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The Larger Mammal Fauna of Hong Kong: Species Survival in a Highly Degraded Landscape

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Kurtis Jai-Chyi Pei, Yu-Ching Lai, Richard T. Corlett, and Kai-Yuen Suen (2010) The larger mammal fauna of Hong Kong: species survival in a highly degraded landscape. *Zoological Studies* **49**(2): 253-264. We spent 3 yr (2000-2003) surveying the status of larger mammals (> 0.5 kg) in the highly fragmented and degraded landscape of Hong Kong using 373 camera-trap sites distributed in 43 terrestrial wildlife habitat patches. In total, 20 mammal species were recorded including 15 larger mammals. The Malayan porcupine (*Hystrix brachyura*) and red muntjac (*Muntiacus muntjak*) were apparently the most abundant species, while the crab-eating mongoose (*Herpestes urva*), Chinese pangolin (*Manis pentadactyla*), small Indian mongoose (*Herpestes javanicus*), and yellow-bellied weasel (*Mustela kathiah*) were the least abundant. The red muntjac, small Indian civet (*Viverricula indica*), and Malayan porcupine had the widest distributions, while the Chinese pangolin, small Indian mongoose, and yellow-bellied weasel were most restricted. Many species were absent from Lantau I., despite its relatively large size (144 km^2) and lower current human disturbance, suggesting past extirpations. The key management need for larger mammals in Hong Kong is the protection and enhancement of habitat links between adjacent protected areas, especially the cross-border corridor between the National Forest Park in Shenzhen, Guangdong Province and the Country Park system in Hong Kong. http://zoolstud.sinica.edu.tw/Journals/49.2/253.pdf

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Southeast Asia has the highest rate of deforestation of any major tropical region, and the forests that remain suffer from large-scale logging and widespread hunting (Sodhi et al. 2004, Corlett 2007 2009). A recent study used a species-area model to extrapolate historical extinction rates for a wide range of well-studied terrestrial and freshwater taxonomic groups from the island of Singapore to the region as a whole (Brook et al. 2003). It predicted the loss of 13%-42% of regional populations for these taxa over the next century, with at least 1/2 of these representing global species extinctions. Among terrestrial taxa, the highest projected losses were for mammals: 21%-48% of regional populations. Most actual extinctions in Singapore, and thus projected extinctions for the region, were among forest specialists, while species that prefer or tolerate open or forest-edge habitats have survived much better. Overall, however, the prognosis for the survival of mammalian diversity in Southeast Asia is highly pessimistic.

Hong Kong (22°N, 114°E) is on the north-eastern margin of the region considered in

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the above studies. In many ways, it can be considered a “worst case scenario” for the survival of mammalian diversity. Seven million people are crammed into a land area of 1100 km^2 that has already seen at least 7000 years of continuous human occupation (Dudgeon and Corlett 2004). All but the most rugged topography has been cultivated at some time in the last few hundred years and there is evidence for massive loss of top soil from the steeper slopes. As a result, although Hong Kong has a forest climate, no substantial remnants of the original forest cover have survived, and the most extensive plant communities today are fire-maintained grasslands, successional shrublands, secondary forests, and exotic plantation monocultures.

Despite this long history of massive human impacts, surveys over the last 20 yr show that Hong Kong still supports a surprising diversity of plant and animal species (Dudgeon and Corlett 2004). The diversity hotspots of different taxa do not, in general, coincide (Yip et al. 2004), suggesting that different groups have been affected in different ways by human activities. Several general factors seem to have been important; however, in permitting the survival of wild species. One major factor is Hong Kong’s very rugged topography, which has not only confined recent urban development to < 30% of the total land area, but has also protected scattered pockets of woody vegetation from fire and cutting. Another factor has been the local tradition of preserving or planting small forest patches (mostly < 4 ha) near villages for reasons of feng shui, the traditional Chinese theory for determining the most favorable location for settlements in order to bring good fortune (Yu 1992, Dudgeon and Corlett 2004). Both oral traditions and the floristic composition suggest that some of these feng shui forests are several hundred years old, and it is possible that some began as preserved fragments of the original forest cover of the region. However, while feng shui theory protects the vegetation, it gives only indirect protection to the fauna of these forests. A 3rd factor is the relaxation of human impacts in upland areas over the last 50 yr. The declining rural population, the progressive abandonment of agriculture, and the active prevention and control of hill fires have resulted in a great expansion of woody vegetation, so that secondary shrublands and forests now cover more than a 1/3 of the total land area (Dudgeon and Corlett 2004). There has also been a big decline in the hunting and trapping of vertebrates over the last 20 yr.

Most of the well-surveyed taxonomic groups in Hong Kong are those that are known to survive relatively well in small forest fragments (plants, amphibians, reptiles, rodents, and many groups of invertebrates) and/or are potentially capable of reinvading when human impacts are relaxed (birds, bats, and butterflies) (Corlett 2000). By contrast, the study reported here is the 1st systematic survey of the larger non-flying mammals: the taxonomic group that is most sensitive to habitat fragmentation and hunting, and for which many species have difficulty crossing large areas of unsuitable habitat. Checklists have been compiled from casual sightings and a small amount of live-trapping data, but the distribution, abundance, and conservation status of most recorded taxa were largely unknown when this study was initiated in 2000 (Shek 2006). The primary aim of this study was to fill in these gaps, by assessing the current status of the larger mammal fauna (body mass > 0.5 kg) of Hong Kong. Mammalian nomenclature follows Smith and Xie (2008).

