Jerrold L. BELANT
Editor-in-Chief, Small Carnivore Conservation

OBITUARY
Harry VAN ROMPAEY
5 April 1936 – 2 February 2007

"L'homme naît faible, il tête d'un an à 18 mois, ne marche seul que vers deux ans, reste longtemps débile, entre dans l'adolescence vers 16 ans, dans la virilité à 30 ans, dans l'âge mûr à 40, dans la vieillesse à 60, et décroît alors rapidement vers le terme de son existence."

René-Primevère LESSON
Manuel de mammalogie, 1827
Chirurgien et naturaliste français

OBITUARY
Harry VAN ROMPAEY
5 April 1936 – 2 February 2007

Une vie dédiée à l'Histoire Naturelle, à sa passion pour l'Afrique, pour les voyages, pour l'Art et ses… mangoustes. Ainsi aimait vivre Harry ! Notre rencontre date de 1982, période à laquelle je résidais à Kisangani - République Démocratique du Congo (Ex Zaïre). J'ignore encore comment, mais de sa Belgique natale, Harry, le premier avait été informé, de la re-découverte, au fond du Congo Kinshasa, du Mani-Mani, la rarissime genette aquatique (*Osbornictis piscivora*). Notre premier contact eut lieu à l'Université d'Antwerpen, dans le laboratoire du Professeur Walter VERHEYEN. Nous partagions les mêmes passions et une franche amitié s'installa, rapidement, entre nous. Depuis, lors de mes *transits* en Belgique, une escale s'imposait, obligatoirement, à Edegem, dans la maison d'Anny et d'Harry où règnent l'hospitalité et la gastronomie. Le programme comprenait inévitablement la revue de l'actualité internationale relative aux genettes et aux mangoustes africaines et une grande partie de ces soirées inoubliables était consacrée au bilan et à la préparation des travaux réalisés en commun. Combien de nuits, de réveillons avons-nous ainsi partagés ?

A ces merveilleux souvenirs, il convient d'associer les contributions scientifiques publiées, telles que les révisions des Cusimanses (*Crossarchus* sp) et des Black-legged mongoose (*Xenogale naso*) de l'Afrique centrale, la description de nouveaux taxons (*Crossarchus ansorgei nigricolor* from the left bank of the Congo River, *Genetta servalina archeri* from Zanzibar) et les articles parus dans « Small Carnivore Conservation ».

Ces lignes qui relatent brièvement ces moments privilégiés trop rares, révèlent un homme passionné, aimant la vie et s'imposant un rythme de travail hors du commun, entièrement voué au grand livre de l'Histoire Naturelle.

Titulaire, en 1962, d'une doctorat en medicine véterinaire à l'Université de Gand, Harry consacra la plus grande partie de sa vie professionnelle à une clientèle urbaine. Passionné par l'Afrique, la faune et la recherche, il entreprit, des voyages sur des sites aussi remarquables que celui de Langata en 1968, au Kenya, où Armand et Mickaëla DENIS filmaient la faune sauvage, et que celui de Karisoke en 1976, au Rwanda, où il rencontra Diane FOSSEY et ses gorilles de montagne. Son carnet d'adresse était exceptionnellement riche et il n'était pas rare de rencontrer chez lui, des biologistes et des naturalistes de renommée internationale, d'horizons aussi divers que Colin GROVES, Roland WIRTH, Chris STUART… Sans oublier les nombreux échanges qu'Harry entretenait, de façon permanente, avec les musées, grands et petits, dès qu'il s'agissait de visiter les collections de Mustelids and Viverrids provenant d'Afrique.

Harry avait, également, la fibre du collectionneur et il a rassemblé, entre autre, pendant une trentaine d'années, une bibliothèque unique, riche de plusieurs milliers d'articles sur les carnivores. Cette somme de connaissances rassemblées et parfaitement maîtrisées par Harry, faisait de lui, l'un des meilleurs spécialistes des mangoustes, comme le témoignaient les nombreuses demandes émanant de chercheurs, pourtant déjà spécialisés dans ce domaine. En 1989, il contribua à la rédaction de l'Action Plan for the Conservation of Mustelids and Viverrids (Weasels, Civets, Mongooses and their Relatives) et il excella, par la suite, en sa qualité d'Editor-in-Chief dans la gestion de ce Newsletter initialement appelé « Mustelid & Vivverid Conservation » (N° 1 à 5) et devenu, par la suite « Small Carnivore Conservation ».

Mais l'érudition d'Harry ne se limitait pas à l'Histoire Naturelle ! Amateur éclairé d'architecture gréco-romaine, titulaire d'une licence en Art indou et en Art égyptien, il était proche de nombreux artistes peintres. Il a notamment rassemblé une collection monumentale de documents, de notes et d'ouvrages sur la peinture animalière. Là aussi, tant les connaissances que le travail accompli témoignent de l'intensité de sa passion. Quelques mois avant son décès, il éditait son « Dictionary of Bird and Wildlife Painters », véritable ouvrage de référence, riche d'un millier de pages qui fera, sans aucun doute, autorité pendant des décennies…

Harry nous a quitté, ce 2 february 2007 et en dépit de l'importance de ses travaux, son œuvre reste inachevée. Il nous revient de poursuivre son travail. Si j'ai conscience de la chance qui a été la mienne, d'avoir partagé de longs et agréables moments avec Harry, il me restera un regret, celui de ne pas avoir toujours su mesurer l'importance de sa contribution!

Marc COLYN

"Man is born weak, he suckles from one year to 18 months, walks unaided only by about two years, long remains dependent, enters adolescence around 16 years, is in his virility at 30 years, in his maturity at 40, in old age at 60, and then quickly decreases to the close of his existence."

René-Primevère LESSON
"Manuel de mammalogie", 1827
French surgeon and naturalist

A life dedicated to natural history, to his passion for Africa, to travel, to Art and to his… mongooses. So Harry loved to live! We met in 1982, when I lived in Kisangani, Democratic Republic of Congo (former Zaire). I still cannot fathom how, but Harry was the first to be informed, from his Belgian homeland, of the rediscovery of the extremely rare Aquatic Genet *Osbornictis piscivora* deep down in Congo Kinshasa, in the Mani-Mani. We first met at the University of Antwerp, in the Laboratory of Professor Walter Verheyen. We shared the same passions and a candid friendship quickly blossomed between us. Since then, during my transits in Belgium, layover in Edegem, in the house of Anny and Harry where hospitality and gastronomy reigned supreme, became an obligatory delight. The programme inevitably included review of international news of genets and African mongooses, and a major part of those unforgettable nights was dedicated to preparing and completing our collaborative works. How many nights and Christmas eve dinners did we share so?

Tied to those wonderful memories are the published scientific contributions, such as the revisions of the Cusimanses *Crossarchus* spp. and Long-nosed Mongoose *Xenogale naso* from central Africa, the descriptions of new taxa (*Crossarchus ansorgei nigricolor* from the left bank of the Congo River, *Genetta servalina archeri* from Zanzibar), and the articles that appeared in *Small Carnivore Conservation*.

These lines, although brief, come from such rare privileged moments, and portray a passionate man who loved life and imposed upon himself a working rhythm far out of the ordinary, entirely devoted to the great book of natural history.

Holder of a doctorate in animal medicine from the University of Ghent in 1962, Harry dedicated most of his professional life to an urban clientele. Impassioned with Africa, fauna and research, he undertook journeys to remarkable sites such as Langata, Kenya (1968), where Armand and Michel Denis were filming wildlife, and Karisoke, Rwanda (1976), where he met Dian Fossey and her Mountain Gorillas. His address book was exceptionally rich, and it was not uncommon to meet in Harry's house biologists and naturalists of international renown, such as Colin Groves, Roland Wirth, Chris Stuart… Nor should be forgotten the numerous exchanges Harry constantly maintained with museums, big and small, visiting whenever he could their collections of African small carnivores.

The fibre of Harry's being was that of a collector, and over about 30 years he assembled, among other things, a unique library of several thousand articles about carnivores. This aggregation of knowledge, gathered and perfectly managed by Harry, made him one of the top specialists of mongooses, as testified by the numerous requests from scientists already knowledgeable about these animals. In 1989 he was part of the team who prepared the *IUCN/SSC Action Plan for the Conservation of Mustelids and Viverrids (Weasels, Civets, Mongooses and their Relatives)*, and he later excelled in his role as Editor-in-Chief of the newsletter initially entitled *Mustelid & Viverrid Conservation* (n° 1–5), which then became *Small Carnivore Conservation*.

But Harry's erudition was not limited to natural history! Enlightened amateur of Greco-Roman architecture, holder of a bachelor in Hindu and Egyptian art, he was close to numerous artistic painters. He notably gathered a monumental collection of documents, notes, and books on animal painting. Here too, the depth of his accomplished work attests to the intensity of his passion. In the several months up to his death, he compiled a *Dictionary of Bird and Wildlife Painters*, a veritable baseline tome of a thousand pages that will undoubtedly remain authoritative for decades…

Harry left us this 2 February 2007, and in spite of his outstanding contributions, his task remains unaccomplished. We must take upon ourselves the responsibility to pursue his vision. If I am conscious of the chance I had to share long and enjoyable moments with Harry, I will always regret the impossibility to portray the full importance of his contribution!

Marc COLYN

Captive breeding of the Small Indian Civet *Viverricula indica* (É. Geoffroy Saint-Hilaire, 1803)

M. BALAKRISHNAN* and M. B. SREEDEVI

Abstract

Breeding Small Indian Civets *Viverricula indica* were observed in two captive colonies in Trichur District of Kerala, south India. One colony was kept in traditional wooden cages individually, except for short periods of pairing. The other colony lived in an open enclosure of tiles and cement. Milk, cooked rice, and bananas formed the regular diet with occasional supply of frogs, garden lizards, rats, chicken, beef, papaya, and pineapple. Frequency of scent-marking increased from 8.2 to 19.5 per 2-hour period in males and from 6.3 to 11.5 in females during the breeding season, and declined considerably after mating. Out of four successful matings, the mean gestation period was 67 days. Litter size varied from two to five. Kittens weighed between 90 and 110 g at birth. They started eating solid food, especially fruits and bits from the mother's food, by the fourth week after birth. Only two months after delivery did females regain the perineal glandular marking activity. Scent-marking by the young was first observed when they were eight weeks old, but the glandular secretion was observed on the marking sites only when they were eight months old. Further information is needed to design optimal holdings for captive breeding civets. Such captive breeding could, if well executed, lower pressure on wild populations, which are harvested for collection of the perineal gland secretion.

Keywords: India, Kerala, litter size, perineal gland secretion, scent-marking

Introduction

The Small Indian Civet *Viverricula indica* (É. Geoffroy Saint-Hilaire, 1803) has been heavily used as a wildlife resource for its prized perineal gland secretion (known as 'civet') since time immemorial. In Kerala (south India), several captive civet holdings are located (Xavier 1994, Balakrishnan 2002, Balakrishnan & Sreedevi 2007). The civet owners are not interested in breeding their civets, as the glandular secretory output is considerably reduced during pregnancy and lactation. Old and dead civets are

Fig. 1. A male Small Indian Civet is sniffing the posterior quarters of a female in oestrus, during breeding activities under captivity.

replaced by fresh ones trapped from the wild. This practice has been one of the reasons for the suspected depletion of the civet populations in south India, in addition to habitat disruption as an impact of human population explosion. Maintenance of civets under captivity is illegal without a license under the Indian Wildlife (Protection) Act 1972. However, as the perineal gland secretion of the civet is a major ingredient in a number of Ayurveda Pharmaceuticals (a traditional system of south Indian medicine), and as it is costly, civets continue to be maintained for this valuable natural resource. If a model civet breeding farm can be established with a valid license, it can be developed as a sustainable wildlife resource, as envisaged under the Convention on Biological Diversity (UNEP 1992), to reduce pressure on natural populations of this civet.

Due to their solitary and nocturnal habits, little is known about the reproductive processes and behaviour of civets (Ewer & Wemmer 1974, Prater 1980, Balakrishnan 2002). Small Indian Civet is known to have two breeding seasons, the first during February–April and the second during August–September (Hongfa & Helin 1995). The present study focuses on the breeding and related activities of the Small Indian Civet with a major objective of developing a captive breeding population, so as to conserve their natural populations by reducing trapping pressure.

Methods

Breeding and related activities of civets were observed in two captive populations; eight animals maintained in Chalakkudy and six animals in Vallachira, both in Trichur District in the state of Kerala, south India. These civets were originally brought from the wild. The colony in Chalakkudy was originally established for the extraction of the perineal gland secretion, whereas the one in Vallachira was established only for the present investigation. Civets in Chalakkudy were maintained individually in traditional wooden cages (size: 120 × 45 × 60 cm), but (for this investigation) were kept together for short periods, to allow pairing. The Vallachira colony was established in an open enclosure (240 × 120 × 90 m), made of tiles and cement. There were three Coconut *Cocos nucifera* trees, one Jack tree *Artocarpus heterophyllus* and one Papaya tree *Carica papaya* in this enclosure. Besides these, various fruiting bushes such as the West Indian Cherry *Malpighia glabra*, Bakery Cherry *Carissa carandas* and Cheruthudali (or Kottaipazham) *Zizyphus oenoplia* were planted inside the enclosure. The floor of the enclosure was covered with natural grass already present in the area. An artificial pond planted with lotus *Nelumbo nucifera* and containing a few fish (*Tilapia* and *Anabas*) was maintained. Six burrows measuring 75 × 60 × 45 cm were made in the open enclosure with mud, clay and bricks for the animals to rest and hide in. All the six individual civets had access all round the open enclosure.

Each civet in Chalakkudy was fed 200 g rice mixed with 50 ml milk daily. Chicken, beef, and eggs were supplied 2–3 times per week. Plantain *Musa paradisiaca*, birds such as crow *Corvus* and pigeon *Columba*, rats *Rattus*, and garden lizards *Calotes* were also given, when available. All feeding was during 17h30–18h00. The Vallachira colony was maintained on a regular diet of beef/chicken (100 g), milk (50 ml), one egg and 3–4 plantains per animal per day. Frogs *Rana*, garden lizards, rats and fruits such as papaya and pineapple were also supplied when available. Animals were fed during 18h00–18h30.

Observations were made regularly on breeding-related behavioural patterns, pregnancy and maternal care of both these populations of civets during 1994–1997. Night observations were made under a 20 W bulb. The unit observation time was two hours, and a total of 3,500 hours of night observations were made because the civets were predominantly nocturnal. Data were recorded on standardised forms. The behavioural activities were also videographed. Additional information on breeding and related activities of the civets was gathered from staff of the civet holdings.

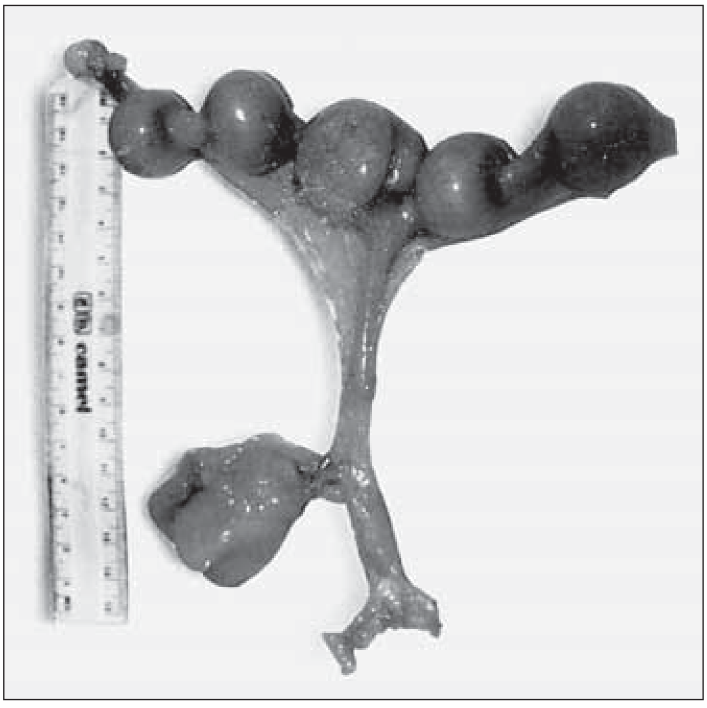

Fig. 2. The fallopian tube of a pregnant civet with five foetuses at approximately 30–35 days of pregnancy. The foetal membrane of the middle one is cut open.

Fig. 3. The genital organs of a pregnant civet with two fully-grown foetuses.

Fig. 4. A mother civet with its newly born kittens, six hours after parturition.

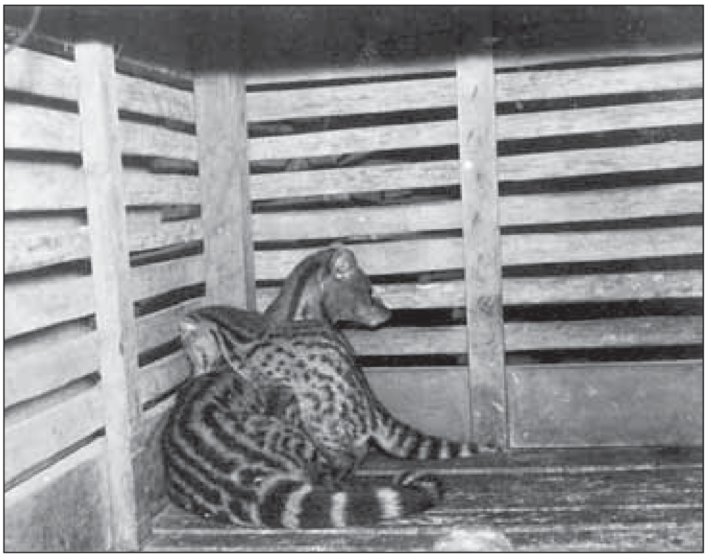

Fig. 5. A six week-old civet kitten growling over the mother during its play behaviour.

Observations

Mating and related activities were observed in captive Small Indian Civets in two seasons, during March–May and during October–December. The frequency of locomotor activity increased during the breeding season. The mean frequency of locomotor activity peaked at 52 times/2-hours of observation time in males and at 40.5/2-hours in females, compared with 31.5 times in males and 26 times in females during other seasons. Vocalisation was most prominent when the females were in heat. The mean frequency of vocalisation increased from 3.6/2-hours to 16/2-hours in males and from 1.7/2-hours to 7/2-hours in females during breeding season. The frequency of scent-marking increased from 8.2/2-hours to 19.5/2-hours in males and from 6.3/2-hours to 11.5/2-hours in females during the breeding season. The frequency of scent-marking was at its highest levels when females were in heat.

Courtship in the Small Indian Civet commenced with a series of "duk-duk-duk" calls from the male. There were 7–8 notes in each of these calls during the oestrous phase of the sex cycle. Males frequently sniffed the scent-marked sites of females. The male also sniffed the posterior quarters of the female (Fig. 1) in heat during courtship. During the first mounting attempts, the female responded with a sharp scream and bit the male. This often ended in a fight, in which both animals might be injured on the nape and tail. Courtship calls re-commenced after 5–30 minutes. After 3–4 such attempts, the female was seen running around the cage, often touching and slightly pushing the male. The male followed and sniffed at the perineal region of the female and finally the female lay down, allowing the male to mount. The body of the female was fully extended with the hind legs slightly raised during this behaviour. The male mounted with forepaws placed on either side of the shoulders of the female. Sometimes, the female tried to move forward in this position, when the male gripped the hair on her nape along with pelvic thrust. The female made a low cat-like call after some time and then the male dismounted. Immediately after dismounting, the female growled and tried to bite the male and then they departed to separate corners of the cage.

Locomotor frequency of the female decreased considerably after copulation. The frequency of feeding increased from once per 2 hours to 8/2-hours by 10 days after copulation and they showed increased appetite. The frequency of scent-marking decreased to a base level of 1.5/2-hours by 10 days after mating, and they stopped scent-marking after 20 days of successful mating. Foetal motility was noticed from the sixth week of pregnancy. There was visible development of teats. Of the four successful matings recorded during the present investigation, the mean gestation period was 67.3 ± 2.1 days. Females did not eat on the day of parturition. Only two months after delivery did the females regain the perineal glandular marking activity.

Litter size varied from two to five. During this investigation, one civet (pregnant while taken from the wild) gave birth to five young. One dead specimen from the wild contained five foetuses in the uterus (Fig. 2), and another two (Fig. 3). Most civet keepers reported litter size as two. Captive civets were infantophagous. In 29% of the known cases, the mother nursed the young ones, in 29% of cases she killed the young ones, and in 42% of cases, the mother killed and ate at least one of the kittens.

The mother breast-fed the young 3–4 times per hour during the first week after parturition. The frequency of breast-feeding reduced to once per hour by the second week and to once per two hours by the third week. This was further reduced to 2–3 times a day by the seventh week. When alarmed, the mother held the kitten in her mouth, gripping the fur on the nape. It licked the whole body of the young ones, and ate the excreta of the kittens.

Weight of the civet kittens ranged between 90 and 110 g at birth (Fig. 4), when they were completely covered with hairs. At birth, they clustered beside the belly of the mother and crawled to reach the teat. The eyes opened on the fifth day. From the eighth day onwards, they walked with a slow pace. By the third week after birth, the kittens rolled over the body of the mother, particularly around the neck region (Fig. 5). They started eating solid food, especially fruits and bits from the mother's food, by the fourth week of age. Scent marking was first observed when they were eight weeks old, but the perineal glandular secretion was not observed until they were eight months old. The body weight of the kitten attained 180–200 g by the end of the second week, 250–300 g by the end of the fourth, 400–500 g by the end of the eighth week, and 1000 g by ten weeks. They were of adult size (3–4 kg) at six months of age.

Discussion

No detailed information is known about the family life and breeding of Small Indian Civet (Prater 1980). Ewer & Wemmer (1974) made some observations on the mating behaviour of the African Civet *Civettictis civetta*. Information from this study could be used to help plan for captive populations of civets. If captive breeding populations of civets are established, they might reduce pressure on the natural populations that civet owners presently depend upon to replace the old and diseased captives (Xavier 1994, Balakrishnan 2002).

The present investigation has revealed that Small Indian Civet has two breeding seasons: October–December and March–May. Young are born in January–February and June–July. January–February is the fruiting season of many trees, such as *Zizyphus* sp., which forms a major food of wild civets in Kerala (Sreedevi 2001). June–July is the rainy season in this area, when wild fruits and other food of civets (Balakrishnan & Sreedevi 2007) are available in plenty (Sreedevi 2001).

Courtship calls are associated with solitary animals that pair only for a short time (Ewer & Wemmer 1974), when the opposite sex can be attracted for mating. Breeding calls and scent-marking were more frequent during the breeding season, before mating. The oestrus phase of females of several species of mammals can be easily recognised by the male through sniffing the posterior quarters or even by sniffing sites scent-marked by the female (Eisenberg & Kleiman 1972, Balakrishnan & Alexander 1985). The present study revealed that male civets sniff the posterior quarters of a potentially receptive female.

The gestation period recorded during this investigation falls within 65–72 days. In an African Civet, the gestation period was recorded as 72 days (Mallinson 1972, cited by Sreedevi 2001). Litter size of African Civet is similar to the present observations of Small Indian Civet: Dorst & Dandelot (1970) recorded 2–4 young per litter and Ewer & Wemmer (1974) recorded 2–3. In Small Indian Civet, the maximum litter size (five) was shown only by wild animals, suggesting that captive populations may suffer from malnutrition, inadequate space, and related physiological effects.

Cannibalism has apparently never been reported in any species of civet. This behaviour has considerable relevance in captive breeding programme as it is believed to be associated with deficiency of phosphorous, salt, cobalt, fibres, and protein. As suggested earlier, wild animals taken into captivity may not rear their progeny in stressful captive conditions (Ewer 1968). Because infanticide may result from cramped and paired caging conditions, civets under captivity should be maintained in semi-natural conditions. Further trials are needed to establish size and layout of cage, and distance from conspecifics.

Acknowledgements

We are grateful to Mr. P. K. Surendranathan Asari, Former Chief Wildlife Warden & Principal Chief Conservator of Forests & Wildlife, Government of Kerala, for his support and encouragement throughout this study.

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Husbandry and management of the Small Indian Civet *Viverricula indica* (É. Geoffroy Saint-Hilaire, 1803) in Kerala, India

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Abstract

A survey of captive Small Indian Civets *Viverricula indica* in Kerala revealed 43 holdings with 86 civets. Among them, 62% of animals had been procured from the wild as young animals, of which 59% came from paddy fields, 28% from thickets, bushes or grassy areas amid forest, and 13% from rubber plantations. Only 11% of captive civets had been born in captivity. Milk, cooked rice, and bananas formed the regular diet with occasional supply of frogs, garden lizards, rats, chicken, beef, papaya, and pineapple. Stomach content analyses of dead civets collected from the wild revealed the presence of rat, babbler, frog, cricket, centipede, millipede, crushed beetle, shells, seeds, berries, fruits and grass leaves. Most civets were kept in individual wooden cages. A reed pole about 65–75 cm long was fixed vertically in the centre of the cage to facilitate scent marking by perineal gland rubbing. The marked secretion from the pole was scraped out by a piece of coconut leaf. The secretory output was of 2–6 g/animal/month. Local people use the secretion for its anti-asthmatic, anti-inflammatory and aphrodisiac properties. As per the information gathered from civet owners, 22% of the captive civets live only for few months and 70% live for 4–8 years. To substitute for deaths, fresh civets are trapped, which exerts pressure on wild populations. To reduce such pressure on natural populations, a captive breeding programme for civets, under control of government, is suggested.

