Small carnivores on small islands. New data based on old skulls

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Introduction

Insular animals have a research and conservation importance that far exceeds their relative numbers.

First and foremost the insular settings often promote allopatric speciation and diversification, sometimes in the form of adaptive radiation, and thus much of the global biodiversity resides in such evolutionary hotspots. The isolation and depauperate faunas of many islands mean many insular populations and species are genetically distinct from their mainland relatives and thus are often of great conservation priority. Indeed most anthropogenic extinctions of animals occurred on islands (e.g. Steadman, 1995; MacPhee & Flemming, 2000).

In addition, the restricted area and isolation of islands often make them interesting "natural experiments" of ecological and evolutionary phenomena (MacArthur & Wilson, 1967; Mayr, 1967; Roth, 1992), and consequently a focus of much ecological, evolutionary and biogeographic research. Indeed Darwin and Wallace developed their theory of evolution by natural selection after inspirational first-hand impressions of insular animals (Darwin, 1845, 1859; Wallace, 1868, 1880).

Records of occurrence of insular organisms are often important in studies relating to the assemblage and evolution of ecological communities (MacArthur & Wilson, 1967; Lawlor, 1986; Burness *et al*. 2001; Meiri *et al*. 2005a).

Small carnivores are no exception to these generalizations: There are eight endemic Madagascar species of small carnivores, up to five species of endemic insular raccoons (although some are probably introduced *Procyon lotor* [Helgen & Wilson,2003; Zeveloff, 2003]), one species of insular coati (*Nasua nelsoni*), and ten species endemic to islands in south and southeast Asia (*Diplogale hosei, Paradoxurus zeylonensis, P. lignicolor, Macrogalidia musschenbroekii, Herpestes semitorquatus, Melogale everetti, M. orientalis, Mustela lutreolina, Mydaus javanensis* and *M. marchei*). In addition, there are two endemic canid species (the extinct *Dusicyon australis* and extant *Urocyon littoralis*) and one endemic insular cat species (*Felis badia*).

Small carnivores inhabit many islands worldwide, and some of these insular populations are of great conservation priority, including many of the abovementioned species and many insular populations of more widespread species (e.g. *Martes flavigula robinsoni* in Java, *M. melampus tsuensis* in Tsushima, Genetta genetta isabelae in Ibiza [IUCN 2002], *Spilogale gracilis amphiala* on the California Channel Islands [Verts *et al*. 2001]).

Moreover, many insular populations of small carnivores are probably threatened, but data regarding them are deficient. For example 60 out of 106 populations of "possibly threatened mustelids and viverrids" listed in Schreiber *et al*. (1989) are insular (see also Cook *et al*. 2001). The problem of data deficiency is actually more acute than these figures suggest, for the simple reason that many insular populations of small carnivores are virtually unknown to science and their unique features and conservation status cannot therefore be explored.

Here I list insular carnivores, compiled from museum specimens, that went unnoticed in recent publications.

Material and Methods

As part of my PhD studies (Meiri, 2004; Meiri *et al*. 2004a, 2005a) I contacted, starting in late 1999, curators and collection managers in natural history collections worldwide and requested data regarding specimens of insular carnivores. In the last five years I visited 31 of these collections and recorded locality data for insular carnivores. I also received many data from Tamar Dayan and Daniel Simberloff, who measured carnivores as part of their ongoing research of carnivore microevolution (e.g. Dayan *et al*. 1989, 1991, 2002; Dayan & Simberloff, 1994; Simberloff *et al*. 2000; Meiri *et al*. 2004a, 2004b, 2005a, 2005b).