MATERIALS AND METHODS

The Hong Kong Special Administrative Region (SAR) of the People’s Republic of China (hereafter Hong Kong) encompasses a biogeographically arbitrary 1,100 km^2 section of coastal southern China, along with adjacent islands (Fig. 1). Hong Kong has a subtropical monsoon climate, with hot, wet summers and cool, dry winters (Dudgeon and Corlett 2004). The mean monthly temperature near sea level varies from 15.8°C in Jan. to 28.8°C in July, and the mean annual rainfall ranges from 1,300 mm at the driest site to > 3,000 mm on the highest peaks. The geology is largely igneous, and the topography is very rugged, with the highest point 957 m above sea level. Natural open habitats in the Hong Kong region must have been rare, with coastal cliffs, beaches, and perhaps seasonally flooded riverine grasslands the only ones extensive enough to support a non-forest flora and fauna.

Although early human settlements in the region must have had some impacts on the biota, the major period of deforestation seems to have begun following increased Chinese immigration in the 11th and 12th centuries (Marks 1998). The process accelerated with population increases in the 16th and 17th centuries, and was essentially completed by the end of the 18th century. There are no descriptions of Hong Kong itself before the mid-18th century, but earlier European visitors to the Pearl River delta region, west of Hong Kong, make no mention of forests (Dudgeon and Corlett 2004). Even the highest slopes were terraced for tea by the late 17th century, and probably earlier, and it is hard to see where any substantial area of forest could have survived in Hong Kong past that time. The total forest cover probably reached a low point in the 19th century and again in 1945, when < 4% of Hong Kong's total land area was forested, all in scattered patches of at most a few hectares in extent. Since then, the forest area has gradually increased, by both planting and natural succession, to around 17% of Hong Kong's total land area, with another 20% covered in secondary shrubland (Dudgeon and Corlett 2004). Forest succession has been most rapid on the lower slopes of hills, while the lowlands are increasingly urbanized, and the upper slopes are still largely covered in fire-maintained grasslands.

Modern Hong Kong exhibits a sharp contrast between rural habitats and very high-density urban areas, with only a small area of low-density suburbs. Urban areas are therefore not a significant habitat for wild mammals, except commensal species, and were excluded from this survey. Major habitats for terrestrial mammals in Hong Kong today include a variety of open habitats (cultivated areas, grasslands, shrubby grasslands, and shrublands) and forest types (lowland forests, montane forests, plantations, and feng shui forests). For this study, terrestrial habitats were delineated based on a land-use map generated by the Lands Department of the Hong Kong SAR with sub-meter accuracy. Terrestrial land-use types were aggregated into 43 terrestrial wildlife habitat (TWH) patches, based on their contiguity (Fig. 1). The total coverage of the TWH patches was 593.7 km^2, which is about 54% of the total area of the entire Hong Kong SAR. Patches vary in size, shape, and degree of connectivity. Seventeen of the larger patches were surveyed, with a total area of 529.9 km^2, which is approximately 89% of the existing wildlife habitat in Hong Kong (Fig. 1).

Wildlife-Two camera traps (Shenzhen Changxin Electronics Technology, Shenzhen City,