Keywords: Ayurveda pharmaceuticals, captive breeding programme, diet, farming, perineal gland secretion

Introduction

The Small Indian Civet *Viverricula indica* (É. Geoffroy Saint-Hilaire, 1803) is a tawny-grey or greyish-brown viverrid, distributed in both forest and scrub/grass hill regions, where there is sufficient long grass or thickets to provide daytime refuge. Its fur coat is lined or streaked, especially on the rear dorsum. Crossbars are found on the sides of the neck. The belly, back and flank regions have spots arranged in rows (Prater 1980). Secretive habits, timid nature and stressful physiological and behavioural characters of civets are often cited as reasons for the dearth of scientific information on civets (Wemmer & Watling 1986). For example, the

Fig. 1. A pair of captive Small Indian Civets in a typical wooden cage. Note the colour difference of the lower part of the reed pole fixed in the centre of the cage, denoting the sites of scent markings. The civet on the right hand side is in a typical scent marking posture with protruded perineal gland pouch.

Sulawesi Palm Civet *Macrogalidia musschenbroekii* was not reported for several years but field investigations revealed it to be rather more widely distributed than had been known from historical records (Schreiber *et al*. 1989).

Several species of mammals possess complex glandular organs exclusively developed for secretion of sebum, which is effective in chemical signalling and is used by people as a fixative for odorous substances (Eisenberg & Klieman 1972, Adams 1980, Balakrishnan & Alexander 1985). Most viverrids have such conspicuous glandular organs lying between the anus and the opening of the reproductive organs known as the perineal glands. These specialised integumentary scent glands are used primarily by the animal in olfactory signalling (Ralls 1971). In 'true civets' *Viverra* and *Viverricula* the scent glands may be seen externally as a fairly large perineal pouch with hairy swollen lips. The secretory substance of this gland, 'civet oil', is popularly known as 'civet'. Civets are extensively used for their perineal gland secretion, which is a prized item in the perfume industry (Ding *et al*. 1988). The African Civet *Civettictis civetta* is highly exploited for this purpose (Schreiber *et al*. 1989). In India, 'civet' is widely used in Ayurveda (a traditional system of Indian medicine) pharmaceutics, to prepare the traditional incense sticks and for flavouring tobacco (Nandkarni 1982, Xavier 1994). The Sri Venkateswara Temple in Tirumala maintains a colony of Small Indian Civets in Andhra Pradesh State, where the perineal gland secretion is used in religious rituals (Xavier 1994, Gupta 2004).

Under the Indian Wildlife (Protection) Act, 1972, the Small Indian Civet is listed in Schedule II (Part II), and hence it is illegal to keep them captive. Even if permission is granted by the concerned government agency, criteria for the maintenance and use of this species are to be followed. There are instances of abuse of wildlife resources as already reported in the case of Ethiopian civet farming (WSPA 2000). Such mistakes are to be corrected if this resource is to be constantly used for the welfare of the people involved in the practice. Although people have been holding civets for generations, scientifically oriented husbandry and management practices are yet to be established for sustainable use of civets as a wildlife resource (Xavier 1994, Sreedevi 2001). The present investigation evaluates the farming practices of civets in Kerala, most of which were illegal, and assesses the possibility of civet farming as a legal programme for sustainable wildlife resource use, following the objectives of the Convention on Biological Diversity (UNEP 1992).

Methods

Survey of captive civets in households and in institutions

A survey was conducted during 1994–1999 in all known civet holding areas in Kerala (Xavier 1994) covering the Administrative Districts of Thrissur, Kozhikode, Malappuram and Palakkad. The Zoological Garden in Thrissur and Oushadi (an Ayurveda pharmaceutical manufacturing company under Government of Kerala) were also included in the survey. Civet keepers were interviewed and relevant information on all aspects of civet holdings including husbandry and management were gathered and recorded. Information on the number of animals available in each of the holdings, type of enclosure/cage used, maintenance of the enclosure, food items provided, quantity of the perineal gland secretion available from each animal, longevity under captivity and substitution against old, deceased and escaped animals were recorded. Information of civets in natural habitats was gathered from indigenous people around civet habitats.

Stomach content analyses

The stomach contents of the dead civets collected from natural habitats were separated and analysed for information on their natural food habits. Seeds, fruits and other vegetative matters collected from the stomach contents were preserved. Animal material in the stomach were preserved in 10% formaldehyde and later examined under a stereo microscope.

Observations

Husbandry and management of civets

Altogether, 43 civet holdings containing 86 civets were available for the survey. Among these, 16 units had only one civet each, 23 units had two civets each and two units had three civets each. There were two units with nine civets each. Only these latter two units were having permission to maintain civets, as issued by the Wildlife Wing of the Kerala Forest Department.

As revealed by the owners of the holdings, 62% of the civets were procured from the wild as young ones (below one month of age, at time of procurement). Fifty-nine percent were collected from paddy fields, 28% from thickets, bushes or grassy areas in forests, and 13% from rubber plantations. Among the civets under captivity, 9.5% were rescued after they accidentally fell into wells and 17.5% were procured from traps set for other animals. Only 11% of the captive civets were born in captivity. Among the captive civets, males formed 55% and females 45%. Among civets procured from the wild as kittens, 54% were females, but among those procured from traps, 82% were males. Sixty-seven percent of civets rescued from wells were also males. Among the civets born under captivity, 57% were males.

To trap civets, a double-compartment mongoose trap was commonly used in Kerala. Civet kittens were also trapped in rat traps. In the closed compartment, various baits such as meat, plantain, frog *Rana* or garden lizard *Calotes* were used. The procured civets were kept in individual cages. Group housing was rare. Milk, cooked rice, and banana formed the regular diet of the captive civets in Kerala. Further, frog, garden lizard, rat, chicken meat, papaya and pineapple were supplied when available. Most cages were of double compartments of average size 120 × 60 × 45 cm, made of teak, jack or areca wood. When the cage was to be cleaned, the animal was shifted to the other compartment. Eighty percent of civets in captivity defecated in one of the corners of the cage, in effect making a 'civetry'. So as to keep the cage clean, 75% of the civet owners removed faeces from the cage every day and 30% of them used water to clean the cage and also spray over the animal once per week. Around 20% of the civet owners cleaned the cage only 4–5 times a year. Among the civets under observation, 22% lived only for a few months, 70% lived for 4–8 years and 6% escaped from cages.

A reed pole (occasionally a pole of teakwood) about 65–75 cm long was fixed vertically in the centre of the cage (Fig. 1) to facilitate scent marking by perineal glandular rubbing of the civet. As they repeatedly use the same area for their scent marking, it was easy to scrape out the glandular secretion from the reed pole using a scalpel or a piece of coconut leaf. Civet owners revealed that the secretory output of the perineal glands would cease after 7–8 years. When old animals were no longer productive, they were either set free or killed and eaten.

The perineal gland secretion of civets

Secretory activity of the perineal glands of civets began when they were 3–6 months of age. However, at this age the output was low and it was not sufficient to be scraped from the sites where they scent-marked through perineal gland rubbing. They were observed to scent mark regularly when they were around eight months of age. Each individual secreted 2–6 g/month. Among civet holders, 70% believed that food items like garden lizard, goat meat, beef and a special variety of plantain popularly known as 'poovan pazham' would enhance the output of the perineal gland secretion. Some farmers remarked that they could augment the glandular secretory output by providing these food items as well as by spraying water inside the cage and over the animal. The glandular secretion found adhered on the reed poles after scent marking was scraped out daily or at least twice per week. During the hot months of the year, if the secretions were not collected in the morning, they would melt and flow down on to the floor of the cage, whence the farmers had to discard it. The butter-like perineal glandular secretion of the civet turns brownish when exposed to air and light. Civet owners mix the glandular secretion with white vaseline, butter, finely ground 'poovan pazham' and even the faeces of civets to increase the quantity while selling. Selling collected secretion was easy, as there was high demand in Ayurveda pharmaceutics. All Ayurveda physicians whom we contacted stated that they were not getting sufficient quantity of 'civet' for their use in the preparations of Ayurveda medicines as per the proportions prescribed in literature.

Experienced civet owners have the opinion that certain physical characters such as pointed snout, coppery tinges on hairs, more than nine rings on the tail, odd tail-ring number and black tail tip are characteristics of civets with better quality and quantity of the glandular secretion.

The Small Indian Civet in the culture of indigenous people and their traditional medicine

The indigenous people interviewed revealed that the Small Indian Civet is a familiar wild animal around their settlements in forest areas and amid bush-dominated areas. They considered civet meat to be tasty, nutritious and medicinal. They were also of the view that eating civet meat would help to regain a person's lost vigour and vitality. They hunt civets with their traditional bow-and-arrow. They also use trained dogs to locate civets taking shelter in holes and under bushes during daytime. When they detect civets in holes, they smoke the entrance to force the civet out, when it is caught or killed.

All indigenous people interviewed were familiar with the perineal gland secretion of the civets, popularly known among them as 'Merukin puzhu' (in Malayalam, the vernacular in Kerala) and 'Merukin puzhuku' (in Tamil, the vernacular in the neighbouring state of Tamil Nadu). By using a knife, the entire glandular area of the civet was removed, which was then dried under sunlight or with smoke. The secretion was squeezed from the glands and preserved for future use. They also make cigars using perineal gland secretion of civets. The gland was cut into small pieces and along with ganja (a narcotic) rolled in tobacco leaves and inhaled as smoke. 'Merukin puzhu' is an ingredient in many traditional medicines of indigenous people, particularly as a cure against respiratory ailments. This glandular secretion is also used as a cure against pimples and discoloration of the face. They also apply this secretion over the body of couples on the day of wedding. They believe that it would act as a sexual stimulant and accelerate chances of pregnancy.

The dried or smoked perineal glands of civets used to be one of the major items among the annual offerings of the indigenous community to the then Maharaja (emperor), to please his highness. This was used to smoke the palace with other incense. Members of the royal family also used the civet gland secretion during traditional smoking.

Food of civets in natural habitats

Seven civets were collected dead from natural habitats (Table 1). Stomach content analyses revealed that they eat a variety of animal and plant parts. The undigested and identifiable contents included rat *Rattus*, babbler *Turdoides*, frog, scorpion, shells of small crab (sub-class: Brachyura), cricket (Gryllidae), centipedes *Scolopendra*, millipedes *Spirostreptus*, crushed beetles, seeds and sweet berries of *Zizyphus oenoplia* and of *Aporusa lindleyana*, crushed pulp of pineapple fruit and grass leaves.

Out of the seven, two stomachs were almost empty. In the case of rats, babbler and frog, only the head region was chewed; other body parts were merely crushed. Feathers were seen intact in the stomach of the civets. In one sample, four young *Rattus* were observed. Stomachs of specimens collected from near human habitations contained boiled rice and fish bones.

Discussion

The captive civet population surveyed in Kerala was male- biased. This may be because males are greater wanderers than females, and as a result are more prone to be trapped or to meet with ac-

Table 1. Identifiable stomach contents of the Small Indian Civets observed as dead in natural habitats.

Place of collection	Sex	Weight, kg	Stomach contents observed
Nilambur	Male	3.0	One small *Rattus*, one cricket (Gryllidae)
Vadakkancherry	Male	2.5	Two crickets, one beetle, grass pieces
Kodassery	Female	3.5	Three centipedes *Scolopendra*, two crickets, fruits of *Ziziphus oenoplia*
Poyya	Male	3.5	One scorpion *Palamnaeus*, two beetles, one cricket
Konnakuzhy	Female*	3.8	Four newly born *Rattus*, two crickets, grass pieces
Kodasserry	Female**	4.0	One small babbler *Turdoides*, fruits of *Z. oenoplia* and *Aporusa lindleyana*
Vellikulangara	Female**	3.5	Legs and shell of small crab (Brachyura), one frog, two millipedes *Spirostreptus*, grass pieces

**Pregnant – two foetuses

cidents. Among Small Indian Civets trapped during the present observations, 82% were males (against 57% males among captive-born animals), and among the civets rescued from wells, 67% were males. Most civet owners had only 1–2 civets during the period of the survey. They were not fully dependent on civets for their livelihood. Only two civet holdings had many animals. These two holders were collecting the 'civet' exclusively for their own use in the preparations of Ayurveda medicines.

Information gathered from civet owners show that their civets came from a variety of habitats such as paddy fields, thickets, bushes, grasslands, rubber plantations and forests. The civets also wander into human settlements, as revealed by the fact that some of them were rescued from wells in such areas. Most captive civets were wild-caught, only a few being born in captivity. Even these latter did not represent successful captive breeding; rather they were born to mothers who were in their late pregnancy when trapped from the wild. Civet owners either let free those civets which ceased to be productive or kill and eat them after 7–8 years of successful maintenance and extraction of the perineal gland secretion. There being no captive breeding of these civets, owners trap new ones from the wild to compensate for the old and diseased ones. This may be placing pressure on wild populations of Small Indian Civet.

In captivity, civets are maintained on a fairly standard diet of cooked rice, milk, egg, banana and meat. However, these foods differ from those of wild civets, which eat a number of species of animals, including vertebrates such as small birds, reptiles and amphibians, and invertebrates such as molluscs, crabs, insects, scorpions, centipedes and millipedes, in addition to a variety of plant parts in the natural diet of civets as revealed during the present investigation. In addition to animal parts in stomach contents, parts of fruits, berries, seeds and leaves demonstrate that these civets are somewhat omnivorous in natural conditions. As they can live on a variety of food items, their distribution is also widespread, not being limited to natural habitats, but also extending to areas of rocky and tree hideouts, bush and grassy habitats around human dwellings. Civets consume grass pieces and excrete them as a wad entangled with mucus, which may act as a scouring or antiparasitic agent, as is known in canids and felids (Macdonald 1992).

Most civet owners insisted to clean the cage so as to maintain hygiene. They also spray water over the animal, which may help reduce heat stress. It appears that when temperature in the cage is low, the 'civet' output is high. The 'civet' output was also enhanced by supply of natural foods such as lizard and 'poovan pazham'. During nights, civets from forest areas also visit nearby human settlements in search of food, especially fruits and berries available in plenty in orchards (Sreedevi, 2001). It is during this extended foraging activity that they accidentally fall in wells. A number of them trapped from paddy fields support the view that they also search for rodents, the population of which is high in paddy fields during the pre-harvest season.

The present study shows that civets are intimately connected with the culture of local human communities, and are used for the medicinal properties of meat and the perineal gland secretion. The indigenous people are familiar with the anti-asthmatic, anti-inflammatory and aphrodisiac properties of the perineal gland secretion of the Small Indian Civet.

The interest of civet owners is to collect maximum amount of 'civet' from each animal in captivity. As civets may not yield the glandular secretion during pregnancy and lactation, civet owners are not interested in breeding their captive civets. As civets are known for their scent marking patterns of rubbing the perineal glandular area on environmental sign posts (Xavier 1994), civet owners collect the glandular secretion from such sign posts (reed poles fixed in the cage). As they are not disturbing the animal in any way, this is a feasible method to collect the glandular secretion without further harming the captive animals. Were they to press the glandular area and squeeze out the secretion, as is being practised with Ethiopian civets, the glandular output might be increased but such activities are inhumane (WSPA 2000). In this respect, the civet owners in Kerala are, on average, better in their treatment of captive civets when compared with some holders elsewhere.

When natural food items of civets are provided to captive animals, the glandular output is expected to improve, as is the health of the animal, which could facilitate breeding conditions. If this could be achieved, the captive-born civets would replace trapped wild civets, so as to reduce off-take of natural populations. Hence a captive-breeding programme for civets is highly recommended (Balakrishnan 2002). Because most of the 'civet' used in the perfume industry comes from Ethiopia, it could be even more beneficial, in conservation terms, to establish a captive-breeding programme for Ethiopian civets.

Studies on mammalian scent marking patterns have revealed that specialised skin glands are present in many mammals (Mykytowycz 1970, Müller-Schwarze 1977, Adams 1980) and are extensively used for chemical signalling (Ralls 1971, Eisenberg & Kleiman 1971, Johnson 1973, Balakrishnan 1987). Such glandular areas are rubbed against environmental sign posts during various social interactions and during routine foraging and other behavioural activities, thereby transferring the glandular secretion with specific communication signals to the marked sites (Mykytowycz 1970, Eisenberg & Kleiman 1971, Ralls 1971). Because civets transfer their perineal gland secretions during scent marking (Sreedevi 2001) onto environmental sign posts in their natural habitats, it should be possible to collect 'civet' from such marked sites. If so, this valuable natural resource could be gathered from civet habitats, without disturbing the animals. The natural 'civet' may be more concentrated than that of captive civets, because the natural populations would be healthier with their natural food rather than the restricted diet provided in captivity. Following appropriate feasibility studies, the concerned government agencies could take appropriate actions under a participatory wildlife management programme involving local people to change from their keeping civets in captivity and instead train the owners to collect 'civet' from scent-marked sites in natural habitats. The intensity of stress on natural populations of civets might presumably be reduced by collecting 'civet' from natural scent marking sites at specific intervals. If so, their reproductive potentiality in natural habitats could be maintained and sustainable extraction of 'civet' would be possible.

WSPA (2000) urged consumers not to buy products containing natural civet musk taking into account the deplorable conditions of civets in Ethiopian civet farms. However, before recommending such drastic measures, the international agency should have suggested alternative means by which this excellent and renewable (if managed on a scientific basis) resource can support rural livelihoods. Whatever restrictions would be imposed, such a resource, used from time immemorial, would certainly continue to be used by local people. Incorporation of local people and their traditional practices in wildlife management and conservation were found to have positive effects in Africa (Bell 1987) and elsewhere (Mishra 1982); the harvest of 'civet' from wild animals could turn out similarly in southern India. There are already many restrictions on the use of biological resources in developing tropical nations, and it is important to avoid further constraints if they are not necessary. Each situation needs review on a case-by-case basis, to determine if the resources can be used sustainably for human welfare, if there will be effective steps to conserve the rich natural heritage of these nations and if the objectives of the Convention on Biological Diversity (UNEP 1992) are to be achieved.

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Modelling the incidence of fragmentation at different scales in the European Mink *Mustela lutreola* population and the expansion of the American Mink *Mustela vison* in Biscay

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Abstract

Fragmentation of populations is a major threat to modern wildlife that may act at different scales. We used a Geographic Information System to create a matrix based on landscape features relevant to European Mink *Mustela lutreola* and modelled breeding and dispersal of minks across it. We also simulated expansion of American Mink *M. vison* populations. Simulations suggested incidence of fragmentation at different scales due to habitat degradation and perturbation by the American Mink. Intensification of urbanisation and river canalisation, and expansion of American Mink populations are a threat to the persistence of European Mink populations in eastern Biscay.

Keywords: canalisation, dispersal, interspecific interaction, riparian vegetation, roads, urbanisation

Resumen

La fragmentación de las poblaciones es un problema que se presenta a diferentes escalas y constituye una de las principales amenazas para la fauna silvestre en la actualidad. Por medio de un Sistema de Información Geográfica creamos una matriz basada en formaciones vegetales y artificiales de importancia para el visón europeo *Mustela lutreola* y simulamos los movimientos de reproducción y dispersión del visón europeo sobre ella. Del mismo modo, realizamos una simulación de la posible expansión de poblaciones de visón americano *Mustela vison* conocidas en la región. Los resultados de las simulaciones sugieren la existencia de fragmentación a diferentes escalas, como consecuencia de la degradación del hábitat y la presencia del visón americano. La intensa tendencia a la urbanización del territorio y a la canalización de ríos y arroyos, así como la expansión del visón americano suponen actualmente una seria amenaza para la supervivencia de las poblaciones de visón europeo del este de Vizcaya.

Introduction

The European Mink *Mustela lutreola* is a riparian mustelid native to the continent of Europe. Its distribution experienced a severe regression during the second half of the 20th century and the species disappeared from most countries (Youngman 1982, Maran & Henttonen 1995). As a result of this decline, nowadays there are two major population nuclei: one in the East (Tumanov 1992, Maran & Henttonen 1995), and the other in the West. The eastern population has disappeared from some countries in the last few decades, and it continues to decline in other areas as well (Maran & Henttonen 1995, Maran *et al*. 1998). The western population seems to be fragmented into subpopulations (Lodé 2002).

These small subpopulations are more extinction-prone due to demographic stochasticity, breeding failure and other problems characteristic of small populations (Goodman 1987). Recently, Lodé (2002) studied the subdivision of European Mink populations in France and suggested that they may be reaching a critical threshold for conservation. Fragmentation has not been considered a threat to the species in the Western European area, and in the Iberian Peninsula the population has been assumed to form a main unit along the axis of the Ebro River with some unconnected streams of the north of the Basque area also holding European Mink (Palazon *et al*. 2002). Streams in the north of the Basque area are short and fast flowing, running into the Bay of Biscay, and drain only small catchments separated by rugged terrain. Therefore, the local landscape itself could be a functional barrier to the movement and dispersal of European Mink and other river dwelling species's populations. Understanding of the structure of landscape and its effects on animal dispersal are needed to achieve conservation goals (Fahrig & Merriam 1994).

Geographically explicit models, those considering geographic data for calculations, have provided a good tool for wildlife and landscape management. In this paper we modelled European Mink movements and dispersal in a complex landscape matrix, as a tool to help in detecting both the problematic areas for the species and the main ways for communication between different subpopulations. In addition, we used the same matrix to model expansion areas of American Mink and to detect places of likely high pressure from them for European Mink populations.

Methods

Study area

The model was created using Biscay (North Iberian Peninsula; c.o. 43ºN, 3ºW) as the study area. Biscay has an area of 2,236 km² and a human population of about 1,200,000. Landscape is hilly and rugged, and altitude ranges from 0 to 1,475 m a.s.l. Climate is oceanic, with annual rainfall ranging between 1,200 and 2,200 mm, and annual average temperatures varying from 13.8 ºC to 12 ºC (January is the coldest month with 6 ºC and July the warmest with 18 ºC.). In the region there are several catchments whose streams are short, small and fast flowing, running into the Bay of Biscay (Fig. 1). Data of European Mink and American Mink distribution in Biscay were taken from the recent survey of Zabala (2006). In addition, in order to detect possible breeding linkage through adjacent populations we included the nearest populations of European Mink as reported by Palazón *et al*. (2002).

Fragmentation scales

Fragmentation of populations can act at multiple scales, from disturbed breeding systems due to small or temporal barriers, to seg-

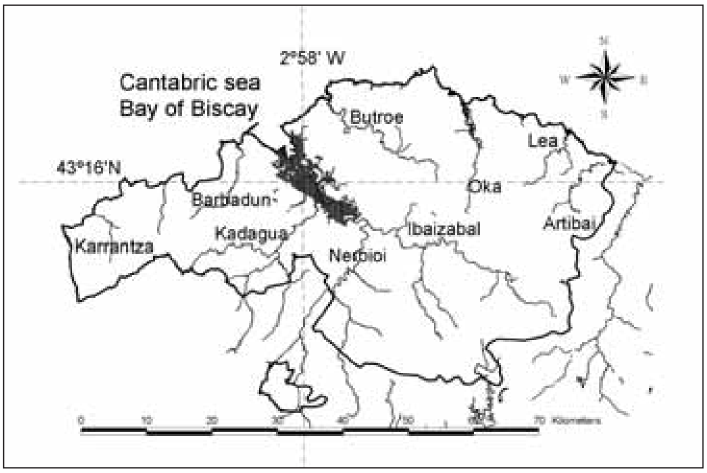

Fig. 1. Biscay and major rivers in the study area. Dark shading represents Bilbao city and major periurban area.