I reviewed the literature to find data on insular carnivore occurrences. Particularly important publications included: Schreiber *et al*. (1989), Wozencraft (1993) and Nowak (1999) for the entire world, Sasaki (1991), Abe (1994), Dobson (1994) and Millien-Parra & Jaeger (1999)(for Japan); McCabe & Cowan (1945), Banfield (1974), Hall (1981), Crowell (1986), Macdonald & Cook (1996) and Conroy *et al*. (1999)(for North America); Heaney (1986), Corbet & Hill (1992), Heaney *et al*. (1998) and Meijaard (2003)(for SE Asia); Corbet & Harris (1991), Masseti (1995) and Mitchel-Jones *et al*. (1999)(for Europe); Kostenko (2002)(for Kuril Islands), but many more were scanned.

Here I list occurrence of mustelids (to the exclusion of otters), procyonids (Florida Keys populations omitted), herpestids and viverrids on islands, that went unnoticed in the literature, based on museum specimens. Introduced populations are not included. Data for other carnivore taxa are available upon request. For each island I list its latitude and longitude.

Results

Sixty-seven small carnivores occurrences derived from museum specimens that were not found in a survey of the literature are listed in Table 1. I deliberately omitted some locality data that seem highly dubious. The Smithsonian Institute, for example, holds a supposedly Singaporean specimen of the Indian Gray Mongoose (*Herpestes edwardsii*, USNM 004000/A38520, see Table 1 for museum acronyms). However Craig Ludwig (USNM, pers. com.) suspects this listing may have been in error, or that this is an introduced specimen. Furthermore, Singapore is and has been (the specimen was catalogued in 1860) a major trade center, and thus records of supposedly Singaporean specimens should be taken with a grain of salt (Chris Smeenk, pers. com.). The natural distribution of *H. edwardsii* does not reach the Malay Peninsula, although this species was introduced there (Wells, 1989). Mistakes in both taxonomy and locality are not uncommon in museum collections (pers. obs.; invariably some collections are better than others in this regard). I have therefore tried to present only data for which the accuracy of seems highly likely (usually meaning that the species is recorded from the adjacent mainland or nearby islands). Some islands I was simply unable to locate (e.g. *Arctogalidia trivirgata*, BMNH 9.4.1.122, from "Bliah Kunder Island", *Mustela sibirica* BMNH 6.11.2.31 and BMNH 8.2.26.107 from "Joshi" and "Jukue" islands, respectively).

Table 1. New island records of insular carnivores.