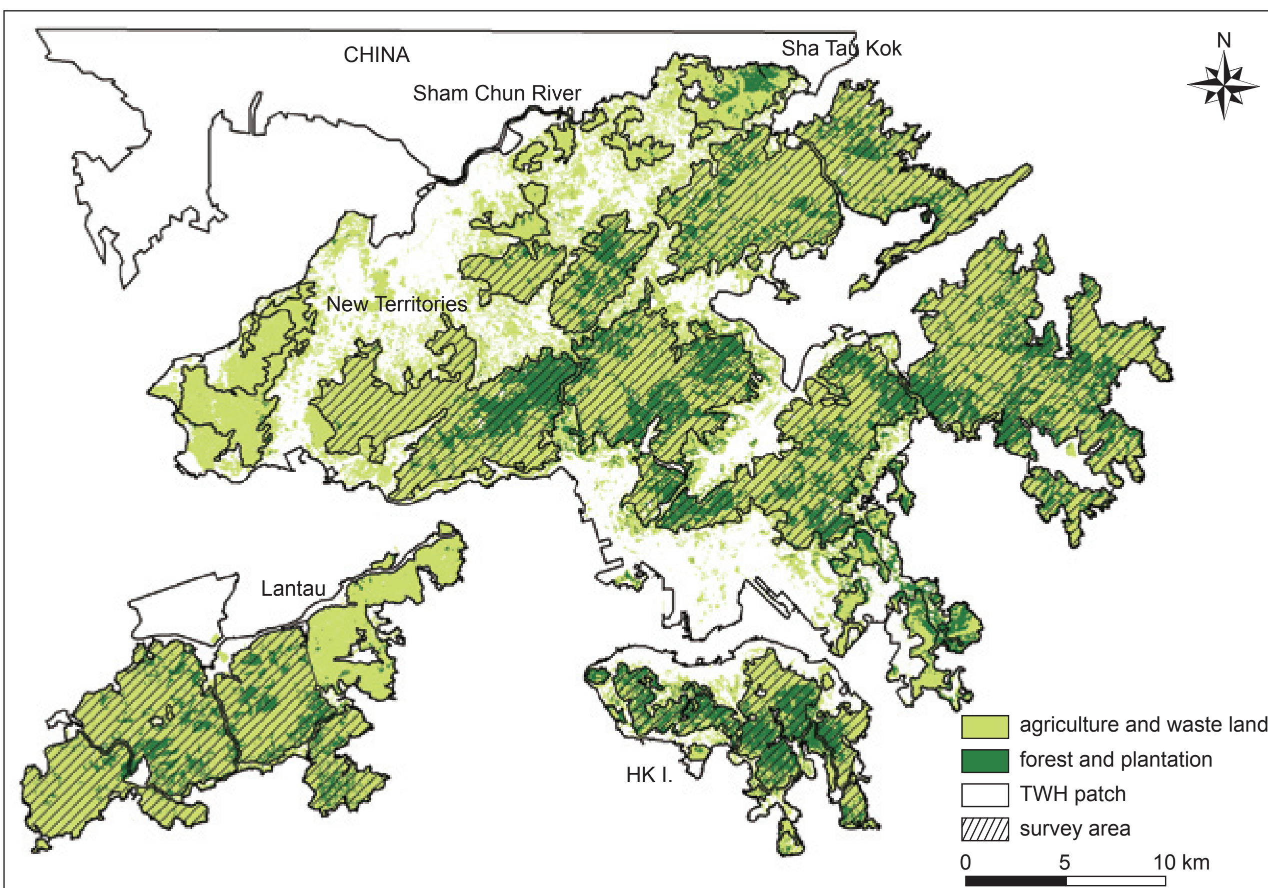

Fig. 1. Study area and aggregated terrestrial wildlife habitat (TWH) patches.

China) are a 1 piece system with a passive infrared sensor that is triggered by moving objects with a temperature different from the ambient air. These cameras were used to conduct this survey of larger mammals in Hong Kong from Sept. 2000 to Dec. 2003. In total, 373 camera sites were set up during the study period, selected to cover different wildlife habitats in Hong Kong (Fig. 2). To collect information more effectively, camera traps were set up at locations where there were animal trails or tracks. The number of camera sites in each TWH patch ranged from 3 to 45 ($\overline{X}$ = 21.9; standard deviation (SD) = 12.5) depending on the size and the degree of habitat heterogeneity. Cameras were installed 1.5-2.5 m above the ground overlooking a trail and were angled downwards at 25°-45°, since prior experience had shown that this arrangement is effective in detecting mammals over the full size range present in Hong Kong. Film collection and battery replacement was conducted every 2-4 wk.

Many studies have used camera-traps to assess the status of terrestrial wildlife. For individually identifiable species, camera-traps can be used to estimate population densities by capture-resight (Karanth et al. 2004, Marnewick et al. 2008). Since estimates from the mark-recapture method and the total number identified are strongly correlated, photographic rates (i.e., the number of camera days per animal photographed) are used to assess cryptic mammal densities (Carbone et al. 2001, O'Brien et al. 2003). However, density estimates from photographic rates should be used with caution, since independent estimates of animal densities at representative sites are needed for calibration and to evaluate the precision of the calibration (Carbone et al. 2002, Jennelle et al. 2002).

In this study, the occurrence index (OI = the number of pictures taken per 1000 camera working hours) was used to represent the relative abundances of mammals at each site. Serial pictures belonging to the same individual taken

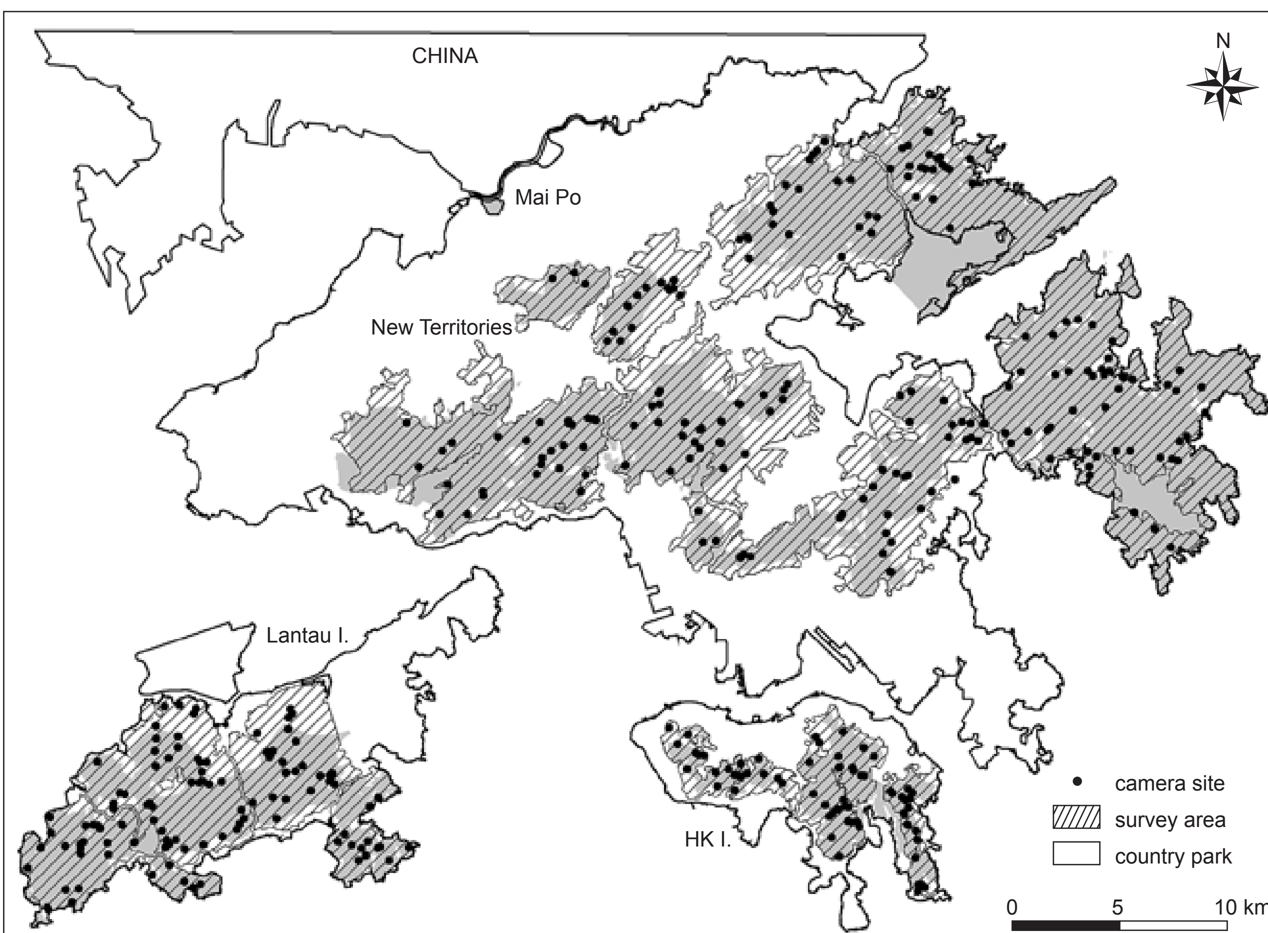

Fig. 2. Camera sites of larger mammal survey in Hong Kong SA.