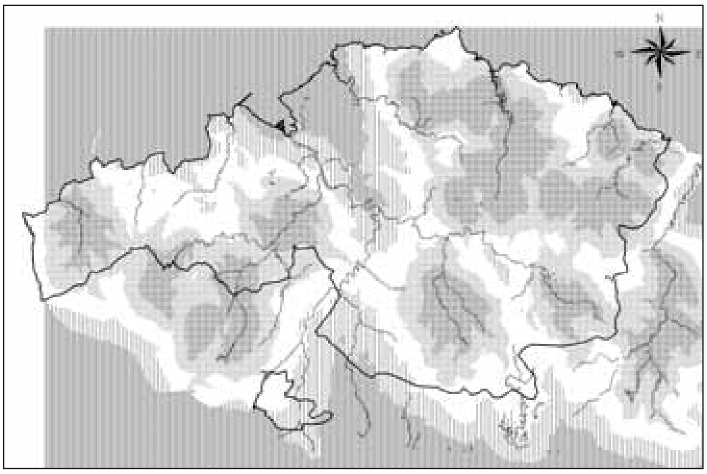

Fig. 2. Breeding units of European Mink. Spotted areas are supposed to be connected, after the Breeding dispersal model. Dense spotting indicates fully connected areas and lighter spotting indicates areas connected by breeding dispersal. White represents areas unlikely to be visited by territorial breeders while vertical-striped ones are major barriers, the darker striping indicating the most unlikely areas to be visited by breeders.

regation of the original population into several subunits linked by short or long distance dispersals, or even into completely isolated subunits (Lord & Norton 1990). Therefore, in the case of the European Mink, we performed different approaches at two different scales:

On the one hand, breeding ecology of European Mink revealed polygynous subunits, with dominant males holding territories that encompassed those of several females (Garin *et al*. 2002a). During the mating period, males exhibited the highest degree of activity and movement as a way for both seeking receptive females and then monopolising females within their territory (Lodé 2001, Garin *et al*. 2002b, Lodé *et al*. 2003). Besides, based on results from related species (Lodé 2001, Lodé *et al*. 2003), we assumed the existence of short breeding dispersal movements of territorial males, specially subdominants or poor quality territory holders, that may link otherwise unconnected breeding units (Lodé 2001). For the calculation of the distance at which breeding dispersal may act, we used home ranges of European Mink from the study area as standard breeding dispersal distances (resident minks are known to stay within their home ranges during the rutting season).

On the other hand, we considered the possibility of metapopulation linkage by short–medium distance dispersive individuals. European Mink populations are assumed to be composed by territorial individuals and by floating ones without a territory (Zuberogoitia & Zabala 2003). The latter may disperse colonising new areas and connecting otherwise isolated populations (Dunstone 1993).

In the case of the American Mink we conducted a single simulation, modelling its expansion along the matrix from currently occupied areas.

Building the matrix

For studying the incidence of fragmentation on the population we used a Geographic Information System (GIS) to build a landscape matrix by digitising 2,230 km of rivers and streams. We mapped rivers and streams with European Mink presence, and after results of Zabala *et al*. (in press), who found that minks were absent from aggressively canalised streams, we assumed such streams to have a negative effect on the dispersal behaviour, and mapped the long canalisations. Out of rivers, all structures were considered equal. Highways, main roads, urban areas and areas with permanent American Mink presence were considered potentially dangerous areas, and cliffs and sheer rocky outcrops were considered as barriers for dispersal (Sidorovich *et al*. 1999, Grogan *et al*. 2001, Macdonald *et al*. 2002, Rondinini & Doncaster 2002). We created 20-metre buffers along linear structures (rivers and roads) in order to keep their representation, and then converted the landscape matrix into a raster layer with 10 × 10 m cells covering the whole Biscay and adjacent areas. Then we reassigned different cost values for each cell depending on their structure (Table 1). Cost values represent the distance that the animal must travel and the risk involved in travelling across the cell. For instance in a cell representing river the cost is 1, representing only the distance, but in a cell crossing a highway the cost is 6, representing the avoidance of such structures and the high chance of being killed in crossing them. Values are different in the two analyses we conducted, because dispersing animals need to cross just once while territorial animals need to cross, and face the risk involved, repeatedly.

The cost involved in crossing each type of cell ranged between 1 and 12 (*ad hoc* established limits) and was settled after the following criteria:

- Both mink species are river-dwelling so, displacements along streams had the lowest cost.
- American Mink may interact aggressively with European Mink driving it out of its way (Sidorovich *et al*. 1999, Macdonald *et al*. 2002). In consequence, we assumed a medium cost for a dispersing individual (probability of encountering an American Mink and being attacked) and highest cost for a territory holder (sharing the same areas continuously supposes many encounters with the other species).
- Aggressive canalisation of streams poses a problem for both mink species because they must cross long areas without protection of vegetal overstorey or underground dens. During a dispersive movement, such areas need to be crossed once so we settled a medium–low cost, while for territory holders crossing these areas many times involves several risks so we assumed a maximum cost for these movements.
- Stream crossing points under highways and roads are usually canalised or made with pipes, structures that may dispel minks

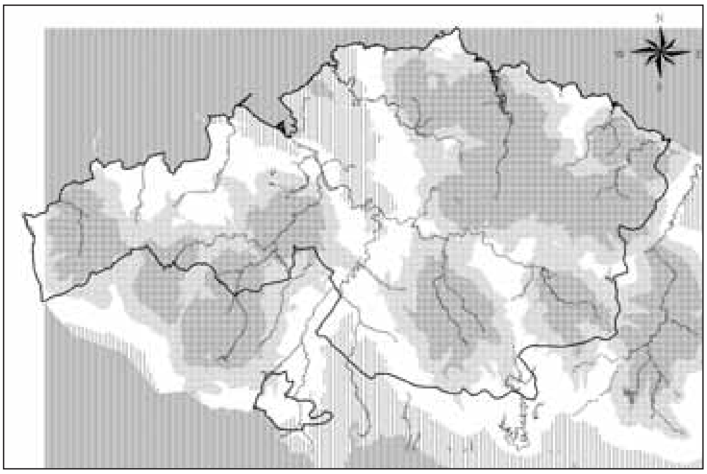

Fig. 3. Short–medium dispersal linkage of European Mink. Spotted areas are those easily reached by dispersing minks, with dense spotting indicating the most easily reachable areas and lighter spotting those less so. White represents areas that require medium distance dispersal movements, while vertical-striped ones are major barriers. Light striping indicates areas that only very far distance dispersing animals could reach, and dark striped areas are assumed to be unreachable by minks.

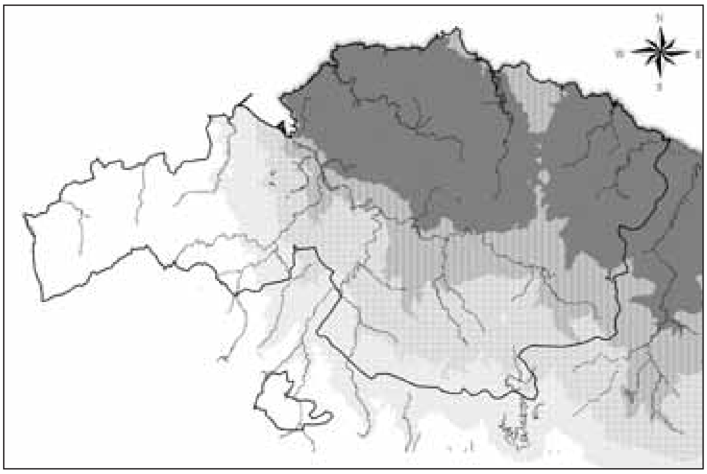

Fig. 4. Modelled expansion of American Mink. The darkest shading shows the areas already occupied. Progressively sparser spotting shows areas progressively less likely to be occupied in a short period of time while white areas are unlikely to be occupied in the short/mid term (more that 10 dispersive movements or generations).

out of streams and force them to move across the road instead of along the canalised bank.

- Territorial minks rarely venture out of the riverbank. In addition, water and thickets and rank riverbank vegetation are the main refuges minks use. Therefore moving across land has been considered to have an accumulative cost.
- Land movements have been considered to have a higher cost if minks must move across roads, urban areas and similar structures.

Over the resulting grid we mapped areas where European Mink is present (from Zabala 2006) and we calculated movement costs considering them as movement origin/destination. For the American Mink simulation, we mapped areas with presence of American Mink populations (from Zabala 2006) and calculated the cost of movements considering known American Mink populations as the origin of dispersing individuals.

Results and Discussion

Breeding movements and breeding dispersal

Results for the breeding simulation are shown in Figure 2, where there are four problematic areas that cause fragmentation of the population into several units of different sizes. In addition many of the subunits are only marginally linked . One of the problematic areas is the Butroe catchment (Fig. 1) that holds a dense American Mink population. Another one is the Lea-Artibai area (Fig. 1) where both mink species are present, but European Mink is relegated to small tributaries of the central upper parts of the catchments. A third one is composed of the central and lower Ibaizabal and Nerbioi catchments (Fig. 1), in which American Mink presence has been sporadically detected and European Mink is absent from big areas. Moreover, those catchments have dense infrastructure along the main river axis and several canalised stretches. The

Table 1. Value (cost of crossing) for European Mink of each cell type in the landscape matrix for breeding and dispersal movements. For American Mink, River and River with European or American Mink had the same value (1).

	Value (Cost)	
Cell type	**Dispersal**	**Breeding**
River	1	1
River with European Mink	1	1
River with American Mink	6	12
Canalised river	4	12
River under highway/Major road	6	10
Canalised river under Highway/Major road	7	12
Land	5	8
Land in areas with European Mink	4	8
Land in areas with American Mink	6	9
Urban	10	12
Highways / Major roads	12	12
Cliffs, Sheer rocky outcrops	10	10
Land	5	8

fourth problematic area is the Barbadun catchment (Fig. 1) in the northern part of western Biscay; there the lack of linkage is due to absence of European Mink from the apparently suitable area.

Short–medium distance dispersal

Results for the short–medium distance dispersal simulation are shown in Figure 3. In this case, Biscay appears to harbour two main populations separated by urban area of Bilbao, the Butroe catchment and the canalised and industrial area of the Nerbioi. The population in the west forms a continuum with an empty area in its north, in the Barbadun catchment.

The eastern population seems well connected in the north, but disruption caused by American Mink presence in the medium–low parts of Lea and Artibai catchments is apparent. Southern areas of the eastern population, in turn, may be fragmented internally, and only marginally linked to the northern area.

Expansion areas of American Mink

The results of the model for American Mink expansion areas are shown in Figure 4. American Mink expansion areas encompass most of the current European Mink presence areas. The only European Mink areas that in the short-term seem to be safe from American Mink expansion are the catchments from western Biscay.

Conclusions

Although geographically explicit models are fallible and heavily reliant on values given to cells, they can be useful as indicators of the most likely scenarios for the short term, and as tools for predicting management hot-spots. In our case, assuming the dispersal values are even broadly reflecting reality, the first two models show that fragmentation in the population of Biscay at different levels is in every case due to two main factors: (1) large urban and periurban areas with canalised streams and degraded riverbanks, and (2) growing American Mink populations. Coastal populations seem most vulnerable because they are in areas of highest American Mink densities and prone to American Mink colonisation (Fig. 4) and currently their gene and individual flow with mainland populations relies upon marginal populations in the upper Ibaizabal and its tributaries. The quality, not simply the existence, of the dispersal routes is of great importance and affects the likelihood that animals use them and that they survive dispersal (Fahrig & Merriam 1994). Indeed, patches connected by dispersal routes of bad quality may act as sinks (Fahrig & Merriam 1994). In the Ibaizabal area, there are a highway, a major road, a railway and many urban areas between the coastal population and the small populations in the south. Besides, unoccupied rivers and streams along dispersal routes are of low quality for European Mink (Zabala 2006, Zabala *et al*. in press) and might also act as a sink by leading minks to establish in poor quality but unoccupied areas. In addition, the area is highly menaced by American Mink expansion and further habitat degradation. Planned canalisation of most main streams and lack of control policies of American Mink are very likely to worsen the situation in the short run. In sum, this means that the best situation for European Mink in Biscay seems to be in the western catchments, where urbanisation is less extensive and local European Mink populations are connected with those from Araba and Burgos, and, at least for now, free of American Mink. The future of the European Mink is uncertain without both habitat conservation and restoration policies, and American Mink eradication.

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Responses of small carnivores to rainforest fragmentation in the southern Western Ghats, India

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Abstract

Small carnivore abundance from track plot, camera-trap, and spot-lighting surveys were compared between a contiguous tract of tropical rainforest and 10 rainforest fragments in the southern Western Ghats, India. Although six species were recorded from the rainforests in this region, surveys targeted three nocturnal species. Small carnivore abundance was higher in contiguous rainforests, especially the endemic Brown Palm Civet *Paradoxurus jerdoni*, whose occurrence was positively influenced by food-tree densities and altitude, and was higher in medium-sized (51–100 ha) fragments adjoining shade-coffee plantations than the more isolated smaller and larger fragments. The omnivorous and widespread Small Indian Civet *Viverricula indica* and mongooses *Herpestes* spp. were more frequent in rainforest fragments than in the relatively undisturbed, large, contiguous tract of rainforest in Kalakad–Mundanthurai Tiger Reserve. Thus, small carnivores persist in fragmented landscapes with altered community structure, but long-term persistence may require protection of private fragments, fostering benign land-uses, and restoration of degraded areas.

Keywords: Anamalai hills, Kalakad–Mundanthurai Tiger Reserve, *Paradoxurus jerdoni*, plantations, *Viverricula indica*

Resumen

Se comparó la abundancia de pequeños carnívoros en una zona de pluvisilva tropical continua (no fragmentada) y 10 fragmentos de pluvisilva en los Ghats sudoccidentales, India, mediante rastreo de huellas, trampeo fotográfico y foqueos. Aunque se detectaron seis especies en la región, los muestreos estuvieron orientados a tres especies nocturnas. La abundancia de pequeños carnívoros fue mayor en la pluvisilva continua que en los fragmentos, especialmente la de la endémica civeta de Jerdon *Paradoxurus jerdoni*, cuya presencia estuvo positivamente influenciada por la densidad de árboles de los que se alimenta y la altitud. El indice de detección de esta especie fue más alto en fragmentos de tamaño medio (51–100 ha) adyacentes a plantaciones cafe de sombra que en los fragmentos más aislados bien fuesen de mayor o menor tamaño. La pequeña civeta indú *Viverricula indica* y las mangostas *Herpestes* spp. omnívoras y de amplia distribución, fueron más frecuentemente detectadas en los fragmentos de pluvisilva que en la zona de pluvisilva continua de la Reserva de Tigres Kalakad–Mundanthurai. Por tanto, los pequeños carnívoros subsisten en paisajes fragmentados en los que la estructura de la comunidad ha sido alterada, pero su supervivencia a largo plazo puede precisar la protección de fragmentos privados, el fomento de usos de suelo benignos, y la resturación de áreas degradadas.

Introduction

Habitat loss and fragmentation are the primary threats to tropical rainforest habitats and species. Studies on tropical rainforest fragmentation have shown that area of available habitat influences changes in plant and animal occurrences and densities, with larger areas usually containing a greater number of species (Laurance *et al*. 1997, Umapathy & Kumar 2000). However, small, isolated forest fragments are also repositories of tropical biodiversity (Turner & Corlett 1996). Species that are particularly negatively impacted by habitat fragmentation are those with specialised habitat requirements or large home-ranges (Laurance 1990, Chiarello 1999). Conversely, many species of frugivorous and folivorous birds and mammals may increase in abundance due to increase in some food resources associated with the openness of the habitat following disturbances (Leighton & Leighton 1983, Johns 1988, Struhsaker 1997). Moderate habitat disturbance often has a positive effect on small carnivorous mammals such as mongooses and civets, a majority of which are habit generalist (Oehler & Litvaitis 1996, Ray & Sunquist 2001).

Since many small carnivores play significant roles in the habitat as predators and seed dispersers, the disturbance or alteration of the small carnivore community due to fragmentation can impact ecosystem dynamics (Terborgh 1988, Dirzo & Miranda 1990, Redford 1992, Crooks & Soulé 1999). In tropical ecosystems, an understanding of the correlates of small carnivore distribution, persistence, or disappearance following habitat fragmentation is lacking. This is partly due to the intrinsic difficulties in assessing the occurrence and abundance of small carnivores that are nocturnal and cryptic, especially when the community is species-rich (Duckworth 1998). In order to effectively survey small carnivores, a combination of methods may have to be used (Zielinski & Kucera 1995, Foresman & Pearson 1998, Silveira *et al*. 2003). In south and south-east Asia, given the difficulties in survey and detection of these species, very little is known of their response to habitat alterations (Heydon & Bulloh 1996, Colón 2002).

The Western Ghats mountain range in India is a global biodiversity hotspot with a high diversity of plant and animal taxa, including small carnivores (Kumar *et al*. 2004, Mudappa in press). The Western Ghats, with an estimated four-fold increase in the number of forest fragments and an 83% reduction in the size of surviving patches between 1920 and 1990, and a very high human population density, is critically threatened by habitat degradation and fragmentation (Menon & Bawa 1997). The rainforests of the Western Ghats have six species of non-aquatic small carnivores including two endemic species (Nilgiri Marten *Martes gwatkinsi*, Brown Palm Civet *Paradoxurus jerdoni*), two endemic sub-species of species otherwise also occurring in Sri Lanka (Stripe-necked Mongoose *Herpestes vitticollis*, Brown Mongoose *H. fuscus*), and two geographically very widespread species (Small Indian Civet *Viverricula indica*, Leopard Cat *Prionailurus bengalensis*). Although a few surveys have been carried out on these species in the Western Ghats, there have been no ecological or behavioural studies on any species except the Brown Palm Civet (Ashraf *et al*. 1993, Rajamani *et al*. 2002, Mudappa 2001, Mudappa in press).

This study in the Western Ghats of India is the first in tropical Asia examining the impact of rainforest fragmentation on small carnivores. Of particular interest were the distribution patterns and occurrence of the endemic Brown Palm Civet (see photograph), an important frugivore and seed-disperser in these rainforests and one of the species with the smallest distribution range among south Asia's carnivores (Rajamani *et al*. 2002). As rainforest fragmentation in the region is a major global conservation concern, we assessed changes in the occurrence and relative abundance of small carnivores in two major and contrasting tropical rainforest landscapes in the southern Western Ghats using a combination of methods such as camera trapping, track plots, and spot-lighting. We also identified habitat and site characteristics that determined small carnivore distribution, persistence, and abundance. Based on these results, the implications for conservation of small carnivores and the value of fragments for conservation in tropical landscapes are discussed.

Methods

Study area

The Western Ghats is a 1600 km long hill range running from the southern tip of the Indian peninsula at 8°N to the River Tapti at 21°N. The region between 8° and 11°N, known as the southern Western Ghats, has two important conservation regions in the Agasthyamalai and Anamalai hills containing high diversity tropical rainforest, classified as the mid-elevation (600–1400 m) tropical wet evergreen forest of the *Cullenia exarillata–Mesua ferrea–Palaquium ellipticum* type (Pascal 1988).

The Kalakad–Mundanthurai Tiger Reserve (KMTR, 895 km², 8°25'–53'N and 77°10'–35'E) in Tamil Nadu state is situated in the Agasthyamalai hills at the southern extremity of the Western Ghats (Fig. 1). KMTR, along with adjoining sanctuaries in Kerala state, includes over 400 km² of contiguous rainforests relatively undisturbed by human activities—one of the largest such tracts in the Western Ghats (Ramesh *et al*. 1997). The average annual rainfall within the rainforest tracts ranges between 2200 and 3500 mm. Small carnivore surveys were carried out around three sites varying in altitude within KMTR (Kannikatti 750 m, Sengaltheri 1000 m, and Kakachi 1250 m) from June 1996 to August 1999 as part of an intensive ecological study of the Brown Palm Civet (Mudappa 2001).

Brown Palm Civet Paradoxurus jerdoni *photo-trapped in Sengaltheri, KMTR.*

Although climatically and biologically similar to KMTR, the rainforests of the Anamalai hills were fragmented between 1890 and 1930 due to establishment of commercial plantations. Most large fragments are within the Indira Gandhi Wildlife Sanctuary (IGWS, 987 km², 10°12'–35'N, 76°49'E–77°24'E, Fig. 1), but around 35 fragments (0.3–300 ha) are on private lands on the Valparai plateau, a 220 km² area dominated by plantations of tea, coffee, *Eucalyptus*, and cardamom (Mudappa & Raman in press). After independence (1947), many reservoirs were constructed and a network of roads established in this region, which further fragmented the landscape. However, even the relatively small fragments on private lands continue to harbour many endemic and endangered species of plants and animals and act as habitat facilitating movement of wide-ranging taxa (Muthuramkumar *et al*. 2006, Mudappa & Raman in press). The fragments within the landscape of plantations have a high conservation value, probably enhanced by their proximity to the surrounding large area of protected forests containing significant wildlife populations (Kumar *et al.* 2002, Raman 2006, Fig. 1).

Small carnivore surveys

The small carnivores in KMTR and Anamalai hills were surveyed using a combination of methods targeting nocturnal/crepuscular species as used in other studies (Zielinski and Kucera 1995, Duckworth 1998, Foresman and Pearson 1998, Silveira *et al*. 2003): a) track plots, b) camera-traps, and c) spot-lighting walks and night drives. Within KMTR, three intensive sites (Kannikatti, Kakachi, Sengaltheri; 600–1400 m asl) were surveyed. In the Anamalai hills, ten forest fragments of varying sizes (11–2600 ha) and disturbance levels (based on habitat degradation due to human activities, Muthuramkumar *et al.* 2006) within the same altitudinal range of mid-elevation tropical wet evergreen forest were sampled between January and May 2000 (Table 1). Survey stations within each site were located by walking a random number of paces in different directions to locate the first station along animal trails or streams through forest with subsequent stations placed at intervals of no less than 250 m.

Track plots were laid by clearing the leaf litter from the forest floor in an area of about 1 m × 0.75 m. Fine sieved soil was sprinkled over this plot, and a combination of baits (banana, dry fish/meat scraps) was placed on it. In KMTR, track plots were set for two successive nights at each station and checked in the mornings. Data from both nights were used as there was no significant difference in small carnivore visitation rate between the first and second night ($\chi^2 = 0.96$, *d.f.* = 1, $P > 0.25$) suggesting that baiting on the first night did not increase visitation rate on the second night. In KMTR, track plots were laid only in Sengaltheri at altitudes comparable to the sites in the Anamalai hills (600 to 1,400 m). In the Anamalai hills, for logistical reasons, track plots were run for only one night in each station and checked the following morning. The number of track plots laid was greater in larger fragments in order to distribute survey effort over a larger area in these fragments (Table 1). The tracks on the plots were distinguished as those of 1) Brown Palm Civet, if they were plantigrade prints with five digits clearly visible, or 2) other small carnivore (Small Indian Civet, Brown Mongoose, or others) based on the size and shape of the prints and if they had four digits and occasionally claw marks. This track identification protocol was unambiguous and based

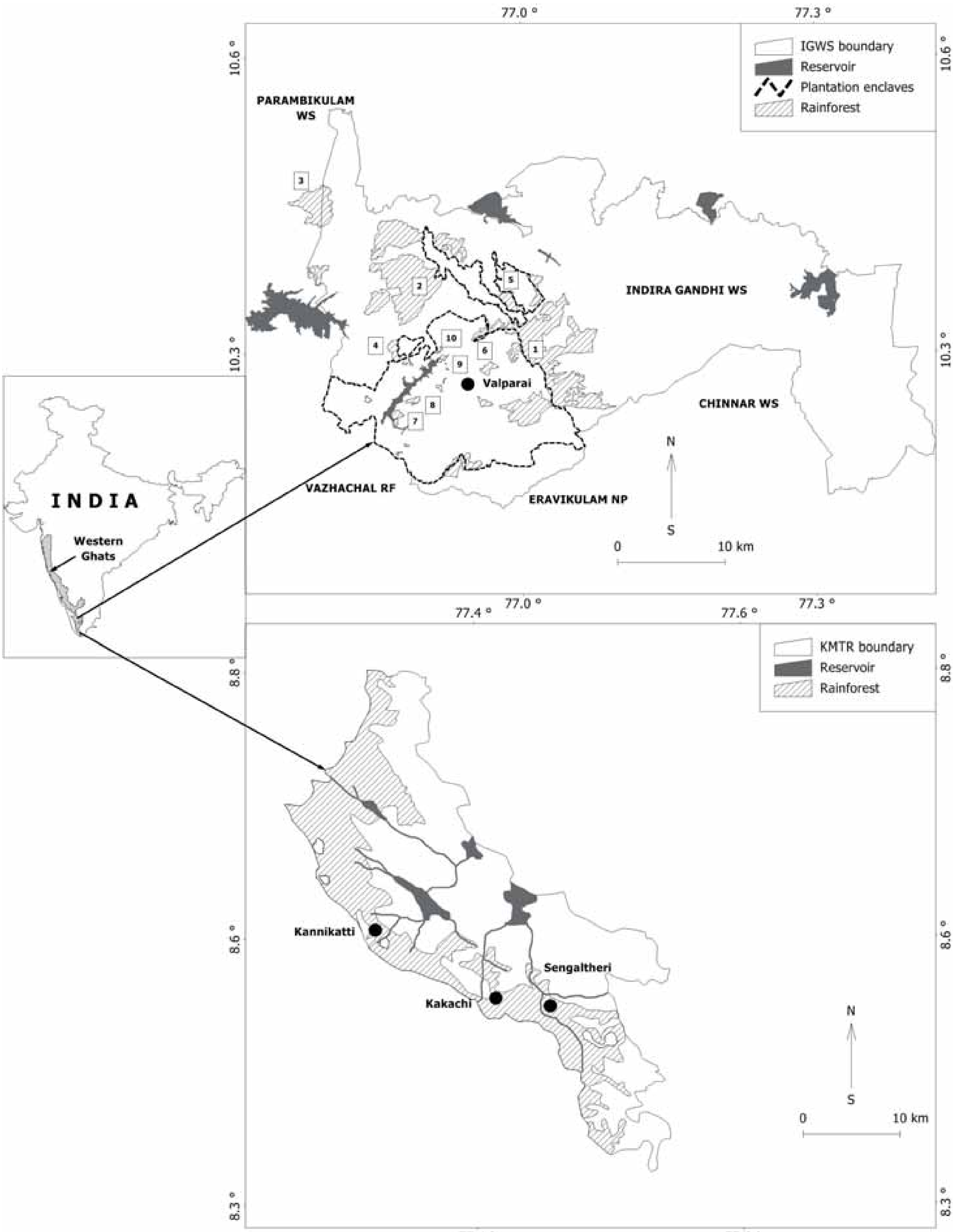

Fig. 1. Kalakad–Mundanthurai Tiger Reserve (bottom) showing the three study sites and distribution of contiguous rainforest and Indira Gandhi Wildlife Sanctuary in the Anamalai hills (top) showing the enclave of private plantations and rainforest fragments. The numbers correspond to the study fragments listed in Table 1.