Species	Island	Sovereignty	Museum	#	Specimen #	Seen by	Lat	Lon
Arctogalidia trivirgata	Kadan Kyun (Mayanpin=King)	Myanmar	BMNH	1	1937.9.10.18	M	12°30'N	98°22'E
Cynogale bennettii	Singapore	Singapore	BMNH	1	5.9.25.1	M	01°22'N	103°48'E
Herpestes javanicus	Madura	Indonesia	BMNH	1	10.4.7.15	M	07°00'S	113°20'E
Herpestes javanicus	Sumatra	Indonesia	RMNH, ZMB	5	RMNH 9843, ZMB 34040	M	00°05'S	102°00'W
Martes americana	Gilford	Canada	RBCM	5	13504	M	50°45'N	126°20'W
Martes flavigula	Singapore	Singapore	USNM	1	3999	M	01°22'N	103°48'E
Martes foina	Cres	Croatia	CNHM			ns	44°54'N	14°27'E
Martes foina	Dugi Otok	Croatia	CNHM			ns	44°09'N	15°03'E
Martes foina	Falster	Denmark	ZMUC	1	2377	S	54°30'N	12°00'E
Martes foina	Hvar	Croatia	CNHM			ns	43°09'N	16°45'E
Martes foina	Lestovo	Croatia	CNHM			ns	42°46'N	16°55'E
Martes foina	Lolland	Denmark	ZMUC	3	5408	S	54°40'N	11°30'E
Martes foina	Pag	Croatia	CNHM			ns	44°30'N	15°00'W
Mustela erminea	Barter	USA	CMN	1	2593	M	70°07'N	143°40'W
Mustela erminea	Cairn	Canada	CM	2	5392	M	56°17'N	76°35'W
Mustela erminea	Douglas	USA	UAM	1	52304	M	58°16'N	134°00'W
Mustela erminea	Falster	Denmark	ZMUC	3	3322	S	54°30'N	12°00'E
Mustela erminea	Flaherty	Canada	CM	4	15189	M	56°14'N	79°17'W
Mustela erminea	Fyn	Denmark	ZMUC	10	2416	S	55°20'N	10°30'E
Mustela erminea	Hinchinbrook	USA	MVZ	1	912	D	60°20'N	146°25'W
Mustela erminea	Innetalling	Canada	CM	1	15198	M	55°05'N	79°04'W
Mustela erminea	Lolland	Denmark	ZMUC	1	3103	S	54°40'N	11°30'E
Mustela erminea	Puget	USA	USNM	1	274190	M	46°10'N	123°23'W
Mustela erminea	Sitkalidak	USA	UMMZ	1	97461	D	57°08'N	153°11'W
Mustela erminea	Tukarak	Canada	CM	25	15188	M	56°27'N	78°45'W
Mustela erminea	Unalaska	Canada	USNM	3	13025	M	53°30'N	167°00'W
Mustela nivalis	Falster	Denmark	ZMUC	1	1219	S	54°30'N	12°00'E
Mustela nivalis	Lolland	Denmark	ZMUC	2	5809	S	54°40'N	11°30'E
Mustela nivalis	Pag	Croatia	CNHM			ns	44°30'N	15°00'W
Mustela putorius	Aero	Denmark	ZMUC	1	749	S	54°43'N	10°20'E
Mustela putorius	Krk	Croatia	CNHM			ns	45°05'N	14°35'E
Mustela putorius	Rab	Croatia	CNHM			ns	44°46'N	14°46'E
Mustela sibirica	Iki	Japan	BMNH	3	8.2.26.75	M	33°47'N	129°43'E
Mustela sibirica	Rishiri	Japan	NSMT	1	10122	M	45°11'N	141°15'E
Mustela sibirica	Sado Shima	Japan	NSMT	9	14651	M	38°00'N	138°25'E
Mustela vison	Broughton	Canada	RBCM	3	1578	M	50°49'N	126°45'W
Mustela vison	Conanicut	USA	FMNH	1	156115	M	41°32'N	71°21'W
Mustela vison	Esther	USA	UAM	1	24834	M	57°51'N	136°26'W
Mustela vison	Foster's	Canada	MCZ	1	B6995	M	44°43'N	67°28'W
Mustela vison	Haystack	Canada	RBCM	1	1564	S	54°43'N	130'37'W
Mustela vison	Judith	USA	AMNH	1	30887	M	35°22'N	76°22'W
Mustela vison	King	Canada	CMN	1	16517	M	52°30'N	127°00'W
Mustela vison	Nunivak	USA	UAM	22	32698	M	60°00'N	166°30'W
Mustela vison	Price	Canada	RBCM	1	4538	M	52°28'N	128°42'W
Mustela vison	Sidney	Canada	RBCM	3	9250	M	48°37'N	123°18'W
Nasua narica	Isla Popa	Panama	USNM	1	360453	ns	09°07'N	81°44'W
Paguma larvata	Koh yao	Thailand	TISTR			ns	09°00'N	98°00'E
Paguma larvata	Rutland	India	BMNH	1	1937.7.22.1	M	11°25'N	92°40'E
Paradoxurus hermaphroditus	Bawean	Indonesia	RMNH	1	34704	M	05°40'S	112°40'E
Paradoxurus hermaphroditus	Con Son	Vietnam	USNM	2	357286	M	08°43'N	106°36'E
Paradoxurus hermaphroditus	Koh Samui	Thailand	TISTR			ns	09°00'N	100°00'E
Paradoxurus hermaphroditus	Koh yao	Thailand	TISTR			ns	09°00'N	98°00'E
Paradoxurus hermaphroditus	Samar	Philippins	ZMB	1	2754	M	12°00'N	125°00'E
Paradoxurus hermaphroditus	Telebon (Telibon)	Thailand	USNM	1	83268	M	07°15'N	99°23'E
Potos flavus	Isla Parida	Panama	BMNH	1	3.3.1.57	M	08°07'N	82°20'W
Potos flavus	Isla Popa	Panama	USNM	5	579215	M	09°07'N	81°44'W
Potos flavus	Isla San Cristobal	Panama	USNM	3	449532	M	09°15'N	82°16'W
Procyon lotor	Cayo Nancy	Panama	USNM	1	464962	ns	09°19'N	82°11'W
Procyon lotor	Isla Bastimentos	Panama	USNM	3	464411	M	09°15'N	82°08'W
Procyon lotor	Isla Popa	Panama	USNM	6	579204	M	09°07'N	81°44'W
Procyon lotor	Isla San Cristobal	Panama	USNM	5	449533	M	09°15'N	82°16'W
Procyon lotor	Sanibel	USA	FMNH	2	49227	M	26°26'N	82°07'W
Viverra tangalunga	Bawal	Indonesia	USNM	1	153841	M	02°43'S	110°05'E
Viverra tangalunga	Java	Indonesia	RMNH, ZMB	2	RMNH 34825, ZMB 13377	M	08°00'S	110°00'E
Viverra tangalunga	Leyte	Philippins	USNM	1	458892	M	10°50'N	124°50'E
Viverra tangalunga	Pinang	Malaysia	ZRC	1	ZRC 4.1449	M	05°22'N	100°14'E
Viverra tangalunga	Telok Pai	Indonesia	USNM	1	125095	M	01°50'S	109°00'E