during a short period (usually within 30 min) were considered a single picture-event to prevent the overrepresentation of a lingering individual. In general, the higher the density of a species in the area, the more pictures that will be taken, but comparisons between species must be treated with caution because of differences in size, life-form, and behavioral patterns. Since the functional relationship between the index and density was not calibrated, the OI was not used to estimate populations but to indicate the relative abundance distributions between TWHs for each species. For each species, the patch OI value was calculated as the average of all camera sites in the patch, and the overall OI value was the average of the patch OIs. The patch OIs for each species were classified into 5 levels for mapping, based on their deviation from the overall OI for that species: medium (within the range of overall OI ± 0.5 SD), low (less than the overall OI - 0.5 SD), moderately high (between the overall OI + 0.5 and 1.5 SD), high (between the overall OI + 1.5 and 2.5 SD), and very high (greater than the overall OI + 2.5 SD). Trap-site occupancy was calculated as the percentage of camera sites at which a species was recorded.

RESULTS

In total, 1,442,581 (range, 417-13,025 per camera site; $\overline{X}$ = 3,868; SD = 2,718) camera working hours were completed at all camera sites. When aggregated by the TWH patches surveyed, the patch total camera working hours ranged 8,097-147,110 ($\overline{X}$ = 84,858, SD = 44,549) h. Twenty mammalian species were recorded during the survey period, including 15 larger mammalian species and Pallas's squirrel (*Callosciurus erythraeus*). The total number of pictures taken was 9,215 (Table 1). The other 4 species were murid rodents and shrews, which could not always be distinguished in the photographs and are not considered further.

On the basis of the overall OI, the Malayan porcupine (*Hystrix brachyura*) (OI = 1.304) and red muntjac (*Muntiacus muntjak*) (OI = 1.006) were the species most often photographed, while the crab-eating mongoose (*Herpestes urva*) (OI = 0.031), Chinese pangolin (*Manis pentadactyla*) (OI = 0.028), small Indian mongoose (*Herpestes javanicus*) (OI = 0.020), and yellow-bellied weasel (*Mustela kathiah*) (OI = 0.010) were the rarest (Table 1). However, the trap-site occupancy of each species showed a different trend. The red muntjac (71.2%), small Indian civet (*Viverricula indica*) (59.1%), and Malayan porcupine (54.2%) had the highest trap-site occupancy, implying a

Table 1. Patch occurrence index (OI) values of 15 larger mammal species in Hong Kong

Common name	Scientific name	Total no. of pictures taken	Rank of total no. of pictures	Patch OI value			
				Minimum	Maximum	Average	SD
Malayan porcupine	*Hystrix brachyura*	2116	1	0.000	2.777	1.304	0.914
Rhesus macaque	*Macaca mulatta*	343	10	0.000	1.536	0.145	0.395
Chinese pangolin	*Manis pentadactyla*	31	13	0.000	0.218	0.028	0.055
Yellow-bellied weasel	*Mustela kathiah*	18	16	0.000	0.107	0.010	0.028
Chinese ferret badger	*Melogale moschata*	832	5	0.000	1.752	0.508	0.444
Masked palm civet	*Paguma larvata*	599	7	0.000	1.354	0.388	0.349
Small Indian civet	*Viverricula indica*	1160	3	0.000	1.573	0.821	0.565
Crab-eating mongoose	*Herpestes urva*	63	12	0.000	0.263	0.031	0.086
Small Indian mongoose	*Herpestes javanicus*	20	14	0.000	0.202	0.020	0.050
Leopard cat	*Prionailurus bengalensis*	288	8	0.000	0.583	0.190	0.176
Feral cat	*Felis catus*	231	9	0.000	0.626	0.163	0.213
Feral dog	*Canis familiaris*	732	6	0.000	0.973	0.447	0.292
Red muntjac	*Muntiacus muntjak*	1563	2	0.000	2.280	1.006	0.618
Wild boar	*Sus scrofa*	952	4	0.000	2.320	0.737	0.767
Feral cattle	*Bos taurus*	245	11	0.000	1.006	0.143	0.271
Total working hours				8096.95	147,110.1	84,857.7	44,549.25

wider distribution, while the Chinese pangolin (5.9%), small Indian mongoose (5.9%), and yellow-bellied weasel (1.5%) had the most restricted distributions (Table 2). Two species known to occur in Hong Kong and large enough for camera-trap detection were not recorded: the Eurasian otter (*Lutra lutra*) and greater bandicoot rat (*Bandicota indica*). Both have highly localized distributions (Shek 2006).