Table 1. List of sites sampled in Kalakad–Mundanthurai Tiger Reserve (KMTR) and in the Anamalai hills, their attributes, and sampling effort in each (size class in parentheses: C – contiguous rainforest, VL – very large, L – large, M – medium, and S – small).

No.	Site	Area (ha)	Altitude (m)	Matrix*	Disturbance level	Camera-trap nights	Track plot nights
Kalakad–Mundanthurai Tiger Reserve							
1	Kakachi	(C)	1250	WEF, T	Low	19	-
2	Sengaltheri	(C)	1000	WEF, DD	Low	59	177
3	Kannikatti	(C)	750	WEF	Low	34	-
Anamalai Hills							
1	Akkamalai	2600 (VL)	1250-1500	T, G, SF	Low	15	60
2	Varagaliar	2000 (VL)	650-800	DD	Low	15	20
3	Karian Shola	500 (L)	750	B, DD	Low	10	30
4	Manamboli	250 (L)	800	T, C, DD	Low	10	30
5	Andiparai	200 (L)	1250	T, SF	Medium	10	30
6	Puthuthottam	92 (M)	1000	T, C, H, E	High	10	30
7	Pannimade	67 (M)	1100	C, T, R	Low	5	20
8	Korangumudi	50 (M)	1000	C, T, H, R	High	10	30
9	Tata Finlay	32 (S)	1000	C, T, E, H, R	High	5	25
10	Varattuparai	11 (S)	1100	T, C, SF, R	High	5	20

*T – tea plantation, G – grasslands, SF – secondary forests, DD – dry deciduous forest, C – coffee plantation, B – bamboo, R – reservoir, H – human habitation, E – eucalyptus plantation, WEF – wet evergreen forest

on standards obtained from track plots with camera traps (or live traps for radio-telemetry study) where species identification could be confirmed.

Camera-traps consisted of fixed-focus 32 mm Yashica cameras (with electronic shutter release, flash, and auto-winder) connected to pressure pads (Mudappa 1998). They were placed a minimum of 250 m from each other on existing forest trails or near streams. The pressure pad was placed on the ground and covered with a thin layer of soil and baited with banana, meat scraps, and occasionally dry fish or wild fruits. Traps were checked every morning, and the frame number, presence of tracks, use of bait, and any other indication of a small carnivore or other animal's visit were recorded. In KMTR, a camera-trap was run for a period of one to five nights at each station; however, for comparisons with camera-trap data from fragments in the Anamalai hills only data from the first night were used. This was because in the Anamalai hills each camera-trap was set at a new station every night in order to maximise the area sampled. Camera-trapping effort also varied in accordance with the size of the fragments in the Anamalai hills (Table 1).

Night walks were carried out in continuous rainforests of KMTR and within fragments in the Anamalai hills. Each night walk averaged 1.5 km in length and was covered in about one hour and ten minutes. The understorey and the canopy were scanned and searched for eye-shine or movements using spotlights (Novino 4-celled flashlight and Britelite Submersible Pro 5000 Series flashlight). Night drives were carried out to sample two contrasting landscapes: the Kakachi route in KMTR had a 34 km² plantation enclave surrounded by rainforests, while the Anamalai routes went through large expanses (c. 220 km²) of plantations with embedded rainforest fragments. All sightings of animals and variables such as habitat type and distance to the nearest rainforest were also noted.

Habitat structure measurement

Total tree and Brown Palm Civet food-tree densities and basal area were estimated using the point-centred quarter (PCQ) method (Krebs 1989) both in KMTR (n = 168 PCQ plots) and all the rainforest fragments (n = 190 PCQ plots, between 10 and 30 plots relative to area of fragment as in the case of survey stations mentioned above), except Varagaliar in the Anamalai hills. For Varagaliar, tree and food-tree densities, and basal area were derived from Ayyappan and Parthasarathy (1999). Habitat structural variables such as canopy height, canopy cover, and shrub density were estimated from measurements taken at 25 points within each study site, spaced at intervals of 50 m. Canopy height was measured using a clinometer or a range finder, canopy cover was measured using a spherical densiometer, and shrub density was estimated by counting the number of woody stems (< 10 cm in girth and ≥ 30 cm height) within 2 m radius plots at each of these 25 points. Area of fragments was estimated from digitised maps of the study sites.

Data analyses

Disturbance levels were assessed in the ten study fragments using habitat structure and a combination of 17 parameters such as presence of people, livestock, trails, and tree-cutting signs, as described in Muthuramkumar *et al*. (2006). The fragments were pooled into size classes for analyses as (1) small, ≤ 50 ha; (2) medium, 51–100 ha; (3) large, 101–1000 ha; and (4) very large, > 1000 ha.

The main index of abundance used in this paper is the success rates in track plots and camera-traps. For cryptic and nocturnal species such as small carnivores, such indices are frequently used to understand trends and patterns of variation across sites (Stander 1998, Carbone *et al*. 2002), until population sizes can be estimated using suitable methods (Jennelle *et al*. 2002, MacKenzie *et al*. 2005). Small carnivore visitation success rate was calculated as the percentage of successful track plot or camera-trap nights. A track plot or camera trap station was considered successful only if at least one track of a small carnivore was observed or a photograph obtained. Multiple tracks or pictures of the same species category on the same night at a station were taken as a single incidence. For analysis of track plot data, the two species categories considered are Brown Palm Civet and other carnivores, as indicated earlier. Success rates between the contiguous forests of KMTR and the rainforest fragments in the Anamalai hills and among fragment size and disturbance classes were compared using chi-square tests (Siegel & Castellan 1988). Track plots and camera-traps were 'passive' sampling techniques that were not influenced by observer or visibility biases related to habitat structure or density of vegetation in the sampling sites. This allows the unbiased comparison of success rates of particular species between sites as well as the relative abundance of species (percentage of visits of one species relative to total visits recorded) among sites. Although this relative success rate may not reflect the true ratio of abundances of various species (see Discussion), differences in relative success rates among sites are likely to be representative of changes in the underlying ratios.

In addition to success rates, encounter rates from direct sightings along night walks and drives are also provided. These, however, are likely to be influenced by detectability biases related to vegetation structure and need to be treated with caution. Hunting pressures were negligible in the study areas (D. Mudappa personal observations) and therefore unlikely to have influenced detectability. To examine differences in habitat characteristics between the contiguous rainforests in KMTR and the fragments in Anamalai hills, the Mann-Whitney U test was used (Siegel & Castellan 1988). For the Anamalai hills, success rates at each rainforest fragment were correlated with habitat and site variables, using Spearman rank correlations. Results were assessed as statistically significant at $P < 0.05$ and moderately significant at $P < 0.10$.

Results

Small carnivore surveys

Three species of nocturnal small carnivores were detected during the surveys in KMTR and the fragments in the Anamalai hills. Their occurrence and success rates in track plots and camera traps in the different sites is presented in Table 2. The overall small carnivore success rate of 48% in the 177 track plots (night 1 = 100, night 2 = 77) in Sengaltheri, KMTR, was significantly higher than the 32.2% (95 of 295 trap-nights) success rate in the fragments in the Anamalai hills ($\chi^2 = 11.73$, *d.f.* = 1, $P < 0.001$). The success rate in the Anamalai hills ranged between 8.0% in Tata Finlay, one of the small-sized (≤ 50 ha) fragments, to 46.7% in Korangumudi, a medium-sized (51–100 ha) fragment. In KMTR, 91% of the small carnivore visitation in track plots was by the Brown Palm Civet and other small carnivore tracks occurred rarely (9%, Fig. 2). In the rainforest fragments of the Anamalai hills, the Brown Palm Civet contributed to 50% ($n = 48$), and other small carnivores 50% ($n = 48$, Fig. 2). Success rate was higher in KMTR than in the Anamalai hills for both the Brown Palm Civet ($\chi^2 = 48.45$, *d.f.* = 1, $P < 0.001$) and for other small carnivores ($\chi^2 = 14.61$, *d.f.* = 1, $P < 0.001$).

Camera-trapping success rate in KMTR of small carnivores was 41.1%, with three species photo-trapped: Brown Palm Civet, Small Indian Civet, and Brown Mongoose. In both study areas, in and around the rainforest sites, Common Palm Civet *Paradoxurus hermaphroditus* does not occur and was neither photo-trapped nor sighted during the study period or subsequently till date. This species, the tracks of which might be confused with those of Brown Palm Civet, was recorded frequently only in drier deciduous forests at lower (< 800 m) elevations within these hills and never in the rainforests. In Sengaltheri and Kakachi, all three small carnivores were photo-trapped, and in Kannikatti only the Brown Palm Civet was photo-trapped. Kakachi had the highest trapping success of 73.7% ($n = 19$ trap-nights), followed by Sengaltheri with 42.4% ($n = 59$), and Kannikatti with 20.6% ($n = 34$; $\chi^2 = 14.29$, *d.f.* = 2, $P < 0.001$). Brown Palm Civet was photo-trapped on 37 nights, accounting for about 80.4% of the success, Small Indian Civet on seven nights (15.2%), and Brown Mongoose on two nights (4.4%, Fig. 2). The capture rate of Brown Palm Civet was significantly positively related to altitude, being 57.9% in Kakachi (1250 m), 32.2% in Sengaltheri (1000 m), and 20.6% in Kannikatti (750 m; $\chi^2 = 7.71$, *d.f.* = 2, $P = 0.021$).

Camera-trapping success in the rainforest fragments of the Anamalai hills was significantly lower than in KMTR, with a success rate of 16.8% ($n = 95$ trap-nights) as against 38.8% ($n = 49$, $\chi^2 = 8.45$, *d.f.* = 1, $P = 0.004$) on night 1 in KMTR, and 41.1% overall ($n = 112$, $\chi^2 = 14.38$, *d.f.* = 1, $P < 0.001$). However, even in the Anamalai hills, Brown Palm Civet was the most frequently photo-trapped small carnivore, contributing to 50% of the success (8 trap-nights), although lower than in KMTR (80.4%, Fig. 2). The capture rate of Brown Palm Civet was also significantly lower

Table 2. Success rates of small carnivore detections on track plots and camera traps in Kalakad–Mundanthurai Tiger Reserve (KMTR) and in the rainforest fragments in the Anamalai hills.

Site	Track plots (%)		Camera traps (%)		
	Brown Palm Civet	Other small carnivores	Brown Palm Civet	Small Indian Civet	Brown Mongoose
Kalakad–Mundanthurai Tiger Reserve			34.7		
Kakachi			57.9	10.5	5.3
Sengaltheri	45.8	4.5	32.2	8.5	1.7
Kannikatti			20.6	0	0
Anamalai hills			8.4		
Akkamalai	13.3	26.7	0	0	20
Varagaliar	5	10	0	0	0
Karian Shola	6.7	20	10	0	10
Manamboli	20	20	0	10	0
Andiparai	26.7	10	0	10	10
Puthuthottam	20	13.3	40	0	0
Pannimade	40	5	40	0	0
Korangumudi	23.3	23.3	10	0	0
Tata Finlay	4	4	0	0	0
Varattuparai	10	5	0	0	20

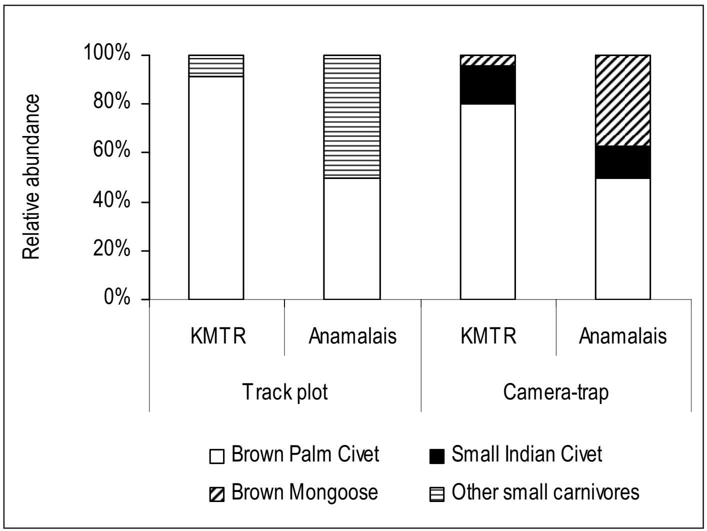

Fig. 2. Relative abundance of small carnivores using track plots and camera-traps—comparisons between the contiguous rainforests of Kalakad–Mundanthurai Tiger Reserve (KMTR) and the fragmented rainforests of the Anamalai hills.

in the Anamalai hills (8.42%) than in KMTR on night 1 (34.7%, $\chi^2 = 18.31$, *d.f.* = 1, $P < 0.001$). In the Anamalai hills, Brown Mongoose was the second most frequently photo-trapped species of small carnivore (37.5%), followed by Small Indian Civet (12.5%, Fig. 2). Although Brown Mongoose was photo-trapped a greater number of times in the Anamalai hills than in KMTR, and Small Indian Civet fewer times, the differences were not statistically significant ($\chi^2 = 2.84$, *d.f.* = 1, $P = 0.09$, and 2.12, *d.f.* = 1, $P = 0.15$, respectively). The camera-trapping success was highest in Puthuthottam and Pannimade, both medium-sized fragments. There were no photo-captures of small carnivores in Varagaliar, the largest fragment of those at low elevation, and in Tata Finlay, one of the small fragments.

Twenty-five night walks (totalling 32 hr 35 min) on forest trails were carried out in Kakachi, Sengaltheri, and Kannikatti in KMTR between November 1996 and September 1997. Three Brown Palm Civets were sighted resulting in an encounter rate of 0.09 animals/hr. In the Anamalai hills, 12 night walks were carried out (13 hr 10 min) in seven rainforest fragments. Time spent in a walk ranged between 30 and 140 minutes, depending on the size of the fragment. Four Brown Palm Civets were seen during these night walks, resulting in an encounter rate of 0.30 animals/hr. The Brown Palm Civets were sighted in one large (Andiparai) and one very large (Akkamalai) fragment.

During seven night drives in Kakachi in KMTR (100 km in 5 hr 15 min), one Brown Palm Civet, seven Small Indian Civets, and one Leopard Cat were seen, giving an encounter rate of 1.7 animals/hr of drive or 0.09 animals/km. We covered a distance of 281.5 km over 11 hr 40 min in 19 night drives in the Anamalai hills. During these drives, one Brown Palm Civet (at a rainforest fragment edge) and two Small Indian Civets (at tea estate edges) were sighted, giving an encounter rate of 0.26 animals/hr or 0.01 animals/km.

Determinants of small carnivore occurrences in rainforests

With the exception of the very large fragment, Akkamalai, and the large Karian Shola fragment, the tree densities of all the other rainforest fragments in the Anamalai hills were lower than any of the rainforest sites in KMTR (Table 3). However, among the habitat variables, only Brown Palm Civet food-tree density was significantly higher in the sites in KMTR as compared with the rainforest fragments in the Anamalai hills (Mann-Whitney *U* test, $Z = -2.54$, $P = 0.007$, Table 3). Among fragments, only tree density was significantly correlated to area ($r_s = 0.721$, $n = 8$, $P < 0.05$). None of the other variables were, however, significantly correlated to either fragment area or altitude. Basal area in the forest fragments was significantly positively correlated to both tree and food-tree densities ($r_s = 0.709$ and 0.697, respectively, $n = 10$, $P < 0.05$). Canopy cover, as expected, was significantly correlated to tree density and basal area ($r_s = 0.782$ and 0.685, respectively, $n = 10$, $P < 0.05$). No other significant correlations were found among habitat structure parameters.

The visitation success rate of Small Indian Civet in the track plots in the Anamalai hills was weakly correlated to area of the fragments ($r_s = 0.612$, $n = 10$, $P = 0.06$), while that of Brown Palm Civet was positively correlated with altitude ($r_s = 0.624$, $n = 10$, $P = 0.054$), the latter similar to the pattern observed in the contiguous rainforests of KMTR. None of the other small carnivore success rates was significantly correlated to any of the habitat variables.

There were no significant differences (χ^2 analyses) among fragments of varying size classes or disturbance levels in the success rates of either individual species or of all small carnivores pooled, in both track plot or camera-trap method. The only exception was that track plot success of Brown Palm Civet was significantly different between sites of varying size classes ($\chi^2 = 11.35$, *d.f.* = 3, $P < 0.01$) with success being highest in medium-sized fragments (26.3%) as compared with small (6.7%), large (17.8%), and very large (10%) fragments.

Discussion

Despite the limited data-set available, this study provides a first documentation of the responses of cryptic nocturnal small carnivores to rainforest fragmentation in south Asia by using a combination of methods in two contrasting landscapes. The use of similar methods in both landscapes allows comparison of overall capture rates as well as variation in inferred relative abundance for each species across sites; however, the actual relative abundance of a given species, compared with the other species, may be at variance with the real ratio, because different species may vary in their attraction to the trap stations, but any such differences could not be assessed.

The higher success rates in track plots (48%) and camera-trapping (41.1%) in KMTR than in the Anamalai hills (32.2% success in track plots and 16.8% in camera-traps) indicate higher abundances of small carnivores in relatively undisturbed contiguous rainforests. This is unlikely to be merely a consequence of greater avoidance of trap stations in the Anamalai hills due to human use of fragments, as success rates were low even in large fragments within the protected area that were not visited or disturbed by people. Greater success rate in contiguous rainforests was mainly due to visitations by Brown Palm Civet, a species that was previously considered rare (Ashraf *et al*. 1993). Brown Palm Civet contributed to only half the success in the Anamalai hills, in contrast to more than three-fourths in KMTR. Thus, although the terrestrial and arboreal small carnivores persist in the fragmented landscape, they occur in altered relative abundances. Encounter rates appeared to be higher in the rainforest fragments than in continuous forest only in night walks. This cannot be concluded to indicate a genuine difference in densities, and was surely an artefact because of poorer visibility due to the much denser foliage and forest stand in KMTR than in the more degraded fragments in the Anamalai hills. Spotlighting was not an effective method of sampling rainforest small carnivores as encounter rates were very low, as noted in other studies (Duckworth 1998, Mudappa 1998).

Another factor influencing the distribution of Brown Palm Civet was altitude, with the species being more common at altitudes above 900 m. In addition, the higher capture rates indicating higher abundances in KMTR are probably sustained by the higher food plant species densities in the relatively undisturbed rainforests, particularly species such as *Palaquium ellipticum, Holigarna nigra, Elaeocarpus* spp.*, Ficus* spp.*, Acronychia pedunculata,* and *Gnetum ula* (Mudappa 2001). Within the fragments of the Anamalai hills, however, food-tree density did not show a direct relationship with the success rates of Brown Palm Civet. The medium-sized fragments had greater success rates, probably because they had (1) some coffee plants (the fruits of which are consumed by civets) in the understorey, and (2) shade-coffee plantations in the surrounding matrix that retained some native, rainforest species as shade trees (including fruit species such as *Ficus* spp. and *Artocarpus heterophyllus*). These fragment characteristics increased the effective food and habitat available to civets. However, these are highly disturbed fragments on private lands, whose long-term survival is threatened. Although two small fragments and one large fragment also adjoined shade-coffee plantations, their influence on civets may have been suppressed by other factors such as smaller area and lower altitude of the fragments.

Forest fragmentation and disturbances such as logging have been shown to have varying effects on different groups of mammals. Species such as tree squirrels, for instance, may increase in abundance (Johns 1988, Koprowski 2005). Similar to results of studies on the impact of habitat disturbances on other mammals (Johns 1988, Wilkie & Finn 1990, Oehler & Litvaitis 1996), there seemed to be a relative increase or no significant change in the abundance of more terrestrial and more omnivorous-carnivorous species like the mongooses and Small Indian Civet in fragments. Within-patch habitat characteristics did not predict the occurrence of these small carnivores, instead these species may remain relatively unaffected by fragmentation because of their ability to use modified habitats in the surrounding landscape matrix (Leighton & Leighton 1983, Laurance 1991). As observed here, earlier work has shown that disturbed habitat fragments are susceptible to invasions by more widespread and generalist species at the cost of restricted endemics and specialists, altering the composition of the community (Oehler & Litvaitis 1996). The changes in relative abundance, favouring common and widespread omnivorous or insectivorous species like all the mongooses and Small Indian Civet, may also be due to the increase in abundance of small mammal prey in the fragments and probable increase in leaf-litter arthropod abundance along edges and in disturbed fragments (Didham 1997, Malcolm 1997, Ray & Sunquist 2001). Since there is understorey cover in the surrounding plantation matrix, these more ground-dwelling species are least likely to be affected by fragmentation (Wilkie & Finn 1990, Laurance 1991).

In Borneo and Malaysia, many species of civets are known to persist in selectively logged forests, although in significantly lower abundances with the predominantly carnivorous (insectivorous) subfamilies of Viverrinae and Hemigalinae being most affected (Heydon & Bulloh 1996, Colón 2002). In contrast, in the present study, the arboreal and predominantly frugivorous Brown Palm Civet suffers from fragmentation probably because of its inability to survive in a matrix of tea plantations devoid of continuous tree cover and sufficient diversity of fruit resources (Mudappa 2001). With the exception of fragments with coffee in the understorey, most others not only have very low food-tree densities, but also harbour many exotics that bear fruits not usually eaten by the civets. This is similar to studies on primates that have also shown highly frugivorous and folivorous primates to be affected by major reduction in food species due to logging and associated disturbances (Johns 1988, Struhsaker 1997, but also see Fimbel 1994). Moreover, in order to meet their daily resource requirements, civets may have to range over a wider area in fragments than in undisturbed rainforests (a maximum of about 60 ha in undisturbed rainforests, Mudappa 2001). Most of the fragments are less than 100 ha in area, and this could explain the lower abundances of this species. The persistence of civets in fragments also needs to be evaluated in future studies in relation to their ability to use surrounding matrix habitats and other threats such as vehicular colli-

Table 3. Habitat structure measurements of different sites in the contiguous rainforests of KMTR and in the rainforest fragments in the Anamalai hills (SE in parentheses).

Sites	Tree density (number/ha)	Food-tree density (number/ha)	Basal area (m^2/ha)	Canopy height (m)	Canopy cover (%)	Shrub density (number/12.57 m^2)
Kalakad–Mundanthurai Tiger Reserve						
Kakachi	738 (4.8)	241	65.10	23.83 (0.7)	93.68 (0.8)	20.77 (2.4)
Sengaltheri	680 (1.9)	280	77.78	20.92 (0.9)	93.84 (0.9)	19.26 (2.7)
Kannikatti	624 (4.0)	244	70.90	24.38 (1.2)	94.66 (0.6)	15.66 (2.0)
Anamalai hills						
Akkamalai	697 (5.0)	209	52.49	22.65 (1.4)	97.70 (0.5)	10.20 (0.6)
Varagaliar	446	82	36.26	28.56 (1.4)	94.68 (0.7)	15.76 (1.7)
Karian Shola	755 (7.6)	181	95.86	27.00 (0.7)	98.20 (0.2)	23.84 (2.4)
Manamboli	582 (5.8)	175	114.41	24.54 (1.1)	94.96 (1.4)	11.64 (1.1)
Andiparai	431 (4.4)	169	84.49	22.66 (1.8)	96.24 (0.7)	26.32 (2.9)
Puthuthottam	239 (2.4)	107	52.49	22.70 (1.9)	89.00 (1.3)	7.88 (0.8)
Pannimade	534 (13.7)	187	47.48	22.43 (1.8)	92.48 (0.8)	34.16 (3.0)
Korangumudi	196 (1.9)	84	31.25	20.74 (2.1)	68.24 (3.2)	8.83 (1.2)
Tata Finlay	331 (5.6)	116	40.31	31.32 (1.9)	96.32 (1.2)	11.04 (0.9)
Varattuparai	295 (7.6)	103	33.47	11.11 (2.2)	95.65 (0.9)	3.73 (0.8)

sions along roads.

Moreover, techniques have been recently developed to enable estimation of the proportion of area of occupied (PAO), or the probability that a site is occupied, by a species of interest based on presence-absence surveys (MacKenzie *et al*. 2002, 2005). Future studies, particularly in areas that are being surveyed for the first time, could be designed so as to enable the estimation of patch occupancy and detection probability of the species of interest at the landscape level.