Museum acronyms: American Museum of Natural History (AMNH), Natural History Museum, London (BMNH), Carnegie Museum of Natural History (CM), Canadian Museum of Nature (CMN), Croatian Natural History Museum (CNHM), Field Museum of Natural History (FMNH), Museum of Comparative Zoology, Harvard University (MCZ), Museum of Vertebrate Zoology, University of California, Berkeley (MVZ), National Science Museum, Tokyo (NSMT), Royal British Columbia Museum, (RBCM), Rijksmuseum van Natuurlijke Historie, 'Naturalis', (RMNH), Thailand Institute for Scientific and Technological Research (TISTR), University of Alaska, Fairbanks, Museum (UAM), University of Michigan Museum of Zoology, Ann Arbor (UMMZ), Smithsonian Institution, Washington D.C. (USNM), Museum für Naturkunde, Humboldt-Universität, Berlin (ZMB), Zoological Museum, University of Copenhagen (ZMUC), Zoological Reference Collection, National University of Singapore (ZRC).

= number of specimens examined. Specimen # was drawn at random from available data when an insular population was known by more than one specimen.

Seen by: D = Tamar Dayan, M = Shai Meiri, S = Daniel Simberloff. ns = specimen not seen by author, but locality data reported by the museum (pers. com. to Shai Meiri and Tamar Dayan). Lat = latitude. Lon = longitude.

Discussion

Some of the data in Table 1 contradict published records. Peterson (1967) lists *Mustela erminea* as absent from Unalaska. Regarding *Herpestes javanicus*, Wells (1989) explicitly states that "a claimed presence in Sumatra…is not supported", based on his measurement of the type specimen of *H. rafflesii* at the BMNH. However Chris Smeenk (RMNH) informs me that Sody (1949) claimed to have collected specimens from this island. Regarding the existence on *Viverra tangalunga* on Java, however, I know of no other records that corroborate it, apart from the two specimens I measured in Leiden and Berlin.

Insular carnivores represent great opportunities for research and often immediate target for conservation efforts. The high profile of carnivores makes them obvious candidates for the role of flagship species (Simberloff, 1998). I hope the new locality data listed here will encourage efforts in both these fronts.

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