When comparing the 3 major regions of Hong Kong, i.e., Lantau I., Hong Kong I., and the New Territories (Fig. 1), the distribution patterns (Table 2) and TWH patch occupancy rates (Figs. 3-5) varied among species. The red muntjac, feral dog (*Canis familiaris*), and Chinese ferret badger (*Melogale moschata*) occurred in most patches and were the most widely and evenly distributed species in Hong Kong. The wild boar (*Sus scrofa*) and feral cat (*Felis catus*) were recorded in all 3 regions, but were less evenly distributed. The small Indian civet, Malayan porcupine, masked palm civet (*Paguma larvata*), and leopard cat (*Prionailurus bengalensis*) were all apparently absent from Lantau I. (as was Pallas's squirrel), while feral cattle (*Bos taurus*) and the Chinese pangolin were absent from Hong Kong I. The remaining species were confined to the mainland New Territories, where the rhesus macaque (*Macaca mulatta*) and small Indian mongoose were quite widespread, but the crab-eating mongoose and yellow-bellied weasel were confined to the northeast.

DISCUSSION

Hong Kong's mammal fauna

Hong Kong populations of the 15 larger mammal species recorded in this survey have varied historical origins. On the basis of their current and historical distributions in the region, 9 species – the leopard cat, small Indian civet, masked palm civet, Chinese ferret badger, crab-eating mongoose, Malayan porcupine, Chinese pangolin, red muntjac, and wild boar – are probably survivors of Hong Kong's primeval mammal fauna. However, the wild boar populations may be mixed with feral domestic pigs.

In view of the relatively uniform structure and successional status of the major wildlife habitats in Hong Kong (Lai et al. 2002), the irregular density distribution patterns of the large mammal species (Figs. 3-4) are more likely to reflect differing histories of decline, expansion, and/or colonization, rather than habitat variations. For example, the feng shui forests, although small (< 4 ha) and usually adjacent to active villages, may have contributed to the survival of more or

Table 2. Species richness and frequency of larger mammal species in different regions of Hong Kong

Common name	Percent (%) of cameras recorded and species richness			
	Lantau I.	Hong Kong I.	New Territories	Overall
No. of camera sites	109	65	199	373
Red muntjac	73.4	46.2	77.7	71.2
Small Indian civet	0	83.1	81.9	59.1
Malayan porcupine	0	60.0	80.0	54.2
Feral dog	31.2	52.3	54.0	47.3
Chinese ferret badger	29.4	49.2	54.4	46.5
Wild boar	4.6	6.2	72.6	42.4
Masked palm civet	0	76.9	53.0	42.2
Leopard cat	0	30.8	54.9	35.5
Feral cat	45.9	23.1	5.6	19.8
Feral cattle	8.3	0	18.6	12.6
Rhesus macaque	0	0	20.0	11.1
Crab-eating mongoose	0	0	11.2	6.2
Chinese pangolin	0.9	0	10.2	5.9
Small Indian mongoose	0	0	10.7	5.9
Yellow-bellied weasel	0	0	2.8	1.5
Species richness	7	10	16	

less forest-dependent mammals during the period of maximum human impacts in rural areas. These feng shui forests, as well as forested upland ravines, may have served as temporary refuges during periods of maximal rural development and randomly preserved certain populations. The importance of history is supported by a preliminary study on the mitochondrial DNA of rodents that showed 3 different genotypes identified for the forest-dwelling *Niviventer fulvescens* collected from the 3 major regions, while no genetic differentiation was found in the more tolerant *Rattus* sp. collected

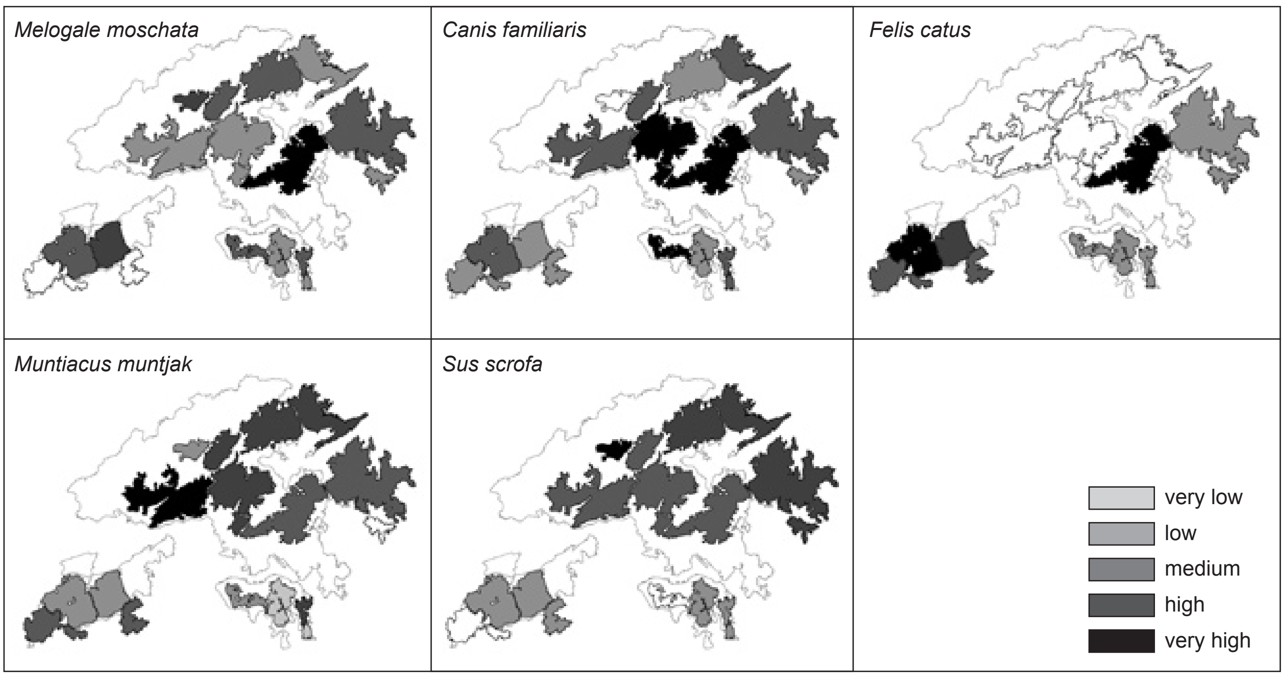

Fig. 3. Overall OI mappings for commonly distributed larger mammal species in Hong Kong SAR.