Conservation implications

The Kalakad–Mundanthurai Tiger Reserve with its large tract of relatively undisturbed rainforests deserves recognition as one of the most significant areas for the long-term conservation of small carnivores in the Western Ghats, particularly the endemic Brown Palm Civet, an important frugivore and seed disperser in these rainforests (Mudappa 2001). In a fragmented landscape, fragments adjoining shade-coffee plantations appear to support higher abundances of Brown Palm Civets than those remote from shade-coffee, thereby indicating such land use to be less ecologically damaging and consistent with broader conservation goals than plantations such as tea. The study indicates three major management measures that would aid in the conservation of small carnivores in the region. First, there is a need to identify and include even isolated and disturbed rainforest fragments on private lands within the management purview of endangered habitats and species, as most of these still contain endemic small carnivore populations. Second, restoration of highly degraded rainforests by planting of food plant species and maintenance of shade-coffee plantations with native shade trees will augment habitat quality and help sustain populations of endemics such as the frugivorous Brown Palm Civet at the landscape level. Finally, to discern trends in small carnivore populations in these areas and assess the success of implemented management measures there is a need for regular and systematic monitoring, using suitable field methods and recent advances in quantitatively rigorous study design, monitoring, and analysis protocols (Pollock *et al*. 2002, MacKenzie & Nichols 2004, MacKenzie *et al*. 2005). These management measures should ideally supplement protection of larger tracts of forests within designated wildlife preserves, and the development of a better information base through additional surveys and monitoring of the status of small carnivores in the region.

Although the persistence of small carnivore species following habitat fragmentation bodes well for their conservation given large areas of protected forest and relatively low pressures from hunting and land-use conversion even on private land as in the Anamalai hills, future research on some key aspects will help reinforce this assessment. These include: (1) the role of the various plantations and land-use practices in the long-term persistence of small carnivores, particularly endemic species such as the Brown Palm Civet and Nilgiri Marten, (2) the role of landscape connectivity and protected forests in dispersal and maintenance of species' populations in the fragments, and (3) to determine the roles of fragments and plantations in the source-sink dynamics at the landscape level for certain species of interest.

Acknowledgements

We would like to thank R. P. S. Katwal, Sukh Dev, V. K. Melkani, and A. Udhayan of the Tamil Nadu Forest Department and many managers of private plantation companies in the Anamalai hills for providing permits and logistic support to carry out this study. This study was made possible by the financial support from the United States Fish and Wildlife Service and Wildlife Conservation Society, USA, and the WCS India Program. T. R. Shankar Raman helped during manuscript preparation and revision. We sincerely thank Poovan, Doraipandi, Sivakumar, and Aiyappan for their assistance in the field. We thank Anindya Sinha, J. J. Thompson, and John Caroll for useful comments that considerably improved the manuscript.

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Notes on diet, habituation and sociality of Yellow-throated Marten *Martes flavigula*

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Abstract

Artificial provisioning of a wild Asian Black Bear *Ursus thibetanus* with boiled rice at Khao Yai national park, Thailand, resulted in regular visits by a small group of Yellow-throated Martens *Martes flavigula*. These animals ate large quantities of the rice, habituated to high levels of close human noise and motion, and were enjoyed by many visiting members of the general public. Although often described as a voracious predator, the species may in fact eat significant amounts of vegetable matter. Group foraging may be usual across its range although no rigorous study has yet been undertaken. The species could be a valuable tool in the eternal challenge of consolidating environmental awareness among the general public of Southeast Asia, given that most evergreen forest mammals are hard to see.

Keywords: artificial feeding, group size, protected areas, public awareness, Thailand

Introduction

The martens *Martes* are generally considered to be voracious predators of live animals, with Prater (1971) describing Yellow-throated Marten *M. flavigula* as "a real menace to all the small creatures living in their neighbourhood. In the treetops they hunt squirrels and birds, raid nests for eggs and young. On the ground their usual quarry is rats and mice, hares, pheasants, and partridges, but they are bold enough to attack larger defenceless animals such as young deer. When pressed for food, carrion, snakes and lizards, and even insects are eaten. Their diet is varied with fruit and honey from flowers". Pocock (1941) cited, without cautioning its reliability, the local reports given to J. M. D. Mackenzie (in Wroughton 1916) that "three or four will attack an unarmed man", and although this now seems extremely fanciful, it indicates the popular image of the genus. Hence, the following observation of Yellow-throated Martens eating rice seems worthy of record, particularly given the high human activity at the feeding site.

Observations

In mid-December 2004, JWKP heard a report of an Asian Black Bear *Ursus thibetanus* readily observable at dusk at the Khao Khieo guard-post, Khao Yai National Park, Thailand (about 14°20'14"N, 101°26'05"E). This site lies amid submontane broadleaved evergreen forest (Smitinand 1968) at about 1350 m altitude. Asian Black Bear has undergone major declines in most of South-East Asia (e.g., Duckworth *et al*. 1999, MOSTE 2000, Lynam *et al*. 2006, Steinmetz *et al*. 2006), such that few of today's wildlife surveyors and conservationists have ever seen the species in the wild. Hence, JWKP went to investigate the situation on 31 December 2004, arriving at about 17h30. The guards at the post reported that the bear was observed daily, coming in to eat the large quantities of boiled white rice they placed on the turf between the station huts and the forest edge. As well as the bear, which emerged well after it got dark, for much of the 40 minutes of daylight after JWKP's arrival, three Yellow-throated Martens were on view, avidly consuming the rice. The station's staff were used to the animals' presence and between them they continued to shout to each other between the buildings, play an uproarious game of cards, watch a blaring television, clatter pans and stride noisily around the compound; while JWKP's two small daughters exclaimed eagerly, repeatedly and noisily at the sight of the animals. These loud, near-continuous, noises, accompanied by much movement, gave no concern to the martens, which regularly came within 10–15 metres of the station's large glass window.

Shortly afterwards, when next passing through Bangkok, JWD was equally keen to avail of this unusual opportunity to see a wild bear in South-East Asia, and with JWKP visited the guard station on 14 January 2005. On arrival at 17h50, three martens were eating at the piles of cooked rice (several large pans full, spread over several square metres of short turf; about 15 metres from the forest edge). As well as eating it on the spot, the martens also carried off and ate large clags of rice. Some were taken into adjacent tree crowns, presumably to allow greater safety. The martens were almost continually in view until dusk (18h20), and intermittently visited the rice-piles until at least 18h50, well into darkness. As before, they were unconcerned by the loud, active, presence of over a dozen people. Twice individual martens came within 20 feet (6–7 m) of the glass window, at least once while chasing a rodent. Station staff reported the daily presence of the martens, and that they could be present at any of the daylight hours. Mounted in the station were numerous high-quality photographs of them at the rice, taken by visiting photographers. Station staff confirmed that no baits other than rice were being provided.

Discussion

Diet

Yellow-throated Marten's diet remains little-studied, and indeed Grassman *et al*. (2005) traced no previous ecological study of the species. Its diet has been characterised as "rats, mice, hares, snakes, lizards, eggs and ground birds...a pest to keepers of poultry,...fawns of...muntjac...reported to kill native house-cats...said to feed upon human corpses...probably...feeds on fruits as well [and has a] fondness for nectar" (Pocock 1941); "squirrels, birds, snakes and lizards, though insects, eggs, frogs, fruit, nectar and berries are also taken. They seem to particularly favor honey" (Lekagul & McNeely 1977); "will kill and eat any small bird or mammal which they can overcome", also partly frugivorous and insectivorous, specifically cicadas, apricots, *Viburnum*, honey and larvae of wild bees (Roberts 1977); "a wide range of small vertebrates and invertebrates, bees' nests and nectar" (Payne *et al*. 1985); Himalayan Tahr *Hemitragus jemlahicus*, flying squirrels *Petaurista* spp., reptiles and insects, based on faecal analysis, with observations of chases of Tahr, Brown Musk Deer *Moschus chrysogaster*, Indian Goral *Naemorhedus goral* and a pheasant *Lophura* *leucomelana* (Sathyakumar 1999). Allen (1938) conceded that "evidently its predaceous habits of diet are modified by a liking for sweets", referring to nectar and honey. Parr (2003) boiled this down to "diverse, omnivorous, diet". We have not traced reference to Yellow-throated Marten coming to food provisioning sites, but the allied Pine Marten *M. martes* is well known to visit bird-tables (where householders put out food for wild birds) in Scotland, UK (Velander 1991). Indeed, some internet tourism advertisements list, as a tourist attraction for Scotland, the opportunity to observe Pine Martens at bird tables, where they are reputedly particularly fond of jam sandwiches and peanut butter (Internet search in May 2005).

Social structure

Grassman *et al*. (2005) called for research into the social structure of Yellow-throated Martens, believing that their several records of animals in groups of two contravene the general pattern for solitary living in mustelids, including *Martes*, proposed by Powell (1979). However, Powell's conclusion considered information about *Martes* only from Holarctic species. By contrast, the tropical *M. flavigula* does not seem particularly solitary; as well as references in Grassman *et al*. (2005) to groups of two, Duckworth (1997) found duos to be regular in Laos, Pocock (1941) considered that the species hunted "usually in couples" in India and adjacent countries, and JWKP has observed duos as follows: crossing a road in mid-afternoon in Khlong Phraya Wildlife Sanctuary, peninsular Thailand, in 1988; chasing squirrels through the mid-storey in Phu Khieo Wildlife Sanctuary, north-east Thailand, in February 1992; and crossing a road in mid-morning in Kaeng Krachan National Park, west Thailand, in January 2006. Even groups of three, as here, are not unusual; JWD watched such a group in the Hukaung Valley, Myanmar, at 26°35'13"N, 96°17'39"E, foraging on a river sand-bar and in adjacent elephant-grass over 12h50–13h05 on 25 Dec 2005; Sathyakumar (1999) referred to four sightings (of 16 contacts with the species) of trios (and only five singles), while Pocock (1941), Tun Yin (1967), Medway (1969), Prater (1971), Lekagul & McNeely (1977) and Payne *et al*. (1985) all referred to groups of more than two as not unusual; J. M. D. Mackenzie (in Wroughton 1916) personally observed a group of five hunting together. By contrast, Roberts (1977) assessed the species as "generally...solitary", although it is unclear upon how many direct observations this was based.

Potential in environmental education

Yellow-throated Marten is often credited with fearlessness ("two specimens feeding in a rhododendron bush paid no heed to a stream of [people] passing along a track only 40 yards below them"; Pocock 1941), and in many modern sightings animals appear neither particularly vigilant nor quick to flush when they do detect people (pers. obs.). It has a reputation for being readily tamed (Pocock 1941), doubtless because it is "inquisitive and bold" (Roberts 1977). Hence, this habituation at Khao Yai to continuous human presence accompanied with loud noise is perhaps not surprising. Despite this, baiting wild individuals of the species into areas of high human activity does not seem to have been placed on record. Doing so could help meet one of the key conservation challenges in forested South-East Asia: the general rarity of sightings of mammals (other than bats, squirrels and primates, and in some areas, deer) by non-specialist visitors to forest protected areas. With rapidly urbanising populations and increasing disposable income, protected areas in South-East Asia host a large number of visitors every year; Khao Yai received about 944,940 visitors in 1992 (Srikosamatara & Suteethorn 1994) and more recently over 1.2 million visitors were estimated per year by Srikosamatara & Brockelman (2002). These protected areas already play a valuable role in sparking and consolidating environmental consciousness among the countries' citizens, an essential process if large areas of natural habitat are to survive. It is likely that with more sightings of 'wild animals', protected areas could provide considerably greater pleasure to visitors, especially among children and youths.

Baiting for animals, using species-appropriate food, could help address the fundamental challenge that even in South-East Asian closed forests with natural animal densities, day-time sightings of most mammals will always be rare. However, any baiting should be preceded by careful feasibility assessment: for example, it is questionable whether luring bears into human-use areas using human foods is wise, particularly considering the conflicts between wild bears and people in North America that result from bears scavenging human food (e.g., Wilson *et al*. 2005). Also, it is presumably unhealthy for martens to eat large quantities of cooked rice. Even in heavily-hunted parts of South-East Asia such as Laos and Vietnam, Yellow-throated Marten remains common and under no particular threat (Duckworth 1997, Long & Minh Hoang 2006, Roberton *et al*. in prep.). It is also widespread and/or readily observed in Cambodia (J. Walston *in litt*. 2006), Thailand (where known from Khao Yai already; Lynam *et al*. 2006, Steinmetz *et al*. 2006), Myanmar (Than Zaw *et al*. in prep.) and Sumatra (Holden 2006), and is widespread and evidently relatively common in the Himalayas (Choudhury 1999, Datta 1999, Sathyakumar 1999). Hence, many protected areas host this species, and, as with Pine Martens in Scotland (see above) it could be an ideal animal to show the public: beautiful, highly active, charismatic, and exotic-looking.

Acknowledgements

We thank the staff from the Royal Thai Army checkpoint for encouraging our visits and discussing the behaviour of the animals. Lon Grassman, Barney Long, Scott Roberton, Rob Steinmetz and Joe Walston provided comparative information.

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Niche differentiation between Common Palm Civet *Paradoxurus hermaphroditus* and Small Indian Civet *Viverricula indica* in regenerating degraded forest, Myanmar

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Abstract

In Hlawga Wildlife Park, Myanmar, a 624 ha protected area consisting of degraded mixed deciduous forest and shrubland, Common Palm Civet *Paradoxurus hermaphroditus* greatly outnumbered Small Indian Civet *Viverricula indica*. Both species were solitary and nocturnal, occupying secluded resting sites during daytime. *Paradoxurus* resting sites were typically (92%) high in the dense canopy of tall (> 10 m) forest trees; those of *Viverricula* (99%) were at the ground level in a dense tangle of shrubbery. The activity level of *Paradoxurus* rose steadily during and following sunset, then remained on a plateau from 19h30 to 03h00, after which there was a steady decline towards dawn. *Viverricula* was relatively inactive following sunset but showed major peaks of foraging activity between 19h30 and 22h00 and again from 00h30 to 03h00. Mean distances moved per night were similar (*P. hermaphroditus*, 212 m; *V. indica*, 232 m). Faecal analysis showed *P. hermaphroditus* to take between 8 and 21 species of fruit per 2-month period throughout the year, with little seasonal fluctuation in total intake. Very small amounts of vertebrate and invertebrate remains were found in *P. hermaphroditus* faeces. A large percentage of *V. indica* faeces contained vertebrate and invertebrate fragments year-round, with a pronounced peak during July/August, corresponding to an abundance of arthropods and relative scarcity of fruits; the latter were taken in very small amounts by this species in some seasons. The most frequently selected fruit and prey species were the same for both civets. The niche of *P. hermaphroditus* in Hlawga can be defined as that of a solitary, nocturnal frugivore, resting, feeding and spending most of its time in the canopy of mixed deciduous forest. The niche of *V. indica* is that of a solitary, nocturnal predator of small vertebrates and arthropods, that forages widely at ground level in different habitat types and rests during daytime in dense shrubbery near the ground.

Keywords: diet, ecological overlap, fire, habitat use, Southeast Asia

Introduction

The family Viverridae includes 18 genera and 34 species (Wozencraft 1989) and shows more ecological diversification in trophic specialisation and substrate use than does any other family of carnivores (Eisenberg 1981). There is a wide dietary range including vertebrates, invertebrates, flowers, and fruits. Despite the many species of viverrids and their wide distribution throughout the old world tropics, the basic biology of most species is known largely from unsystematic field observations and captive studies, with rather little quantitative ecological information on Asian civets (e.g., Joshi *et al*. 1995, Rabinowitz 1991). Carnivores, including some viverrids, are threatened by habitat degradation and illegal killing in at least some parts of Asia (e.g., Johnsingh 1986). Hence, a study of the ecology and threats to the small carnivore community in Hlawga Wildlife Park, Myanmar (formerly Burma) was carried out between 2000 and 2003. A total of seven small carnivore species was encountered, including three civets (one found only by an evidently released animal), two mongooses and two small cats (Su Su 2005). The present contribution reports on the relative abundance, diel activity, habitat use, nature and location of resting sites, and feeding ecology of the two most numerous small carnivores in Hlawga, Common Palm Civet *Paradoxurus hermaphroditus* and Small Indian Civet *Viverricula indica*. Information on these aspects of the two species' ecology provides an insight into the way in which their respective niches are differentiated. It also reveals aspects of their ecology which may render them vulnerable to human impacts on the Hlawga ecosystem. Under Myanmar conservation legislation, all members of the family Viverridae are accorded at least "protected" status (= all-year protection from any form of harvest or killing), while *V. indica* is "totally protected" (= all-year protection from any form of harvest or killing with especially high penalties).

Study Area

Hlawga is a 624 ha protected area, constituted in 1982, 35 km north of Yangon at 17°02'–04'N, 96°05'–08'E. It is surrounded by a large rural population housed in 17 villages and two military camps. A central core area of 327 ha is separated by a 2-m high chain-linked fence from a surrounding buffer zone and a public highway along the southern boundary. The core area contains undulating terrain, with streams and lakes, covered by secondary mixed deciduous forest consisting of fairly tall trees bearing a variety of creepers and climbers, interspersed with a few small patches of rattan cane. The buffer consists of degraded forest from which most large trees have been removed and has a mosaic of dense patches of small trees (including planted exotics) and shrubs, separated by grass and herbaceous ground cover. A monsoon climate defines three distinct seasons: a rainy season from mid-May to October; a cool 'winter' from November to February and a hot season during March and April. Over the three-year study the mean annual rainfall was 210 cm; the mean maximum and minimum temperatures throughout the study period were 32.8 ºC and 22.4 ºC respectively, the extremes being 37.5 °C in April and 17.7 °C in January.

In addition to the seven species of small carnivores, the core area contains four species of deer, Eurasian Wild Pig *Sus scrofa*, and a large and increasing population of Rhesus Macaques *Macaca mulatta*; no large carnivores are present. A variety of small mammals including rats and mice, two species of squirrel, a treeshrew *Tupaia* and bats are present. The known avifauna comprises 147 forest and shrubland species and 34 species of waterfowl, including migrants (Khin Swe Win 2003), and many more species no doubt occur. Reptiles include monitor lizards *Varanus* sp(p)., smaller lizards and various snake species; anuran amphibia are abundant in the vicinity of the water bodies that also contain many species of freshwater fishes. Arthropods abound, including ants, termites, Orthoptera, Coleoptera, millipedes, centipedes and scorpions.

Methods

Abundance and distribution data on the target species were gathered from observations using a spotlight at night and systematic recording of signs (footprints, faeces and resting sites). Camera-traps (Cam-Trak South Inc., Georgia, USA) were deployed over fortnightly periods at random locations along trails throughout the core area from September 2000 to October 2002 (total 783 trap nights). Live traps (wire mesh: 63 × 20 × 20 cm) were also placed randomly to sample small carnivores.

Habitat use (home range; distances moved) information was obtained from a small number (*P. hermaphroditus*, eight; *V. indica*, two) of radio-collared individuals (164–166 MHz, Biotrack, UK) located at 1–3 day intervals using a hand-held receiver and Yagi antenna (Telonics TR2, Arizona, USA). Overnight locations at 2.5-hour intervals yielded data on nocturnal activity patterns. All location points were recorded as UTM by G.P.S. (Garmin International Inc., Kansas, USA) and analysed by ArcView 3.3 software (Environmental Systems Research Institute, California, USA).

Seasonal availability of flowers and fruits, as a potential food source, was estimated by monthly phenology recording. Observations on the relative abundance of potential prey, in the form of small vertebrates and arthropods, were recorded regularly and seasonal fluctuations noted. A more precise estimate of small mammals available was obtained by systematic live-trapping.

Diet was assessed by monthly analysis of faeces collected throughout the study period. Faeces were identified to species as described in Su Su (2005). They were first assessed with the naked eye or a magnifying glass. Dry faeces were then broken up and, after removing discrete fragments with forceps, passed through a fine sieve to remove unwanted particles. Wet faeces were rinsed several times with a formalin: ethyl alcohol: acetic acid (2:1:1) solution, pouring off unwanted particles. Identifiable fragments (seeds, bones, hairs, etc.) were put into a Petri dish for grouping by taxa and checking against a previously prepared reference collection of identified seeds (Hundley & Chit Ko Ko 1961, Hundley 1987, Kress *et al*. 2003), arthropod parts and mammalian hairs, bones and teeth (Lekagul & McNeely 1977, Mukherjee 1998). Each sample was scored for presence or absence of food items on the list of identifiable fragments and then all fragments were counted to establish proportions in the monthly samples for each species.

Results

Relative abundance and distribution

The apparent 'relative abundance' of the two civets in Hlawga varied, based on the four major types of evidence collected (Table 1). Ratios of *P. hermaphroditus* : *V. indica* range from 5.5:1 to 19.1:1, indicating *P. hermaphroditus* as the more abundant of the two species. The locations of records indicate that both species are widely distributed within the park, with *V. indica* occurring in the buffer zone much more frequently than does *P. hermaphroditus*. Home ranges based on daytime resting site locations of radio-tagged individuals showed that *P. hermaphroditus* remained in the mixed deciduous forest except for a mean 8% seasonal use of the buffer zone shrubland. By contrast, *V. indica* resting sites were 99% in the shrubland but with night-time foraging in both habitat types. Both species were solitary, the only social grouping observed being that of a family of Common Palm Civets (Su Su 2005).

Activity patterns

Activity levels, as determined from radio-telemetry, showed both species to be totally nocturnal, strictly resting during daylight hours and foraging at night. Table 2 shows the pattern of night-time foraging movements of radio-tagged individuals obtained by recording each animal at approximately 2.5-hour intervals between dusk (about 17h00) and dawn (about 05h30). In the case of *P. hermaphroditus*, activity built steadily from dusk to a plateau between 19h30 and 03h00, after which it declined gradually until dawn. Conversely, *V. indica* showed relatively little movement during and immediately following dusk (17h00–19h30) but major activity from 19h30 to 22h00 and again between 00h30 and 03h00, tailing off fairly rapidly as dawn approached. There was little difference between the mean total distances moved during the hours of darkness by the two species (*P. hermaphroditus* 212 m; *V. indica* 232 m). However, as indicated above, movements of *P. hermaphroditus* were largely confined to the forest habitat, while those of *V. indica* embraced the shrubland habitat as well.

Resting sites

For their day-time resting sites *P. hermaphroditus* normally selected tall (>10 m) forest trees which have a dense tangle of climbing plants, such as lianas, in the canopy. Out of 279 resting sites observed, 42% were in *Dipterocarpus alatus* Roxb. and 15% in *Crypteronia pubescens* Blume, both of which trees are frequently over 40 feet (12 m) tall. In the buffer zone shrubland, where there are very few tall trees, *P. hermaphroditus* rested in a tangle of shrubs (sometimes surrounding a small tree) as little as 2 – 3 m above the ground. For example, 7% of all resting sites were in a complex of shrubs surrounding small *Plectocomia macrostachya* Kurz trees. The majority of resting sites were not in tree species that provide *P. hermaphroditus* with flowers and fruits, but *P.*

Table 1. Relative abundance of P. hermaphroditus *(CPC) and* V. indica *(SIC) shown by four main methods of detection.*

Method	Numbers		Ratio	
	CPC	**SIC**	**CPC**	**SIC**
Footprints	2499	146	17.1	1
Faeces	2373	124	19.1	1
Camera trapping	160	29	5.5	1
Spotlighting	128	16	8	1

Table 2. Comparison of P. hermaphroditus *and* V. indica *consecutive night-time foraging distances over five time periods.*

	P. hermaphroditus		*V. indica*	
Time periods	**n**	**Mean distance moved (m)**	**n**	**Mean distance moved (m)**
17h00–19h30	98	150.79	17	39.71
19h30–22h00	98	225.87	17	414.55
22h00–00h30	98	258.58	17	237.24
00h30–03h00	98	251.43	17	341.64
03h00–15h30	98	175.79	17	124.91

macrostachya is an exception to this. Generally the animal simply slept hidden in the centre of the densest part of the canopy or shrubbery without any apparent modification of its surroundings. However, in a few cases twigs and leaves appeared to have been pulled together to form a spherical 'nest' in high canopy. About 45% of resting sites were used once only and the highest number of repeat uses of a single site by an individual was 55 (over a period of 294 days). *Viverricula* resting sites were normally at or only a little above ground level within the cover of extremely dense shrubbery. Some 68% of sites were located in a dense tangle of shrubs surrounding a *P. macrostachya* tree. Unlike *P. hermaphroditus*, *V. indica* only eats the fruit of this tree only occasionally. A shrub complex consisting of *Licuala peltata* Roxb., *Pandanus wallichianus* Martelli and *Plectocomia* sp. accounted for a further 16% of *V. indica* resting sites. *Viverricula* occasionally rested in a hole in the ground, such as a cavity formed by earth movements resulting from heavy rain. Both tagged *V. indica* used 60% of their resting sites only once and the greatest number of repeat uses of a single site was 15 (over a period of 250 days). *Viverricula* showed a greater mean distance moved between consecutive resting sites per 24 hours (214 m) than *P. hermaphroditus* (160 m), a ratio of *V. indica* : *P. hermaphroditus* = 1:0.75.

Feeding ecology

Phenology records obtained over 17 months revealed 42 species of trees, shrubs, and climbers in Hlawga that produced a profusion of flowers and fruits. Of these, seven species bore flowers or fruits for 10–12 months each year. Between 16 and 34 species were available in any one month, with a major peak during December to February and a minor peak in September. Availability was lowest between June and August at the height of the rainy season.

Field records of potential prey showed a year-round occurrence of small vertebrates, including murid rodents and squirrels, birds, lizards and snakes, and anuran amphibians. Invertebrate prey, such as millipedes, scorpions, and crickets, are subject to seasonal fluctuations in numbers. Some 1041 trap nights, using banana as bait, produced only squirrels *Callosciurus*, of which 105 were trapped, confirming their availability as potential prey for small carnivores.

The faeces of *P. hermaphroditus*, often consisting of a pale gelatinous mass containing undigested fruits and seeds, were frequently found on trails and clear patches of forest floor. The faeces of *V. indica* varied in size but were basically cylindrical with tapering ends. They were dark in colour, smelly and contained hairs, bone fragments and arthropod remains (often relatively intact), as well as a few seeds. From September 2000 to May 2003, 2373 *P. hermaphroditus* and 124 *V. indica* faeces were collected and analysed.

Fruits and/or seeds from 31 plant species were identified (plus a small number which remained unidentified) in the faeces of the two civets. The distribution of the ten most frequently eaten species between the two, on a 2-monthly basis, is shown in Table 3. *P. hermaphroditus* ate a variety of fruits throughout the year, varying from eight to 21 species per 2-month period. The percentage of *V. indica* faeces containing fruits was much lower, with no evidence of fruit during July/August and November/December. For the remaining periods, between two and four species were recorded per 2-month period. The most commonly eaten fruits by both civets were of a climbing plant, *Gnetum scandens* Roxb., which formed a high percentage of fruits eaten in all 2-month periods in which fruits were taken by respective species. The highest percentage of faeces containing this fruit was 95% (January/February) for *P. hermaphroditus* and 19% (May/June) for *V. indica*.

In all seasons, a much greater percentage of *V. indica* faeces contained animal remains than those of *P. hermaphroditus* (Table 4). The first four items listed appeared in a mean 32% of *V. indica* faeces year-round and in only 2.5% of *P. hermaphroditus* faeces. However, both civets are consuming similar prey and the numbers of species eaten during respective 2-month periods are similar, being greatest in January/February (*P. hermaphroditus,* 7; *V. indica,* 9) and least in November/December (*P. hermaphroditus,* 3; *V. indica,* 4). Fruit was the dominant type of food consumed by *P. hermaphroditus* year-round, with very little fluctuation. The intake of animal prey by this species is low throughout the year, being almost zero from March to August. Conversely, *V. indica* shows a high intake of prey throughout the year, with a pronounced peak in species fragments during the wet months July/August when

Table 3. Percentages of faeces of P. hermaphroditus *(CPC) and* V. indica *(SIC) containing fruits/seeds of the ten most commonly eaten plant species, with a summary based on all 31 species identified.*

Plants	Jan/Feb		Mar/Apr		May/Jun		Jul/Aug		Sep/Oct		Nov/Dec	
	CPC	SIC	CPC	SIC	CPC	SIC	CPC	SIC	CPC	SIC	CPC	SIC
Gnetum scadens	95	9	78	4	47	19	46		25		32	
Plectocomia macrostachya			4		13		45		21	4	11	
Grewia microcosm L.	2		<1		7		9		39	8	29	
Wallichia disticha T. Anderson			<1		8	5	10		3			
Licuala peltata			1		15							
Uvaria macrophylla Roxb.	3		1						4		25	
Bridelia burmanica Hook. f.			5		3						3	
Pandanus wallichianus Martelli			1		4		1		<1			
Ficus religiosa L.	3	9	2				<1				3	
Carallia brachiata Merr.	1	9	2	4			1				1	
Number of faeces	317	23	592	23	376	21	673	17	321	24	94	16
Total number of single species fragments in faeces	343	8	601	2	400	7	757	0	317	4	99	0
Number of species in faeces	9	4	21	2	20	4	10	0	13	3	8	0
Number of species fragments / Number of faeces (%)	108	35	102	9	106	33	112	0	99	17	105	0

Table 4. Percentages of faeces of P. hermaphroditus *(CPC) and* V. indica *(SIC) containing fragments of the six most commonly eaten prey, with a summary based on all prey categories identified.*

Item fragments	**Jan/Feb**		**Mar/Apr**		**May/Jun**		**Jul/Aug**		**Sep/Oct**		**Nov/Dec**	
	CPC	**SIC**	**CPC**	**SIC**	**CPC**	**SIC**	**CPC**	**SIC**	**CPC**	**SIC**	**CPC**	**SIC**
Jullus remains	5	35	<1	17	3	19	1	82	8	42	13	38
Bones & hair (*Rattus*)	1	39	1	57	3	52	<1	41	3	21		13
Scorpion remains	2	35	<1	35	1	10	1	47	3	17	11	44
Insect remains (unidentified)	<1	17	1	30		38	1	35	1	4		
Gryllus remains				4	<1	5	1	29	6	13	8	19
Bird feather	<1	4	<1	9								
Number of faeces	317	23	592	23	376	21	673	17	321	24	94	16
Total number of single species fragments in faeces	31	34	14	35	29	28	45	38	71	25	29	18
Number of species in faeces	6	8	5	6	5	6	5	5	8	7	3	4
Fragments / number of faeces (%)	10	148	2	152	8	133	7	224	22	104	31	113

millipedes *Jullus*, scorpions, and crickets *Gryllus* are abundant. A small amount of fruit was taken during most seasons except in July/August, when fruit is relatively scarce, and during November/December.

Discussion

All methods of recording *P. hermaphroditus* and *V. indica* in Hlawga point to the population of the former being at a much higher density. This could be predicted by the diets of the two species, with the largely frugivorous *P. hermaphroditus* showing the relatively high density of a herbivore with an abundant food resource and *V. indica* a much lower density typical of a predator that forages widely on a seasonally fluctuating food supply.

Results from radio-tagged individuals show the two species to use their shared mixed deciduous forest and shrubland habitats in largely different ways. *P. hermaphroditus* found most of its year-round needs of food and shelter in the tall trees of the forest habitat, except for limited (8%) seasonal use of the shrubland. *V. indica*, by contrast, foraged widely in both habitat types but spent 99% of its day-time resting hours in the shrubland. This distinction of habitat use reflects the difference in type and location of the resting sites of the two civets. While the rather arboreal *P. hermaphroditus* preferred the security of dense canopy high above the ground, the more ground-dwelling *V. indica*, which might well be better able to defend itself against predators, selected dense cover in shrubbery near to the ground. Thus, there is limited potential competition for resting sites between the two species.

Both species foraged during the hours of darkness. There was little difference between their respective periods of major activity, both being most active between 19h30 and 03h00. However, that *V. indica* showed little activity during the sunset twilight (17h00–19h30) may indicate a need for complete darkness before successful predation, especially on vertebrates, can be readily achieved. It may also reflect a fear of meeting humans wandering around during this period. There is a sharp distinction between the storeys at which most of the foraging of the two species takes place. While the largely fruit diet of *P. hermaphroditus* is obtained high above ground level from tall fruiting trees and climbers, the majority of *V. indica* food is available at ground level, except potentially for limited seasonal intake of the same fruit species as consumed by *P. hermaphroditus*. Even so, it is possible that at least some of this is ripe fruit which has fallen to the ground. Because fruit consumption by *V. indica* occurs during seasonal fruit abundance, it is unlikely that there is competition for this resource.

Linked to habitat use and foraging styles, the respective diets of these two small carnivores show their niche differentiation clearly. Although both species are in a strictly literal sense omnivorous, *P. hermaphroditus* is predominantly a frugivore, and *V. indica* is primarily a predator of small vertebrates and arthropods. It seems, however, to minimise the amount of energy required for hunting by selecting opportunistically both animal and plant food items, such as arthropods and fruit, during seasons of local abundance. This is most clearly illustrated by the large peak in mainly millipede remains in its faeces during July/August when fruit is relatively scarce and is not eaten at all. Conversely, prey remains are at a low in September/October when advantage is taken of a brief peak in fruit availability. While both species of civet tend to feed on some of the same plants and many of the same animal species, the limited intake of animal items by *P. hermaphroditus* and the fact that increases in the normally low level of fruit intake by *V. indica* are confined to periods of seasonal fruit abundance suggests there is little competition for food during any season.

Hence the niche of *P. hermaphroditus* in Hlawga can be summarised as that of a small, solitary, nocturnal frugivore which mostly feeds and rests in the canopy of trees typical of mixed deciduous forest, in which habitat type the population spends the great majority of its time. The niche of *V. indica* is different, being that of a small, solitary, nocturnal predator on small vertebrates and arthropods, that forages widely in different habitat types at ground level and seeks daytime shelter in dense vegetation near to the ground.

The lifestyle of *P. hermaphroditus* might render it vulnerable to the cutting of forest trees for timber or fuelwood, which reduces both its daytime shelter and its food supply. *V. indica*, on the other hand, is vulnerable to the seasonal burning of shrubland that destroys its resting sites and the ground cover that facilitates its hunting, particularly of small vertebrates. Both vertebrate and invertebrate prey species are killed by large-scale fires, so that *V. indica* food supply in the shrubland habitat is seasonally depleted. Conservation management in relation to both these small carnivores thus should enforce measures (already legally in place) aimed at minimising illegal felling of trees and burning of shrubland, both of which are prevalent in Hlawga Wildlife Park in spite of its status as a protected area.

Acknowledgements

The senior author wishes to express her thanks to the Division of Nature and Wildlife Conservation, Forest Department for permission to work in Hlawga and for logistic assistance, and to the Wildlife Conservation Society International and Myanmar Programs, notably Saw Tun Khaing, Than Myint and Alan Rabinowitz, for financial support, the lending of camera-traps, and advice and discussion. Women in Conservation, UK provided radio-collars and a radio receiver was lent by the Smithsonian Institution. This author is grateful to Dr Soe Yin, Rector of the University of Yangon, and Professor Tin Nwe, Zoology Department, University of Yangon, for their encouragement. Chris Wemmer and Peter Leimgruber from Smithsonian Institution, who shared their knowledge, are also gratefully acknowledged. The junior author acknowledges financial assistance for visits to Myanmar from ITTO and the Third World Academy of Sciences.

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Announcement

25th Mustelid Colloquium, 4 -7 0ctober 2007, Trebon, Czech Republic

Czech Otter Foundation Fund and Agency for Nature Conservation and Landscape Protection of the Czech Republic.

With the support of the Ministry of the Environment of the Czech Republic.
With the auspicies of the Mayor of the Town of Trebon.

We would like to invite you to attend the 25th Mustelid Colloquium. The meeting will be held at Trebon in South Bohemia (Czech Republic) from October 4th - 7th 2007 and it is co-organised by the Czech Otter Foundation Fund and the Agency for Nature Conservation and Landscape Protection of the Czech Republic.

The conference is open to everyone with an interest in the Family Mustelidae and this year for the first time also for those interested in the Raccoon Dog. Scientists, students, conservationists, both, professionals or volunteers, are welcomed. Plenary and poster sessions will cover various aspects of ecology, behaviour, biogeography, genetics, physiology, population and habitat management, and conservation biology related to the above mammals. Additionally there will be a series of workshops and/or round tables on various topics which will be specified latter.

Additional information can be found at www.mustelid2007.org.

Small carnivores in mixed-use forest in Bintulu Division, Sarawak, Malaysia

Giman BELDEN, Robert STUEBING and Megom NYEGANG

Abstract

Camera-trapping in the Sarawak's Planted Forests Project, Bintulu Division, supported by direct observations revealed regular usage of the exotic *Acacia mangium* plantation by Tangalung *Viverra tangalunga,* Common Palm Civet *Paradoxurus hermaphroditus* and Short-tailed Mongoose *Herpestes brachyurus*, and occasional records of most of the diverse community of small carnivores in the remaining natural forest of the project area. The rare Sunda Otter Civet *Cynogale bennettii* was recorded in natural habitats. Conversion occurred too recently to allow prediction of eventual small carnivore communities in the plantations. More information is needed on this greatly under-researched topic, given that most of the world's surface will not contain pristine natural habitats into the long term.

Keywords: acacia, adaptability, Borneo, exotic plantations, forest buffers, forest conversion

Introduction

Little field information has been published over the past 30 years on small carnivore families of Southeast Asia. In particular, there is almost no information concerning their distribution and status in forest plantations or logged forest. In February 2005, Grand Perfect Conservation began a collaborative research programme with the Conservation Research Center, Smithsonian Institution, USA, to conduct baseline surveys, using remote trip cameras, of the diversity and status of terrestrial mammals, including small carnivores, in a mixed-use forestry project. Direct observations, registration of tracks and faeces, and results from interviews with local residents were also taken into account, but were used only as supporting information because the identity of certain species of small carnivores can sometimes be misjudged using such methods (Choudhury 1997).

The Forest Department Sarawak's Planted Forests Project (the Planted Forest Zones, or PFZ; Fig. 1) is located in the Bintulu Division of Sarawak. About 40% of the area of low rolling hills will eventually be planted with *Acacia mangium*, an exotic species native to Australasia (including New Guinea). Management boundaries were established in early 2003, although planting of *A. mangium* had started in 1999, as soon as old-growth forest was cut down. Plantation had been extended to an area of approximately 38,000 ha within the PFZ by 2005, with a target of 205,000 ha by the end of 2009 (Stuebing & Wong 2005). Forested areas remaining will consist of stream buffers, swamps, steep slopes and other land unsuitable for planting, as well as shifting cultivation (including Native Customary Rights) lands. These lands will function as wildlife 'reservoirs'. Samarakan Planted Forest Zone, which covers about a third (about 60,000 ha) of the whole plantation area, consists of a majority of acacia plantation. About 10% of the zone is set aside as river buffers and wildlife corridors for biodiversity protection.

Preliminary results (February 2005–June 2006) from about 2000 camera-trap-nights (which yielded about 300 photographs of large mammals and non-volant small mammals), and the other techniques, include records of six viverrid, two herpestid and two mustelid species in the PFZ. This paper provides general notes on the distribution and status of these species, particularly in the acacia plantation. Background to the study, including fuller profile of the survey areas, the precise camera-trapping protocol, and species tallies for the first few months of camera-trapping, is given in Belden *et al*. (2007).

Species notes
Details on each photograph of each species taken are given in Belden *et al*. (2007), with the text below expanding on discussion and speculation about each species's local status.

Yellow-throated Marten *Martes flavigula*
The marten has been recorded only from the Samarakan area of the PFZ, both inside acacia plantation adjacent to the forested area and in the forested area itself. Two photos of this species were taken during daytime. No other direct observation or recent reports exist for this species from the study area.

Malay Weasel *Mustela nudipes*
Two observations of the weasel were recorded in Tubau Planted Forest Zone, both observed running across skid trails between blocks of acacia plantings. It is one of the most easily recognised small carnivores with its bright orange body contrasting with its pale whitish head (Payne *et al*. 1985), and hence the field sightings are taken as certain records. No photograph has yet been taken for this species in the PFZ, but across its range it seems to be very difficult to record in camera-traps (Duckworth *et al*. 2006). There are no reports as yet from the Samarakan area of the PFZ or any of the wildlife reservoirs. Its current status is still unclear.

Tangalung (Malay Civet) *Viverra tangalunga*
The Tangalung is the most commonly seen civet in the area, and inhabits hills, plantation adjacent to forested areas, lowland forest and riverine buffer. It was observed walking near human habitation inside the acacia plantation. This species was recorded throughout Tubau (north-east Bintulu) to Samarakan (southern part of Bintulu). Camera-trap photographs were taken mainly at night (13 photos), but with three by day. Although usually regarded as nocturnal (e.g., Payne *et al*. 1985), it is perhaps mostly crepuscular (e.g., Colón 2002, Azlan 2005), and significant day-time activity levels were reported from Buton island, off Sulawesi (Jennings *et al*. 2006).

Common Palm Civet *Paradoxurus hermaphroditus*
The Common Palm Civet is one of the two most common civets recorded, and has been observed in mainly at night with a few photos by day. The so-called 'toddy cat' seems to adapt well to disturbed environments such as the acacia plantation, as it was often recorded within acacia blocks although these were within 300–400 m from natural forest. This species is frequently taken by

local hunters for food or as a pet; however this is not obviously affecting wild populations because most local hunters, particularly in Sarawak, prefer to hunt bigger animals due to difficulty and cost of obtaining bullets (M. Nyegang personal observation).

Binturong *Arctictis binturong*
The Binturong was not commonly recorded by camera traps, perhaps due to its largely arboreal behaviour. One photo of this species was taken from disturbed forest surrounded by acacia plantation. One living animal was confiscated by the camp manager from his workers and was released straight away into the conservation area. It is evidently sometimes mistaken with young Sun Bear *Helarctos malayanus* by non-specialists, and still no recent records or reports have been collected inside acacia plantation. Its current status remains unclear.

Small-toothed Palm Civet *Arctogalidia trivirgata*
One live Small-toothed Palm Civet from Binyo-Penyilam Conservation Area (peat swamp 'lakes' and lowland *kerangas* forest), south-east Bintulu, treated as a pet by local people was observed. Three individuals were captive in Taman Tumbina (Flora and Fauna Park) in Bintulu division (G. Belden personal observation). No camera-trap photo has been taken of this species in the PFZ, reflecting the difficulty to detect it by ground-level camera-trapping due to its arboreal behaviour (e.g., Walston & Duckworth 2003, Holden 2006). It is impossible to tell whether it might adapt to the radical environment changes of the acacia plantation. Hunters in the plantation area (although not necessarily elsewhere in Sarawak) prefer Small-toothed over Common Palm Civet for food and as pets, and some use illegally-obtained bullets, which are cheap, so they do not need to think about their cost so much. Even so, it seems to be still common in the Tubau planted forest zone. For example, ten were seen in two hour's spotlighting one night in early 2007 (G. Belden, personal observation).

Sunda Otter Civet *Cynogale bennettii*
This semi-aquatic civet is probably the rarest of all viverrids yet found in the PFZ, and perhaps in Borneo. Little information is available regarding its status and behaviour (Veron *et al*. 2006). One photo of this species was taken in March 2005 from Bukit Sarang Conservation area (south-west Bintulu), an area covered by freshwater swamp forest combined with a limestone hill forest which serves as a wildlife reservoir. A recent direct observation (at approx. 6 metres range) in the same area (B. Lardner personal communication to Veron *et al*. 2006) also confirmed this species in the area. Further study to assess this species's local status is underway.

Short-tailed Mongoose *Herpestes brachyurus*
Of the three species of mongooses found in Borneo, the records of short-tailed animals are assumed to relate to Short-tailed Mongoose rather than the morphologically very similar Hose's Mongoose *H. hosei*, which differs mainly by skull characters (Payne *et al*. 1985). Short-tailed Mongoose appears to be relatively common

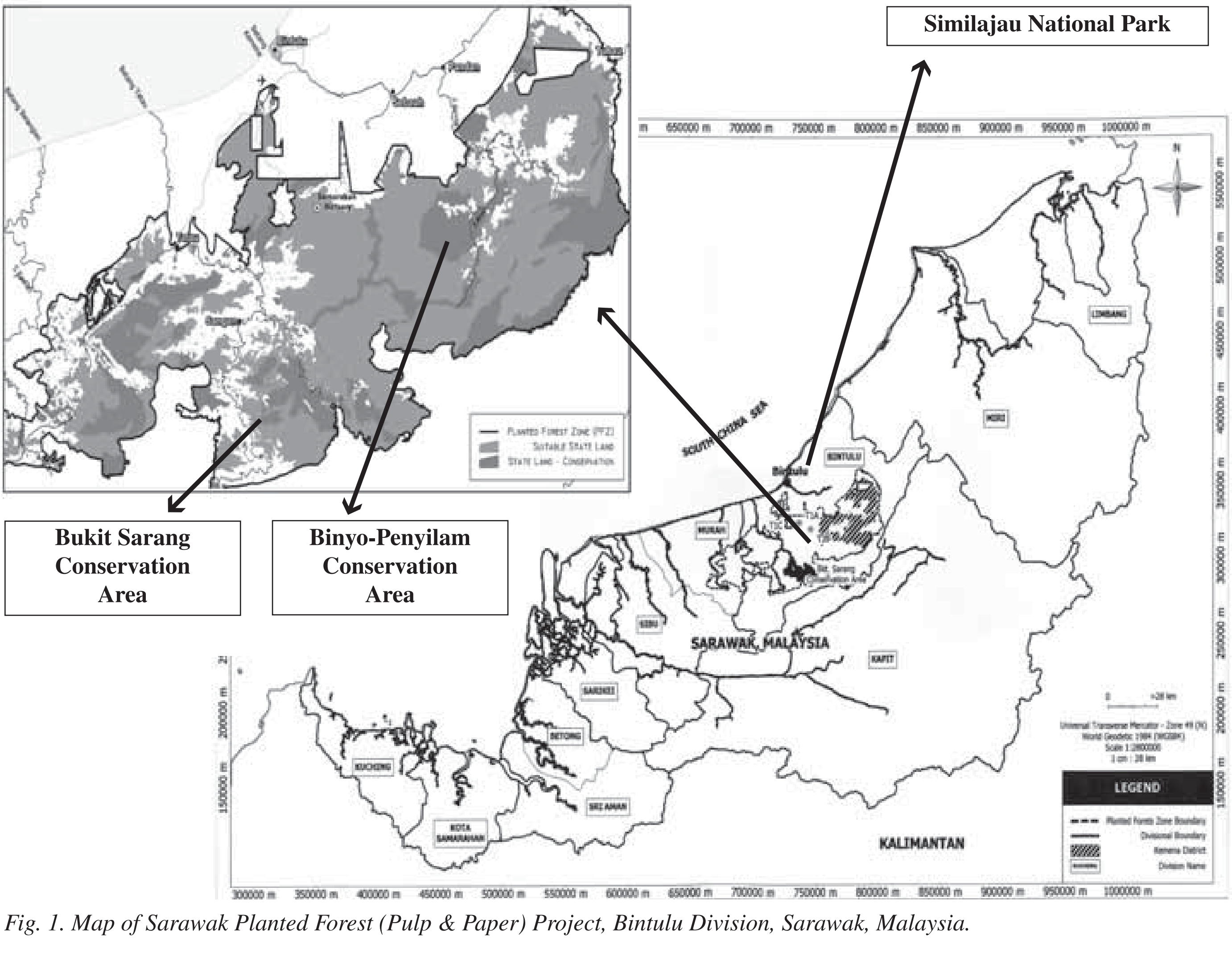

Fig. 1. Map of Sarawak Planted Forest (Pulp & Paper) Project, Bintulu Division, Sarawak, Malaysia.

in acacia plantings and has been recorded in forested areas as well. Sometimes it can be seen being chased by dogs as it seems to be frequently found near human settlements. It has been recorded equally by day and by night in acacia plantings. One pair of mongooses was seen walking across the main road near the Samarakan nursery. It is not a species hunted by local people.

Collared Mongoose *Herpestes semitorquatus*
The only observations from the PFZ are a single clear photo from an acacia plantation in August 2006, and a lone observation of an individual running quickly across the main road leading to the Samarakan plantation area in early 2006. Since this species can be confused with Short-tailed Mongoose, information from interviews is unreliable. The current status of *H. semitorquatus* in the PFZ remains unclear, and indeed little is known about its natural history. Future assessments will be conducted to obtain anecdotal information regarding its patchy distribution in such plantations.

Discussion

Few recent studies have focussed on the ecology and conservation status of small carnivores, particularly in plantations or other areas where habitat has been seriously disturbed (e.g., Azlan 2003). Most research has been directed at large carnivores and game species, and was carried out in areas of primary or relatively little-disturbed forests. The Bintulu PFZ is a study area which can reveal the impacts of land conversion and the types of conservation measures that need to be applied to ensure long-term survival of the small carnivore fauna. As noted above, the local conservation status of species including *Cynogale bennettii*, *Herpestes semitorquatus*, *Mustela nudipes*, *Arctogalidia trivirgata* and *Arctictis binturong* is still not clear. In the PFZ, planting of *Acacia mangium* will have been extended substantially, with a target of 205,000 ha, by the end of 2009. This will certainly influence species abundance and possibly affect population persistence. It may be a particular problem for those which seem to occupy mature habitats, especially *Cynogale bennettii* and *Arctictis binturong*.

Based on current results, silvicultural habitats may be found to support high numbers of certain small carnivores. *Viverra tangalunga, Paradoxurus hermaphroditus* and *Herpestes brachyurus* all tolerate or even reside in acacia plantations, despite the seemingly radical differences between acacia and natural forest. Nevertheless, establishment of additional ‘reservoirs’ or wildlife corridors should be considered to minimise the potential of local population reductions or losses. Also, the current status of each of these species needs to be interpreted cautiously for two reasons. Firstly, the habitat conversion took place relatively recently, and it may take some years for populations to reach a new equilibrium (which might be local extinction) following such disturbance (Tilman *et al*. 1994). Secondly, the old-growth forest remaining nearby could serve as a source for a resident population in the artificial habitats, or supply transient animals during dispersal. A deeper understanding of small carnivore population dynamics in acacia plantations and other highly disrupted habitats is needed.