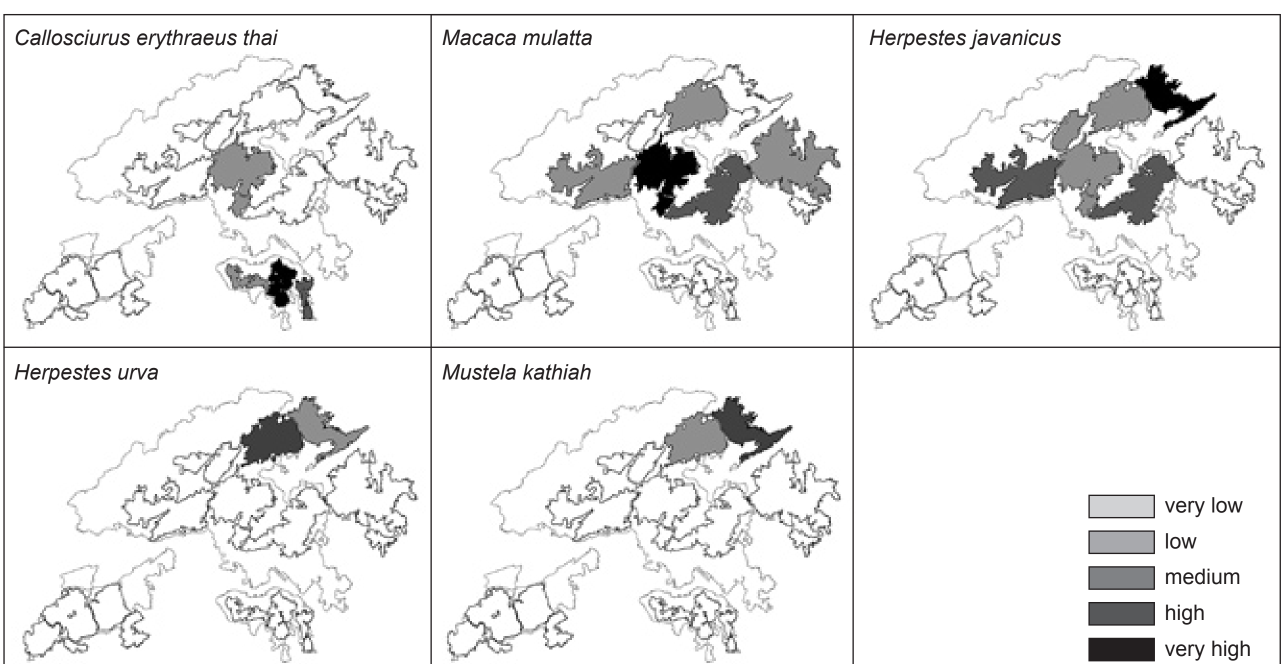

Fig. 4. Overall OI mappings for restricted larger mammal species in Hong Kong SAR (for legend refers to figure 3).

throughout Hong Kong (L.K. Lin unpubl. data). If this explanation is generally true, then significant genetic variation among at least the 3 major regions would be expected for other species that survived the period of minimum forest cover in Hong Kong.

Hong Kong's rhesus macaques are well within the native range of this species, but the current population was apparently established from introductions that began around 1915 (Dudgeon and Corlett 2004). Pallas's tree squirrel is also within the native range of the species as a whole, but populations in Hong Kong were established from escaped or released individuals of 2 exotic subspecies less than 40 yr ago (Dudgeon and Corlett 2004).

The yellow-bellied weasel was the 1st confirmed record for Hong Kong. It is conceivable that a small population had previously been overlooked, but its current rarity and restriction to the northeastern New Territories, near the only remaining non-urbanized corridor for dispersal from adjacent areas of the Chinese mainland, suggests it has recently colonized or re-colonized Hong Kong. The crab-eating mongoose has a similar current distribution as the weasel. Although this species was present in Hong Kong in the past, it was believed to have been extinct by the 1950s (Marshall 1967, Hill and Phillipps 1981), and it is possible (but not provable) that the current population is a result of re-colonization by the same route as the yellow-bellied weasel. The small Indian mongoose was first definitely recorded in Hong Kong in the 1980s and is now abundant in the Mai Po Marshes Nature Reserve (outside our survey area) and widespread throughout the central and northern New Territories (Dudgeon and Corlett 2004). It is a conspicuous diurnal animal in open habitats so it seems improbable that it was previously overlooked, but there is insufficient information to distinguish between natural colonization from the mainland and a deliberate introduction.

Feral cats, dogs, and cattle are apparently also recent additions to Hong Kong's mammalian fauna, with feral cattle, in particular, only becoming established within the last 2 decades following their abandonment as farming became uneconomic (Dudgeon and Corlett 2004). Near the margins of urban areas, many of the dogs may be 1st-generation strays, but those in more-remote rural areas seem to be genuinely feral. Feral dogs are now the most widespread carnivore species in Hong Kong, but feral cats have a much more restricted distribution, being widespread only on Lantau I., where the ecologically similar leopard cat is absent.