Natural forests continue to be to converted to plantations. Clearly, it is important to continue to work towards conserving small carnivore diversity in plantation landscapes. Careful assessments of original densities and abundance of each species, as well as long-term monitoring are fundamental to success in such conservation programmes. The more we know the more we will be able proceed towards effective conservation management.

Acknowledgements

This study was a collaborative project between Grand Perfect Sdn Bhd and the Conservation and Research Center, Smithsonian Institution, USA. The authors would like to thank the conservation staff, Mr Azizan Juhin, Ms Angela Paul, Ms Roslina Ragai, Ms Chin Sing Yun, Ms Diana James Junau, Mr Joanes Unggang, Mr Stephen Stone, Mdm Latiffah Waynie, and Ms Jacinta. Appreciation is also forwarded to Mr Engkamat Lading of Sarawak Forestry and Mr Azlan Jayasilan for their administrative and field support during the camera trapping survey. Many thanks also to William Duckworth for reviewing my earlier manuscript. Special thanks to Mr Su See Kong and his fellows in Bukit Sarang Conservation Area for their assistance in the field.

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Camera-trap avoidance by Kinkajous *Potos flavus*: rethinking the "non-invasive" paradigm

Jan SCHIPPER

Abstract

Nocturnal arboreal mammals are challenging to study in the wild, especially in dense tropical forests. Camera-trapping is a non-invasive method to study elusive species and is increasingly used to document species presence, habitat use, and density. However traditional camera-flash systems may in fact be "invasive" when used to study animals that completely rely on vision to navigate the rainforest canopy at night. This study demonstrates that using standard flash photography in camera-traps can lead to avoidance behaviour in Kinkajou *Potos flavus*. Researchers wishing to study nocturnal arboreal mammals should explore infrared techniques when using camera-traps in the canopy.

Keywords: arboreal, canopy highway, Costa Rica, frugivore, neotropical, nocturnal

Resumen

Los mamíferos nocturnos arbóreos son muy difíciles de estudiar en el campo, principalmente en bosques tropicales densos. El uso de cámaras trampa es considerado un método "no invasivo" para estudiar los mamíferos huidizos (esquivos) y es muy útil para confirmar su presencia, evaluar el uso de hábitat y estimar densidades. Sin embargo, el flash de las cámaras fotográficas podría ser invasivo para estudiar especies que tienen ojos adaptados para la visión nocturna para poder navegar las copas de los árboles en la oscuridad. Este estudio demuestra que el uso de flash en sistemas tradicionales de cámaras trampa puede afectar el comportamiento de algunas especies que podrían cambiar sus rutas de movimiento dentro el dosel. Por lo tanto, sugerimos buscar alternativas para cámaras trampa (ej. técnicas infrarojo), que no tengan ningún efecto sobre las variables que queremos medir, tales como presencia y frecuencia de pasaje por un punto de muestreo.

Introduction

The Kinkajou *Potos flavus* is a relatively poorly understood nocturnal, arboreal, and frugivorous carnivore, which inhabits tropical forests throughout Middle and South America. These seemingly contradictory ecological parameters have arisen from evolutionarily selective pressures to exploit the bounty of resources in the rainforest canopy, namely, fruit, leaves, and insects (Kays 1999). These traits also differentiate the Kinkajou from most other neotropical small carnivores (with the notable exception of the sympatric olingoes *Bassaricyon* spp.). Kinkajous are difficult to study *in situ*, and most of what we do know about them in the wild comes from a handful of studies, notably in Guatemala (Walker & Cant 1977), Panama (Kays & Gittleman 1995, 2001, Kays 1999) and French Guiana (Julien-Laferrière 1993, 1999). In this study, we examine Kinkajou behavioural responses associated with the use of camera-traps, specifically, the effect that standard flash photography has on trap avoidance behaviour. This behavioural response has subsequent impacts on data analysis and interpretation of inferences of abundance derived from this method. Based on our observations and findings, I do not recommend the use of standard flash camera-traps for the study of Kinkajou or nocturnal arboreal species whose hyper-sensitive eyes, though ideal for climbing trees at night, are not suited well for standard flash photography.

Arboreal tropical forest mammals can be extremely challenging to study in the wild (Kays & Allison 2001), which with the notable exception of primates, explains why so little is known about them. Most of the scientific information available for Kinkajou comes from *ex situ* work with captive animals (Ford & Hoffman 1988), therefore developing non-invasive techniques to study this species *in situ* is a priority for ecological research. Camera-traps are becoming an increasingly useful "non-invasive" tool for studying ecological parameters and activity patterns of elusive and otherwise difficult to study species (Sanderson & Trolle 2005). Camera-trap design and functionality have improved greatly over the past few years and they have begun to incorporate digital and infra-red technology, though not without limitations. As camera-traps continue to aid scientists in answering previously difficult research questions, there is some need to evaluate the potential effects this research and monitoring tool can have on the species being studied. Below, I present ecological notes on the observed effect of camera-trapping on Kinkajous in Costa Rica. Inference would suggest that information described for Kinkajou would also pertain to the olingoes and other nocturnal arboreal species.

Many different types of information can be collected from a camera-trap array—including patterns of density and distribution, habitat use, and activity. The interpretation of such data often assumes that species do not have a behavioural response; however that assumption is not always valid. If a behavioural response occurs, analytical tools should be used which account for heterogeneous capture probabilities (e.g., a nested model such as M_h or M_{bh} in program CAPTURE) otherwise results will be biased (Otis *et al*. 1978, White *et al*. 1982). We have noticed in our work in the neotropics that a number of species will change their behaviour, often several times, during a camera-trap study (J. Schipper unpublished data). We attribute some of these changes to the cameras themselves and others to the presence of researchers. One behaviour effect which can have a compounding effect on data and estimates of "recapture" necessary to calculate density in a capture-recapture framework is trap shyness. This behaviour effect has been observed in a number of carnivores, including Tiger *Panthera tigris* (Wegge *et al.* 2004). Another effect, which I will describe herein, is trap avoidance—a behaviour I observed with Kinkajou during a 20-day canopy camera-trap campaign.

Study Site

This study was undertaken in the Gandoca–Manzanillo National Wildlife Refuge (9°37'N, 82°39'W), located in the southern coastal Caribbean plain of Costa Rica between the towns of Puerto Viejo and Manzanillo, Canton de Talamanca, Provincia de Limon. The region is dominated by lowland coastal moist forests interspersed with swamp forests and wetlands. The wildlife refuge laws do not exclude people, thus the study site was located in a mosaic of forest patches amidst hotels and residences. Outside the existing protected areas, there are extensive banana plantations mixed with plantain, cacao, and other crops. The study site was selected for this particular investigation because of numerous reports of "night monkeys (mono nocturno)" and a canopy camera-trapping system was devised in attempt to record Western Night Monkeys *Aotus lemurinus* that have not been recorded in Costa Rica in over 40 years (Timm 1994). Researchers later learned that the local Creole language had adopted the term "night monkey" to refer to *Potos flavus* and not to the nocturnal primate, although this was not historically the case. Thus the study described herein began as a search for night monkeys and became an experiment on the effect of placing camera traps in treetops on Kinkajous.

Methods

The information provided herein is based on observations and photographs taken over a 20-day period (6–26 November 2004) at one trap site, nested within a 100+ site camera-trapping campaign that lasted two years. Observational data collection began one week prior to setting the camera-trap and extended until the end of the study. The camera-trap used in this study was placed in the canopy of a large *Persea* (Lauraceae) tree. Direct observations were made periodically during the study by flashlight and binoculars in order to document species behavioural response. These observations consisted of following an active individual or group of Kinkajous as they moved through the treetops of the study site from one forest fragment to another, which they did every 3–5 nights (weather permitting) as part of their foraging routine.

We used a standard film camera-trap (PTC Technologies), modified to improve moisture resistance and security, set with a 1-minute time delay between photographs and 24-hour activity (day/night). The camera-trap was attached to the main trunk of the tree 15 m above the ground, facing horizontally down a branch that extended into a neighbouring canopy. This interlinking of canopies, sometimes referred to as "canopy highways" allows animals to cross relatively effortlessly between trees and, in this case, between forest patches. Thus using such a "highway" as a camera-trapping site greatly increases the probability of capture and catch per unit effort. However, care must be taken to ensure that the sensor beam is crossed diagonally. Species approaching directly do not actually "cross" the passive infrared sensor to trigger the cameras until it is too late and photos tend to be out of focus, at best. Prior to selecting a site for setting the camera-trap, it is useful to watch diurnal species approach the problem of crossing from tree to tree. In this study, we watched how various species (including squirrels) would navigate the branches at the site to lend some insight on how and where to place the camera.

The tree chosen for placing the camera-trap was located in a strip of forest connecting two fragments along the coastal zone, providing a critical link between fragments and between neighbouring trees for movement. Interviews with local people had suggested that there was occasionally nocturnal activity in the treetops in this area. A bow and arrow (weighted with nails) were use to place a monofilament line over the desired branch in the tree crown, which was then used to hoist a nylon cord. A braided static climbing rope was then hoisted up using the nylon cord, which was then used to ascend the tree. Jumar ascenders, connected to a climbing harness (see Perry 1978 for access technique), were used to climb the rope and access the trap site. Once in the canopy, the camera-trap was fixed to the tree using two nylon straps. The camera was set facing outwards from the tree trunk to a branch which was known to serve as a movement corridor for arboreal species. The sensor was directed to detect movement approximately 10 feet away, such that the field of view was sufficiently ample for

From top to bottom: Kinkajou looking at camera-trap; Kinkajou stunned from flash; Kinkajou returning to where it came from after third flash from camera trap.

any error in levelling of the apparatus. The camera-trap was tested with great caution as it is quite difficult to move horizontally on a vertical rope.

Direct observations of the site were made from a hide nearby at ground level and by scanning the nearby trees for movement. Investigators waited for a group of Kinkajous to approach the site, then watched the group as it made its way across the trap-site. As the purpose of this study was to simply record the presence of nocturnal arboreal mammalian species, traps were neither paired nor rigorously maintained (as access to the canopy is somewhat strenuous) during the relatively short period of study.

Results

A total of ten photographs of Kinkajous were taken during the 20-day period of the study. Six of the photos were taken almost consecutively on the second night of the study, after which there were no photos for 10 days when another four pictures were taken. Observation of the site prior to installation of the camera demonstrated that a group of Kinkajous (three individuals, including two juveniles) were using the site every 2–5 days. On the second night of operation of the camera, the group attempted to cross the branch where the camera-trap was aimed, however the lead animal would not pass the point at which the camera was triggered. Instead the individual would ascend the branch until its photograph was taken (see sequential photographs, 1–3) and not further. On no occasion did the other individuals in the group attempt to pass the spot, and in fact, during the study the group never traversed the site.

Our findings suggest that Kinkajous exhibit a progressive avoidance behaviour over time following the triggering of a canopy camera-trap with a traditional flash. Although the physiological reason for this behaviour is not clear, I believe that the brightness of the flash temporarily affects their vision and is likely to cause great distress to the individual. There is a small recovery period following the flash when the individual does not move at all—which I believe to be due to the fact that it is temporarily blinded by the flash. This seems plausible as their eyes are much more sensitive to light than humans, who would react similarly to such a flash. The Kinkajou would only approach to the point a photo was taken, get very anxious and look stunned following the flash, turn around, sometimes call out, and repeat the process. However, the individual always stopped and turned around to rejoin the other members of the group after being flashed upon, and would not advance past the camera-trap. We refer here to this behaviour as trap avoidance, and distinguish this from trap shyness because where ‘shyness’ suggests reduced visitations, avoidance suggests a complete abandonment of the area—in this case, a branch along a frequently-used canopy highway.

Placement of a camera-trap in the canopy is not without its complications. Finding an appropriate branch configuration that is functional both for research and for a species’ movement is a challenge, though we have found attaching directly to the trunk is helpful for several reasons: 1) it prevents excessive sway from wind and thus false triggers, 2) the wider contact surfaces prevent slippage of the camera-trap and thus misalignment, and 3) the camera-trap is much easier to access along a trunk than on outer branches. One additional recommendation is that, when on an emergent tree or along clearings (where a horizon is visible), the camera should not be facing towards sunrise or sunset as it will reduce the chances of photographing crepuscular animals and also cause false triggers.

Conclusions

Trap avoidance or the behaviour change in which a species avoids the precise spot in which a trap is located, is the observed result of flash photography in the canopy at night. A possible solution for future efforts would be to use infrared flash or infrared film, or low-light night vision technology that does not employ a bright light aimed directly at the study subject.

The implications of this behaviour are three-fold. First, camera-trapping in this case should not be considered a non-invasive study technique and it appears to have caused certain stress both to the individual being photographed and to what is presumed to be a family group. Second, the camera flash acted as an effective deterrent and prevented the kinkajou from passing the spot and thus blocked the group from continuing on an otherwise normal foraging routine. Third, this behaviour effect would preclude effective density estimation (absolute or relative) of animals or effective monitoring, as the use of flash influences the probability and likelihood of recapture (thus skewing any possibility of analysis using capture-recapture techniques). In addition, if there had been an alternative method to crossing the fragment without passing the camera this would doubtless have been used (and could result in a recapture rate of zero once the group learned how to avoid the camera flash). Kinkajous do not have patterned coat variation, however they can be readily identified by scars, fur markings and other physical characteristics (similarly, we can easily distinguish individual Pumas *Puma concolor* and Baird’s Tapirs *Tapirus bairdii* with some practice). The ability to identify individuals is an important attribute in estimation of absolute density using capture-recapture techniques. The next logical step in researching the effects of flashes on nocturnal arboreal species is to try infra-red camera-traps to see if there is any notable trap avoidance over time.

It should be noted that standard flash camera-trapping is not a useful tool for studying this and similar species. In three years (over 7,000 trap nights) of using camera-traps in this and other nearby forests, only one photo of a Kinkajou was taken on the ground, walking across a dirt road where the canopy connectivity had been broken. During observational studies, it was also noted that even low powered flashlights are enough to stop a Kinkajou in its tracks for some time and brighter lights seem to cause greater disturbance.

In conclusion, I propose that researchers wishing to study nocturnal arboreal species consider the possible effects traditional camera flashes might have on the species of interest. Although in most cases camera-trapping is an excellent non-invasive tool, this is not always the case. Regrettably, this study was not designed to systematically collect information on behavioural effects and was done opportunistically. However, we have documented by direct observations and photographs that the installation of a camera-trap in the canopy acted as a barrier for movement between two forest fragments linked only by a narrow stretch of trees. By using an alternative flash system (infra-red) this problem could presumably be avoided. Thus, researchers should seriously consider the use of infra-red camera-trapping systems when studying species which might be adversely affected by flash photography—such as Kinkajous and olingoes. It is proposed that arboreal species that risk falling out of a tree should they be startled due to their specialised nocturnal vision are the most likely to show trap avoidance behaviour, while nocturnal terrestrial species that do not risk falling are more likely to develop trap shyness or display no unusual behaviour. Further research is needed to expand upon this hypothesis. However, the lesson learned is to take these factors into consideration when working with "light-sensitive" species, as camera-trapping is not always a non-invasive technique.

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Addendum

Addendum to: Anisimova, E. I., Katchanovskaya, P. D. & Katchanovsky, V. A. 2006. European Mink *Mustela lutreola* as a host of the *Spirometra erinaceieuropaei*. *Small Carnivore Conservation* 34&35: 25.

In the last issue we excluded the photographs accompanying this article showing the helminth *Spirometra erinaceieuropaei* (marked by arrows) in dissected European Minks. We reproduce them here, with apologies to the authors.

Evaluation of two covered track stations to detect forest carnivores

Jerrold L. BELANT

Abstract

Numerous types of baited track stations have been used to detect forest carnivores. I compared the efficacy of wooden and plastic covered track stations to detect American Marten *Martes americana*, Fisher *M. pennanti*, and Northern Raccoon *Procyon lotor* in Michigan, USA, during 2002–2003. The number of sample units in which species were detected and mean latency to detection for each species was similar for wooden and plastic track stations. Also, the total number of detections for each species was similar for both track station types. Rain did not adversely affect either track station. Plastic covered track stations required more effort to set up and were more expensive, but weighed less than wooden track stations. Wooden covered track stations are most suitable when working in areas with vehicle access whereas plastic covered track stations are more suitable when working in remote areas.

Resumen

Numerosos tipos de estaciones de huellas con cebo han sido utilizadas para la detección de carnívoros de bosque. Compare la eficacia de estaciones de huellas cubiertas por plástico y madera para la detección de Martín americano *Martes americana*, Pescador *M. pennanti* y Mapache del Norte *Procyon lotor* en Michigan, EUA, durante el 2002 y 2003. El numero de unidades de muestreo en que las especies fueron detectadas y el promedio de latencia para detección para cada especie fue similar para estaciones de plástico y madera. A su vez, el número total de detecciones para cada especie fue similar para ambos tipos de estaciones. La lluvia no significo un factor adverso en ninguna estación. La estaciones cubiertas por madera son más ajustables cuando las áreas de trabajo cuentan con acceso para vehículos mientras que las estaciones cubiertas por plástico son más útiles en áreas remotas.

Keywords: American Marten, Fisher, *Martes americana*, *Martes pennanti*, Northern Raccoon, *Procyon lotor*, survey methods, track plates

Introduction

The need for land management agencies to monitor forest carnivore populations has increased in recent years (Ruggiero *et al.* 1994). Consequently, numerous techniques have been developed or refined to facilitate carnivore monitoring (e.g., Gese 2001, York *et al.* 2001, Belant 2003a, 2003b). Track stations are one method used frequently to detect presence and habitat use of many carnivore species (Barrett 1983, Loukmas & Halbrook 2001, Fecske *et al.* 2002). Track stations can be classified as open or covered (Zielinski & Kucera 1995), with the type of station used dependent on the species being surveyed and other factors, including weather conditions.

Although several types of covered track stations have been used to survey carnivores (King & Edgar 1977, Zielinski & Kucera 1995, Gompper *et al.* 2006), comparisons between types of track stations have been limited (e.g., Foresman & Pearson 1998). Several factors could influence carnivore detection at covered track stations including materials used to construct track stations, size of entrance opening, and tracking medium or substrate. Zielinski & Kucera (1995) attempted to standardise use of track station devices in forest carnivore surveys. My objective was to compare wooden and plastic covered track stations, the two covered track stations emphasized in Zielinski & Kucera (1995), for the detection of American Marten *Martes americana*, Fisher *M. pennanti* and Northern Raccoon *Procyon lotor*. Performance comparisons were based on species detection rates, latency to first detection (LTD), effort for field placement and cost.

Study Area

The study was conducted in the central Upper Peninsula of Michigan, USA (46°20'–40'N, 85°50'–86°10'W), on land administered by the Hiawatha National Forest (HNF) and the Pictured Rocks National Lakeshore (PRNL). The study area consisted of uneven-aged forests. In areas with well-drained soils, tree species were predominantly Sugar Maple *Acer sacharrum* and American Beech *Fagus grandifolia*. Areas with moderate- to poorly-drained soils contained several coniferous tree species including spruce *Picea* spp., Balsam Fir *Abies balsamea* and White Cedar *Thuja occidentalis*. From concurrent carnivore monitoring and radio-telemetry studies, I determined that American Marten, Fisher, and Northern Raccoon were present throughout the HNF study area, whereas only American Marten and Northern Raccoon were present at PRNL (J. L. Belant, unpublished data).

Methods

Wooden and plastic covered track stations used in this study were constructed as described by Zielinski & Kucera (1995) with two exceptions. I used screws in place of rubber straps to hold wooden track stations together and used photocopy toner (Belant 2003b) in place of soot as a tracking medium. Wooden covered track stations consisted of a box with inside dimensions of about 25 × 25 × 81 cm. The boxes were made using four pieces of 13-mm thick, medium-grade plywood. Both ends of the boxes were open. An aluminum plate (20 × 75 cm) containing the tracking medium (photocopy toner) was then placed on the inside bottom of the box. Plastic covered track stations consisted of a 1.5-mm thick sheet of plastic (40 × 80 cm) that was bent into a half cylinder with the edges placed inside a raised lip on each of the outer edges of a galvanized steel base (28 × 80 × 0.1 cm with a 1.0 cm raised lip along the two 80 cm sides) and were kept in place by a combination of the force acting to straighten the plastic and the use of adhesive tape. Both ends of the plastic track stations were open. As with wooden covered track stations, a similar sized aluminium plate containing the tracking medium was placed on the steel base inside each plastic track station. Both types of tracking stations were designed to be disassembled for transporting by foot into remote field sites (Zielinski & Kucera 1995).

Three wooden and three plastic track stations were used (six stations total) in each of eight sample units during the 2002 trial and each of seven sample units during 2003 trials. Each sample unit comprised 4 mi² (10.4 km²) as recommended by Zielinski & Kucera (1995) and was located at least 1 mile (1.6 km) from other sample units. Track stations were placed systematically within each sample unit at 0.3-mi (0.5-km) intervals within 50 m of gravel roads with low vehicle use. For the first station placed in each sample unit, I randomly assigned the track station type (wooden or plastic) and side of the road (left or right) from which the forest was entered to place it. The next track station was of the other type and placed in the forest on the opposite side of the road of the preceding track station. This process was continued until the six track stations were placed.

Track stations were placed on the HNF on 1 October 2002 (Fall) and checked every two days for 28 days. During 2003, track stations were placed on 13 May (Spring) and 3 October (Fall) and similarly checked at 2-day intervals for 28 days. Track stations were baited with chicken wings and scented with commercial trapping lures. Track stations were set at the bases of large trees or along large woody debris, with the rear opening covered by sticks to preclude access by the species being investigated. Stations were rescented at 6–8 day intervals or after heavy rain and rebaited as necessary. Carnivore tracks were identified to species and recorded; contact paper was removed from track plates and stored in acetate envelopes. I distinguished American Marten and Fisher tracks using field guides (Murie 1954, Halfpenny 1986, Rezendes 1999) and measurement criteria developed by the Michigan Department of Natural Resources (MDNR; R. Earle, MDNR, USA, unpublished data). Northern Raccoon tracks were readily distinguishable from American Marten and Fisher tracks.

To assess efficacy, I determined and compared the number of each type of track station that was visited by each species and the cumulative total of new stations visited during each trial. I also recorded latency to detection (LTD; the number of days until first detection) for each target species found at each track station and calculated means (±SE). I used *t*-tests to compare mean LTD between track station types for each species during each trial (SAS 1990). I also used multiple range permutation procedures (MRPP) and permutation tests for matched pairs (PTMP; BLOSSOM software; Foresman & Pearson 1998) to compare rates of LTD for wood and plastic track stations by sample unit for each season and detection rates between seasons at PRNL. Statistical significance was established at $P < 0.05$.

Results

In HNF during fall, American Marten, Fisher, and Northern Raccoon were detected in six, four, and five sample units, respectively (Table 1). Adequate data to perform MRPP analyses were obtained only for American Marten; the number of sample units this species was detected in was similar (PTMP = 0.198, $P = 0.54$) for wooden and plastic track stations. The number of sample units Fishers and Northern Raccoons were detected in appeared similar for wooden and plastic track stations.

At PRNL, the number of sample units where American Martens were detected was similar for wooden and plastic track stations during spring (PTMP = 0.905, $P = 0.81$) and fall (PTMP = 1.00, $P = 0.85$; Table 1). Although sample sizes were too small for analyses, the number of sample units Northern Raccoons were detected at appeared similar for wooden and plastic track stations during both seasons.

Mean LTD was similar ($P \geq 0.37$) between track stations for each species during all trials at HNF and PRNL and ranged from about 14 to about 18 days (Table 2). Cumulative percent of stations with tracks detected for each species was comparable for both track station types during the trial at HNF (Fig. 1). During spring, the overall cumulative number of plastic track stations where American Martens and Northern Raccoons were detected was 10–15% less than detections at wooden track stations (Fig. 2). During fall, overall cumulative detections of both species were similar for wooden and plastic track stations.

As both types of track stations used in this study were covered, rain did not appear to adversely affect their efficacy. Of 672 total detection opportunities for all track stations at HNF, American Martens were recorded 18 times (3%), Fishers were recorded six times (1%) and Northern Raccoons were recorded 12 times (2%). The total number of detections for each species was identical for wooden and plastic track stations (18 detections each).

Of 588 total detection opportunities at PRNL during spring, American Martens were detected 22 times (4%), 13 times at wood track stations and nine times at plastic track stations. Northern Raccoons were detected 12 times overall (2%); 10 detections were at wood track stations and two detections were at plastic track stations. The total number of detections for both species was over three times greater during fall than spring at PRNL. Of 588 total detection opportunities during fall, American Martens were de-

Table 1. Success of wooden and plastic covered track plate stations used to detect medium-sized forest carnivores on the Hiawatha National Forest (HNF) and Pictured Rocks National Lakeshore (PRNL), central Upper Peninsula of Michigan, USA, 2002–2003. Numbers indicate sample units (n = 8 for HNF; n = 7 for PRNL) in which the species was detected. Percentages are in parentheses.