In view of the high density of camera sites and large number of camera hours, as well as information compiled from local interviews and

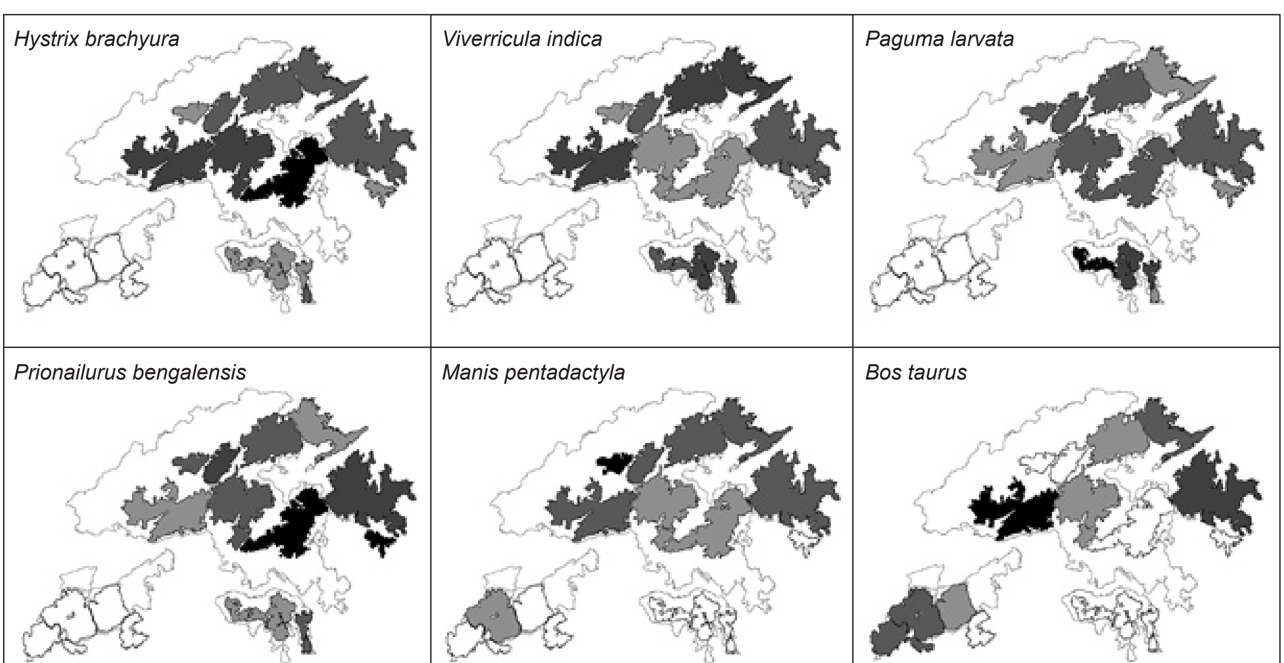

Fig. 5. Overall OI mappings for locally extinct larger mammal species in Hong Kong SAR (for legend refers to figure 3).

casual sightings, it is unlikely that any other large mammal species survive in inland habitats in Hong Kong. Four carnivore species reliably recorded in the last century, tiger, leopard, large Indian civet, and red fox, are undoubtedly extinct. Excluding these extinct species, the addition of the squirrel, plus 8 species of murid rodents (including 5 or 6 commensals) and 2 species of shrew (Chung and Corlett 2006), gives a total current non-volant terrestrial mammal fauna of 26 species. A 27th species, the Eurasian otter (*Lutra lutra*) occurs in very small numbers in the coastal Mai Po Marshes Nature Reserve in northwestern Hong Kong (Shek 2006). In addition, 26 bat species have been recorded in Hong Kong (Shek and Chan 2006), to give a total of 53 terrestrial mammal species.

It is almost certain that other mammalian species became extinct in Hong Kong before local records began, including flying squirrels and additional species of primates, carnivores, and terrestrial herbivores (Corlett 2006), although there is no direct evidence for most of these taxa. The known and inferred extinctions were mostly either a danger to people, their livestock, or their crops (tigers, leopards, dholes, bears, and elephants), highly valued in traditional medicine (tigers and rhinoceroses), preferred prey of hunters (primates, large deer, and civets), and/or highly dependent on forest (primates, flying squirrels, and other forest rodents). The survivors have few things in common, but they are all relatively small and all capable of utilizing non-forest habitats at least to some extent.

The spatial distribution of larger mammals in Hong Kong

The most striking feature of the geographical distribution of larger mammals in Hong Kong is the absence of many species from Lantau I., despite its relatively large size (144 km^2) and rugged topography that has confined development to a narrow coastal strip. The absence of macaques and tree squirrels probably reflects the absence of deliberate introductions, while the absence of the small Indian mongoose and yellow-bellied weasel is also not surprising if they have colonized Hong Kong only recently. However, Lantau also has neither civet species, nor leopard cats or porcupines, all of which occur on the smaller (78 km^2) and more-developed Hong Kong I. It is possible that some of these species were never present on Lantau I., but it seems more likely that they were extirpated and have been unable to recolonize across the marine barrier, although this does not explain their survival on Hong Kong I. Indeed, porcupines have been recorded on several islands of < 2 km^2 in area (Reels 1996). Within the mainland New Territories, which supports all of the recorded mammal species, most species are widespread, except for those that are likely to be recent invasions or introductions.

One interesting observation is that nearly 1/2 of the existing larger mammals in Hong Kong are typically forest edge and open-area species elsewhere (Table 2), which was not expected for such a highly urbanized area where city boundaries are usually immediately adjacent to forest edges. A recent study at Kenting National Park (22°N, 121°E), Taiwan, at a similar latitude, found the opposite: despite high wildlife habitat coverage (80% forest and 13% open habitats; Chen and Chung 2003), 80% (4/5) of forest-edge and open-area species, including the Chinese pangolin, small Indian civet (Francis 2008, Chen et al. 2009), leopard cat, and the sika deer (*Cervus nippon taiouanus*), became locally extinct when intensive human development near forest edges occurred during the past century (Pei 2004). As mentioned earlier, both spontaneous and managed reforestation has been much faster in the foothills than in higher elevations in Hong Kong, and these foothill forests may have buffered these edge species. An analysis of landscape elements would be helpful to test this hypothesis.

Implications for conservation

Among native mammals, both civet species, the ferret badger, red muntjac, wild boar, and Malayan porcupine are widespread and abundant in existing protected areas, and thus of least current conservation concern. The only obvious threat would be from fragmentation of the existing populations if future development of the road system severed existing links between Country Parks. Currently, the only barrier between adjacent Country Parks is typically a secondary road that is relatively quiet at night. Regular sightings and road kills show that the surviving large mammal species cross such roads, but widening or increased traffic could change this.

The leopard cat is widespread but apparently less abundant than the preceding species. Additional research is needed to determine if the Hong Kong populations are viable, particularly that on Hong Kong I. Although the Chinese pangolin is widespread, only 31 pictures were taken in total. If this is an accurate indication of the abundance of this species, then the pangolin will need active conservation support, and population recovery measures should be considered. Natural dispersal into adjacent Country Parks is possible for the pangolin once the population density increases; however, to encourage the movement, active microhabitat management should also be undertaken in surrounding areas. There are no recent records of this species being trapped or hunted in Hong Kong, but given its high commercial value this remains a potential threat.

The crab-eating mongoose and yellow-bellied weasel have similar restricted distributions in the northeastern New Territories. The low numbers of both species suggest that, like the pangolin, they will need active conservation support to survive, including possible reinforcement by additional individuals from the nearest wild population north of the Hong Kong border. The small Indian mongoose was also rarely photographed in this survey, but it favors non-forested habitats that were not intensively surveyed, so its abundance was certainly underestimated. Native or not, this species is currently of no conservation concern.

The population of rhesus macaques (and hybrids with released exotic long-tailed macaques, *Macaca fascicularis*) is currently expanding at a rate > 5% per year and was expected to reach 2,000 individuals by the year 2007 (Wong and Chow 2004). Aggressive encounters with park visitors continue to be a problem, despite a ban on feeding implemented in 1999, but this species is clearly of no conservation concern.

The remaining 3 large mammal species are feral populations of domesticated animals. Packs of feral dogs are present throughout the protected area system, apparently as self-sustaining wild populations, although they intergrade with urban strays (Dudgeon and Corlett 2004). In addition to consuming waste human food, both field observations and photographic evidence show that they kill civets, muntjacs, and porcupines, making them the top mammalian carnivore in Hong Kong. In view of the expense and difficulty of effective dog control, research is urgently needed to assess the severity of their impacts on prey populations. Feral cats are less abundant and some of the pictures in this survey may be of wide-ranging domestic cats. Most are relatively small animals, and their wild prey is likely to consist only of small vertebrates, such as rats, mice, shrews, and birds. However, their possible conflicts with the leopard cat population should not be overlooked. Feral cattle are the largest wild mammals in modern Hong Kong. Their numbers have increased rapidly over the last decade as a result of breeding, rather than additional releases, and they are spreading into previously unoccupied areas. Their impacts on the vegetation of open areas and forest understory are obvious, both by trampling and by selective grazing and browsing, and they appear to facilitate the invasion of exotic plant species (Leung et al. 2009). Again, further research is needed into both their current impacts and possible means of control.

The impoverished mammalian fauna of Lantau I. provides a unique opportunity for the experimental reintroduction of missing taxa into a well-studied mammal community. Among the missing carnivores, the leopard cat is an obvious target, as a species of potential conservation concern, but this would require finding a source of surplus individuals in the Hong Kong region. An alternative or additional possibility would be to reintroduce one or both of the carnivores that were lost from Hong Kong in the 1950s, the red fox and the large Indian civet. Interactions between any carnivore introductions and the established feral cat population would be of particular interest.

Hong Kong's protected area system already includes > 40% of the total land area (Fig. 2), with an additional ca. 20% protected from development by rugged topography. As far as large mammals are concerned, the key management need is the protection and, if possible, enhancement, of the links between adjacent protected areas, most of which are probably too small to support viable populations on their own. Radio-telemetry studies are needed to understand how these links are used at present. Habitat improvements and the protection of small additional areas may be needed to ensure that wildlife movements within Hong Kong continue to be possible. The last potential corridor for terrestrial wildlife movements between the rest of China and Hong Kong is in the northeastern New Territories, where rural habitats in Hong Kong's Frontier Closed Area abut similar habitats on the Shenzhen side of the border fence, especially the Sha Tau Kok area (Fig. 1), providing a link between Shenzhen's 31 km^2 Wutongshan National Forest Park and Hong Kong's Country Park system. None of this corridor receives formal protection at present, so development is a constant threat. Urgent consideration should be given to preserving this link.

CONCLUSIONS

The main general conclusion from this study is that a diverse mammalian fauna can persist in a highly degraded tropical Asian landscape. But how typical is Hong Kong? Most other areas of tropical East Asia with a similar degree of landscape degradation appear to have much more highly impoverished mammalian faunas (pers. obs. by the authors), although no intensive surveys were done. If these apparent differences are real, they almost certainly reflect the absence of recent hunting pressure in Hong Kong and its prevalence throughout almost all the rest of the region (Corlett 2007 2009). Hong Kong thus shows the potential for such landscapes, but not the current situation in most of them.

The large differences between the current distributions of mammal species within Hong Kong suggest that historical accidents played major roles in the composition of the fauna, with individual species expanding from their last refuges or reinvading Hong Kong after a relaxation of human pressures in rural areas over the last few decades. We expect the same pattern to prevail elsewhere in tropical Asia when human pressures relax over the next 30-50 yr as a result of declining birth rates and rural-urban migration. This in turn suggests that there will be many opportunities for conservation interventions to ensure that the newly available habitats are re-occupied with their full potential of mammalian faunas. Hong Kong is an ideal place to practice this.

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