			Detection rate for:		
Location	**Season**	**Species**	**Wooden**	**Plastic**	**Combined**
HNF	Fall	American Marten	5 (68)	4 (50)	6 (75)
		Fisher	2 (25)	3 (38)	4 (50)
		Northern Raccoon	4 (50)	3 (38)	5 (63)
PRNL	Spring	American Marten	6 (86)	3 (43)	6 (86)
		Northern Raccoon	3 (43)	2 (29)	3 (43)
	Fall	American Marten	4 (57)	5 (71)	5 (71)
		Northern Raccoon	3 (43)	4 (57)	5 (71)

Table 2. Mean latency to detection at wooden or plastic covered track stations for 3 forest carnivore species on the Hiawatha National Forest (HNF) and Pictured Rocks National Lakeshore (PRNL), central Upper Peninsula of Michigan, USA, 2002–2003.

			Mean latency to detection for:							
			Combined		**Wooden**		**Plastic**		**Test statistics**	
Location	**Season**	**Species**	Mean	SE	Mean	SE	Mean	SE	t	*P*
HNF	Fall	American Marten	15.5	2.2	14.0	3.3	16.9	3.1	0.64	0.54
		Fisher	13.7	0.8	13.3	1.3	14.0	1.2	0.38	0.72
		Northern Raccoon	17.8	2.8	20.5	3.9	15.0	4.2	0.96	0.37
PRNL	Spring	American Marten	11.1	1.6	9.7	2.5	12.3	2.1	0.79	0.44
		Northern Raccoon	11.1	2.6	8.0	4.0	12.4	3.3	0.74	0.49
	Fall	American Marten	12.1	1.7	10.2	1.9	14.0	2.7	1.14	0.27
		Northern Raccoon	13.3	2.7	10.0	3.2	16.7	4.1	1.29	0.23

tected 63 times (11%), 22 times at wood track stations and 41 times at plastic track stations. Overall, Northern Raccoons were detected 41 times (7%), 14 times at wood track stations and 27 times at plastic track stations.

Wooden track stations were easily placed and stabilised because the screws which held the four panels together provided rigidity. Plastic track stations required more effort to set up because of attaching the plastic cover to the base plate with adhesive tape. Also, the plastic cover was less rigid which required additional time placing logs and branches against the cover to ensure stabilisation. Excluding track plates, wooden track stations weighed about 4.3 kg; plastic track stations weighed about 2.5 kg. Materials to construct wooden and plastic track stations cost about USD 7.0 and USD 8.3, respectively, per station.

Discussion

Based on the number of sample units in which species were detected, the two covered track stations performed similarly for American Martens, Fishers and Northern Raccoons. Thus, either type of track station should be equally effective to assess carnivore presence or activity. Although materials used to construct track stations could influence relative use by carnivores, in suitable habitat, variables such as track station placement or size of track station opening would be expected to have a greater effect on forest carnivore detection (Zielinski & Kucera 1995).

In all cases, mean LTD was greater than the number of days (12) recommended for track station surveys for detection of American Martens and Fishers (Zielinski & Kucera 1995). Such

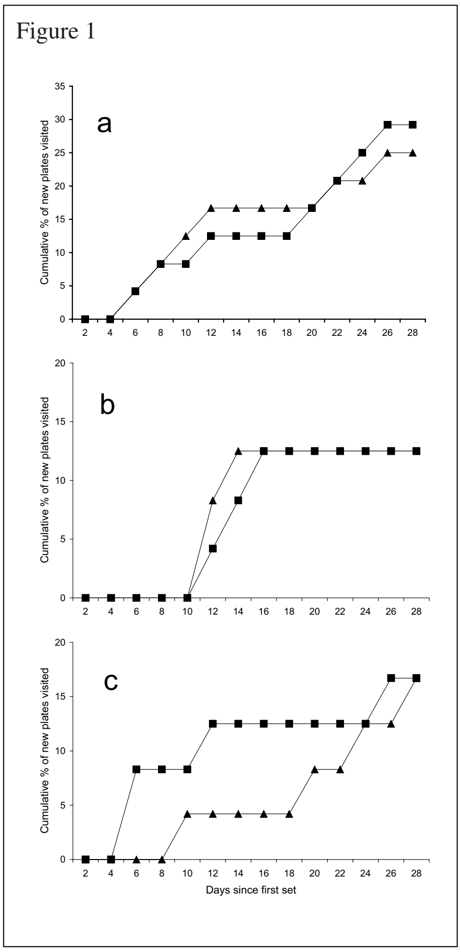
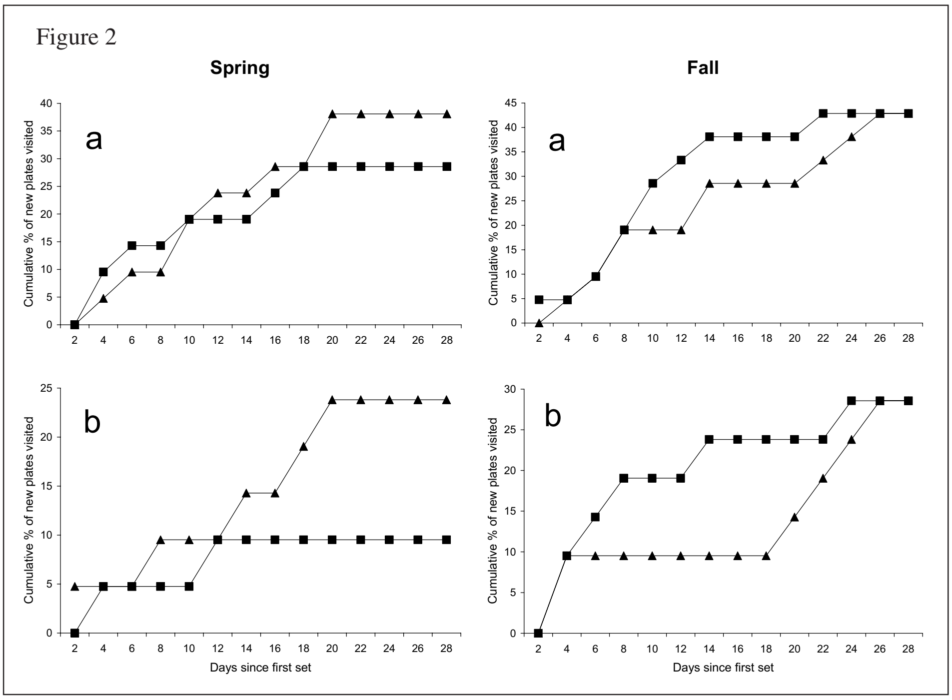


Fig. 1. Wooden (triangles) versus plastic (squares) covered track-plate visitation by (a) American Marten, (b) Fisher, and (c) Northern Raccoon, Hiawatha National Forest, central Upper Peninsula of Michigan, October 2002.

Fig. 2. Wooden (triangles) versus plastic (squares) covered track-plate visitation by (a) American Marten and (b) Northern Raccoon, Pictured Rocks National Lakeshore, central Upper Peninsula of Michigan, May–June (spring) and October (fall) 2003.



faster detection rates were recorded on the same study area in HNF during 2001 (J. L. Belant, unpublished data). Factors including availability of alternative food (Bull *et al.* 1992), carnivore density, and season may affect LTD. Because of the experimental design employed, stations in this study were placed systematically in contrast with placement of stations to maximize detection during occupancy studies. Longer track station deployment times than recommended by Zielinski & Kucera (1995) should be considered when systematic placement of stations is necessary to meet study objectives or when carnivore abundance is anticipated to be low. An alternative approach to increase probability of detection would be to conduct multiple surveys in the same study area (Zielinski & Kucera 1995).

The cause of variation observed between spring and fall trials at PRNL in the total number of American Marten and Northern Raccoon detections observed at wooden and plastic track stations is unknown. Similarly, the reason for fewer total number of wood track stations used by these species during spring at PRNL is unknown. It is likely, however, that both occurrences were artifacts of track station placement relative to individual animal distributions and movements. In this study it would have been possible for an individual animal to be detected 14 times at one track station in a single trial. This form of pseudoreplication can confound interpretation of results and is why the sample unit (block) design was employed in this study.

Detection rates were considerably greater during fall than spring for American Martens and Northern Raccoons. Increased detection rates in fall were probably related in part to increased movements of juveniles during dispersal or home range establishment (Sanderson 1987, Strickland & Douglas 1987). In addition, females with dependent young can have restricted home ranges during spring (e.g., Sanderson 1987), which could reduce detection rates. When logistically feasible, annual timing of field surveys to detect carnivore presence should include periods of greatest animal activity or abundance.

Plastic track stations cost 19% more than wooden track stations. Less expensive sources, particularly for the plastic sheeting, may be available. I recommend use of wooden covered track stations in areas readily accessible by vehicles because of their similar efficacy at detecting American Martens, Fishers, and Northern Raccoons; lower cost; and reduced time and effort required to stabilise them during placement. Plastic track stations are recommended in remote areas because of reduced weight. Covered track stations used in this study are likely suitable for other mustelid and procyonid species; entrance size and length of the track stations could be modified to accommodate the species being investigated. Also, it is likely that other materials used to construct track stations (e.g., plastic culvert or corrugated plastic; Loukmas & Halbrook 2001, Gompper *et al.* 2006) would allow detection of species in this study. Additional comparisons of carnivore detection rates with alternative materials and designs to assess their relative efficacy and also to improve track station performance are warranted.

Acknowledgements

I thank A. Hales, L. Kainulainen and J. Wolford for their assistance with fieldwork. Track stations were constructed by B. Bradley. C. Yee (Hiawatha National Forest) provided access to study sites. Funding for this study was provided be the U.S. National Park Service, Pictured Rocks National Lakeshore and Fee Demonstration Program.

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Case report: tuberculosis in introduced American Mink *Mustela vison*

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The American Mink *Mustela vison* is not a native species in South America: it was imported to Argentinean farms in the 1920s. Since then, an unknown number of animals have escaped, creating the population of free-ranging mink. Tuberculosis (TB) is a re-emerging zoonotic disease with a wide range of potential hosts (Davis *et al*. 1981). The causative agent of bovine tuberculosis, *Mycobacterium bovis*, is found among a great variety of animals, and transmission to humans constitutes a public health problem. Several authors stated that TB is frequent in captive animals (Wenzel 1982, Nordstoga 1992, Stetter *et al*. 1995). TB can cause severe loss in mink farms (Zimmermann 1972, Martino & Villar 1991) but very little information is available on naturally occurring diseases of wild mink, although there are a few reports of bovine TB in captive and free-ranging canids (Williams & Thorne 1996).

In this report we describe the pathologic findings in two adult dead mink (a 7-yr-old male and a 2-yr-old female) in the last two years during a logging operation in the province of Buenos Aires, Argentina. Carcasses were discovered at different times and locations. At necropsy, the animals were extremely thin (male: 1.4 kg and female: 1.25 kg) and had only thin fur. Multifocal tuberculous lesions (1–2 mm grey or yellowish nodules) were found in different organs and systems, mainly in the lungs, liver, spleen, intestine and mesenteric lymph nodes (Fig.1). Gross necropsy, histological examination including use of Zielh–Neelsen stains, and mycobacterial culturing showed evidence of mycobacterial diseases in both animals. The lesions were fixed in phosphate-buffered 10% formalin, embedded in paraffin, sectioned at 6 µm, and stained with haematoxylin and eosin for light microscopy. Histological examination revealed nodules of varying size separated by dense connective tissue stroma, but typical giant cells of the Langhans type were absent (Fedorov & Domnin 1977, Beck *et al*. 1974, Martino & Villar 1991). Examination of Zielh–Neelsen stained slides of samples revealed numerous acid-fast bacilli bacteria, and aerobic bacterial and mycobacterial culture results were also positive. Histological examination of Zielh–Neelsen stained sections showed numerous acid-fast bacilli bacteria in the pulmonary granulomas, lymph nodes and gastrointestinal organs, and *M. bovis* was consistently isolated from the granulomas. Tissue samples were decontaminated with cetylpyridinium chloride and then inoculated onto pyruvate supplemented 7H11 medium and Lowenstein Jensen media. The strains were identified as *M. bovis* by the following bacteriological criteria: growth stimulation by pyruvate, growth inhibition by thiophen, negative for nitrate reductase and pyrazinamidase activity, and smooth colony morphology. The cause of death was, therefore, determined as disseminated TB, on the bases of cytological and histological examinations, and on culturing test.

Generalisation may sometimes occur, especially when the infecting agent is *M. bovis,* which is more pathogenic both in mink and canids than the avian type (Nordstoga 1992). The predominance of lesions at advanced stages (pulmonary and digestive tract infection) observed in both cases, is either suggestive of an oral (via contaminated feed or water) or respiratory route. The natural route of infection is probably peroral in 90% of mink cases (Beck 1974, Nordstoga 1992). Wild canids are susceptible to bovine TB, but the disease is rare in these species in the wild, except where common in their prey (Williams & Thorne 1996). The two principal routes for TB in animals are respiratory and alimentary, but the relative importance of each route varies between and within species under the influence of factors such as age, nature of diet and behaviour (Jackson *et al*. 1995). Thus, the source of the infection could not be easily disclosed here. Nevertheless, mink from the area studied might probably contract TB via eating infected raw bovine or lagomorph carrion, or via eating insects from point-source cowpats, as it was suggested for Eurasian Badgers *Meles meles* (Hancox 1995). TB has been repeatedly diagnosed in another introduced species, the European Brown Hare *Lepus europaeus* from our country (Kantor *et al*. 1984), where bovine TB is still a major infectious

Fig. 1. Disseminated TB in introduced mink with multiple granulomatous nodules in lungs (horizontal arrow) and liver (vertical arrow).

disease among cattle (Kantor & Alvarez 1991, Van Soolingen *et al*. 1994). Wild animal TB represents a permanent reservoir of infection and may pose a serious threat to a disease control and elimination programme. According to Cosivi *et al*. (1998) infection occurs when wild (e.g., mustelids, including badgers; possums) and domesticated animals share pasture or territory.

Deoxyribonucleic acid (DNA) fingerprinting will be performed to compare *M. bovis* strains from these two mink with current bovine isolates from the area. Results could indicate if mink and bovine strains are genetically similar or not, and thus, disclose the responsibility in the infections.

A better understanding of the pathogenesis of TB in introduced mink will also come as our knowledge of details of routes of infection and the immunological response mechanisms improves (Jackson *et al*. 1995).

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Brief notes on the Altai Weasel *Mustela altaica* on the Tibetan plateau

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The Altai Weasel *Mustela altaica* has a fairly wide world range, occurring in India (across the Himalayas from Kashmir to Sikkim), Nepal, Bhutan, west and north China, east Kazakhstan, Kyrgyzstan, Tajikistan, Mongolia, and small parts of Russia (south and south-east Siberia, Primorski Krai), with possible extension to northern Korea (Allen 1938, Wangchuk *et al*. 2004, Wozencraft 2005). It is one of many *Mustela* species that occurs in China. Rather little information is internationally available on the current conservation status of the species, it making typically nothing more than incidental mention in papers on other subjects (e.g., Harris & Loggers 2004). It is under consideration for international red-listing as 'Near Threatened' because it is believed to be in decline (Global Mammal Assessment *in litt*. 2006). Hence, this note provides information on field sightings made incidentally in the species's range while JH was birdwatching and while MF was studying ungulates.

During 1995–2006, we found the weasel several dozen times during frequent visits to eastern and southern Qinghai province, China (Fig. 1). By contrast, we saw the related Steppe Polecat *M. eversmanii* only three or four times. Altai Weasel was seen in at least ten sites in eastern Qinghai by JH, all along the main road from Wenquan to Xiewu, along the road from Huashixia to Banma, in the South Koko Nor Range (i.e., the mountains directly south of Qinghai Lake), and at Datong. In southern Qinghai, MF found it several times in Zhiduo county: in Suojia district in 1998, 2004, and 2005 (twice at Muqu and once at Yaqu), and received a report from Zhahe township in 2006 (Fiona Worthy pers. comm.). A weasel seen running across the highway between Xining city and the airport in 2006 also seemed to be this species. Animals were seen from moving vehicles, from horseback, when on foot and when stopped for short road-side respites. Apart from the Xining observation, which was at 2,300 m, observation sites were spread across the altitudinal range of 3,000–4,700 m. All sightings were during the daylight hours, but for logistical reasons sightings were less likely to be made by night (elsewhere, the weasel has been reported as mainly nocturnal and crepuscular, but sometimes active also in day time; Heptner *et al*. 1967). The most common habitat where Altai Weasel was observed was, at least in Zhiduo county, alpine meadow comprised primarily of *Kobresia* sedges and a variety of other grassland species.

The frequency of incidental encounters suggests that, at least in this part of its range, Altai Weasel is probably still fairly common. However, looking at the landscape, several factors may place the weasel at risk. In most places the natural vegetation cover has been partially to seriously overgrazed by domestic bovids (yak and yak/cow hybrids) and sheep: only a few areas remain with little or no human/livestock impact on the grassland vegetation. The impact of overgrazing also appears to be increasing due to a demonstrated warming of the Tibetan plateau in recent years (Miehe 1988, 1996, Cyranoski 2005, Perkins 2007). Habitat change is sufficiently widespread and severe, that it is undoubtedly driving weasel population declines through reduction in prey.

Altai Weasel preys heavily on pikas *Ochotona* (probably mostly Plateau Pika *O. curzoniae* in the area of sightings) and all sites where the weasel was observed also held pikas. This pika reaches relatively high densities across much of the Tibetan plateau and has been found to be the primary prey of most of the predators of land vertebrates in the Tibetan plateau ecosystem (Smith & Foggin 1999). However, being perceived by policymakers and local administrators as an agent of habitat degradation and a competitor for forage of domestic stock, the pika has long been the focus of widespread control efforts, often by poisoning, which have resulted in their elimination from large areas of the Tibetan plateau (Smith *et al*. 1990, Smith & Foggin 1999). While it remains locally abundant in some areas (see Harris & Loggers 2004; also authors' personal observations), even

Altai weasel photographed on the Tibetan plateau.

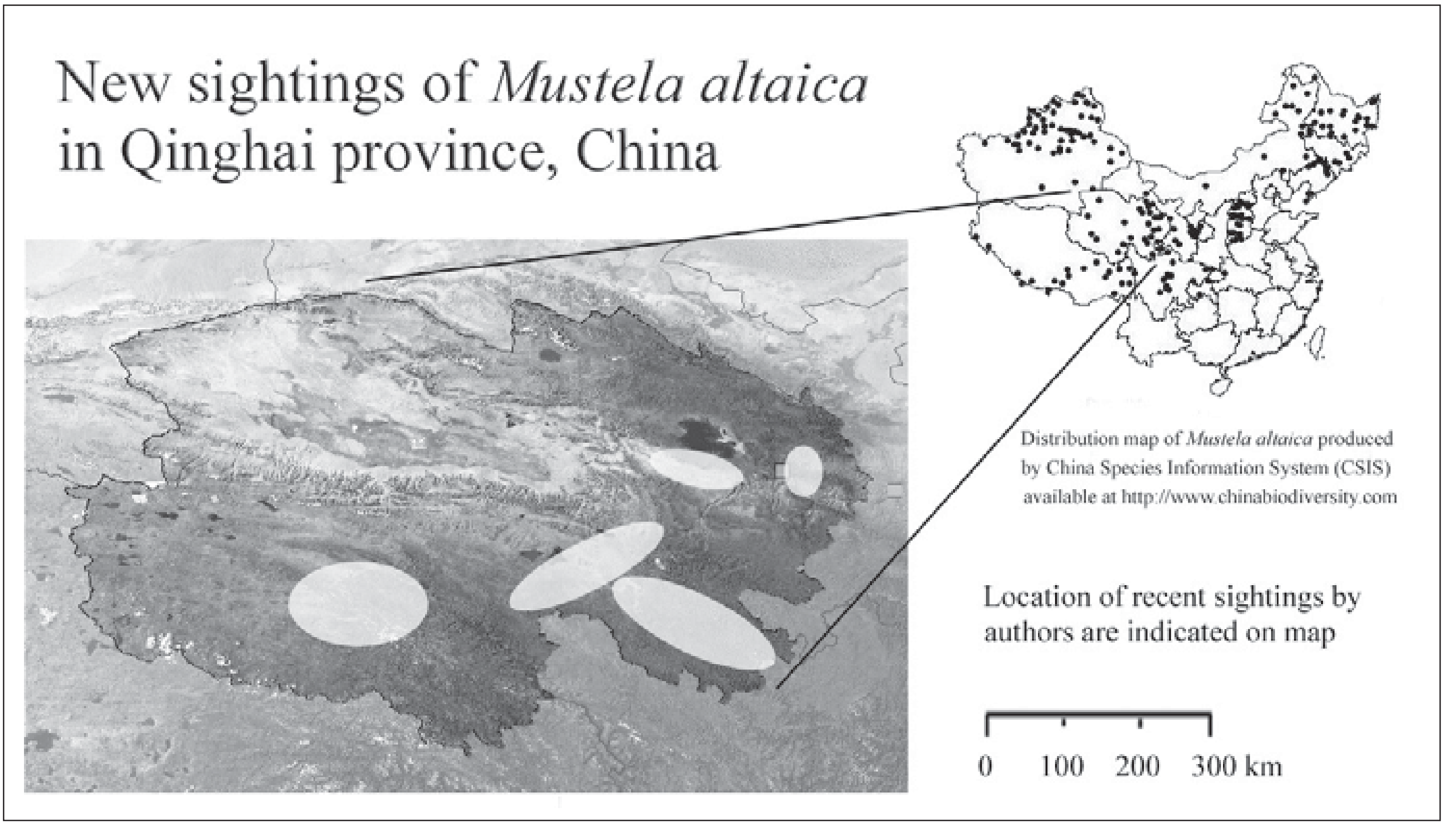

Fig. 1. Map of the study area.

those populations are now under renewed threat of eradication due to on-going campaigns to remove pikas from the ecosystem, both outside and inside nationally-designated protected areas. Although the weasel also eats a variety of other small mammals and birds (Pocock 1941), it is certain that pika populations at natural levels would allow much higher numbers of weasels to persist than in areas were pikas are eradicated, and the precise effects of heavy reductions in pika numbers on weasels remain unknown. As agents of habitat shaping, severe pika declines might affect weasel populations not just through their reduced value as direct prey, but also through indirect effects of habitat change on other potential prey. By analogy, following a crash in European Rabbit *Oryctolagus cuniculus* populations in Britain, the ecological effect on many species, and the ways in which those changes acted, were profound, complex and in some cases unpredicted (Sumption & Flowerdew 1985).

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Sightings of Javan Ferret Badger *Melogale orientalis*

Nick BRICKLE

The Javan Ferret Badger *Melogale orientalis* is endemic to the islands of Java and Bali (Riffel 1991), where it is the sole representative of the purely Asian genus *Melogale*. Its endemic status and the low proportion of Java that retains natural habitat led the most recent global conservation action plan for small carnivores (Schreiber *et al*. 1989) to consider the species as "known or likely to be threatened". In the action plan, the species's relatively high conservation priority ranking, combined with the sympatry of several other small carnivore taxa endemic to Java or the Greater Sundas and also, presumably threatened, led to the action plan declaring 'Java' as one of the seven core areas for priority action for mustelid and viverrid conservation. Yet despite this, Javan Ferret Badger remains rather little known; indeed, Riffel (1991) stated that the species "is virtually unknown with respect to its ecology and conservation status". There seem to be very few published recent records since Riffel's (1991) review. Hence, I document two sightings from Gunung Gede National Park, West Java, Indonesia, on 16 October 2006. In the first, I saw two animals together, in thick undergrowth around 5 m from a raised section of the main tourist trail, at about 17h45 (dusk; half-an-hour before dark). They scuttled away quietly when approached. Next, one was seen alone, again in thick undergrowth, about 2 m from the trail at about 18h15 (just as it was getting dark), which also scuttled away. Both locations lie at about 1,700 m altitude, in primary montane forest about 2 and 3 km interior from the forest edge.

The trail carries many visitors on most weekends. Often lots of litter is dropped, especially in the location of the second record, which lies near a waterfall that is the attraction of many people's visit. The day of observation fell, however, in the third weekend in Ramadan and the place was completely devoid of other people.

In Gunung Gede National Park, Sunda Stink Badgers *Mydaus javanensis* regularly raid bags of campers (including my own personal experience) and there are also regular reports of ferret badgers from this area, typically contained within informally circulated 'trip reports' and notes of visiting birdwatchers. Schreiber *et al*. (1989) gave the priority conservation action for this species to be the generation of further information on its status. So, even though Gunung Gede is a historical site for the species, with three specimens collected in 1970 (Riffel 1991), it may be useful to record continued presence. Many more records are needed before the species's conservation status can be authoritatively assessed.

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Kinkajou *Potos flavus* (Photo: Jan Schipper)

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