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Mamm. biol. **66** (2001) 251–255
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http://www.urbanfischer.de/journals/mammbiol

Mammalian Biology
Zeitschrift für Säugetierkunde

Short communication

Notes on the ecology of sympatric small carnivores in southeastern China

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Receipt of Ms. 30. 10. 1998
Acceptance of Ms. 20. 02. 2001

Key words: *Herpestes urva, Paguma larvata, Vivenicula indica,* activity, home range

The civets are diverse and prominent elements of old world tropical communities, demonstrating more ecological diversification in trophic specialization and substrate use than any other family of carnivores (Eisenberg 1981). They are also the least known carnivore group in the world (Wemmer and Watling 1986), especially in Asia, even though many species have ecological and economic significance and have long been harvested for their pelts, meat, and musk. We radio-tracked 5 masked palm civets (*Paguma larvata* H. Smith, 1827), 2 small Indian civets (*Viverricula indica* Demarest, 1817) and 1 crabcating mongoose (*Herpestes urva* Hodgson, 1836) in northern Jiangxi Province, southeastern China during April 1993–November 1994 to understand more about the small carnivore community there.

The study site near Taohong Village is located in northern Jiangxi Province about 15 km south of the Yangtze River and about 490 km WSW of Shanghai. It is in a small, V-shaped valley about 6 km long at the foot of Mount Taohong and surrounded by a stretch of low and undulating hills (50–530 m above sea level). The climate is moist monsoon type with typical temperate climate seasonal changes. The average annual temperature is around 16.3 °C, and the annual precipitation is 1 326 mm, of which over 40% falls as rain during May–July.

All the arable lands at the bottom of the valley are under cultivation and many gentle hills and slopes also are now farmland. Above the farmland the major vegetation is a combination of tall grasses (*Themeda triandra*, *Imperala cylindirca*, and *Arundinella* spp.) and secondary growth of shrub species (*Lespecdeza bicolor*, *L. formosa*, *Rhus chinensis*, and *Rhododendron simsii*) that is maintained by annual firewood collection and frequent fires. Only in some remote areas or regions posted by the local forest farms do small patches of deciduous broadleaf and, in rarer frequency, evergreen-deciduous broadleaf forest remain.

The northwest part of Taohong Village is included in the Taohongling Sika Deer Reserve that was established to protect a remnant population of the endangered subspecies of sika deer (*Cervus nippon kopschi* Swinhoe, 1873) in 1981. A general survey on the fauna and flora of the reserve was carried out in and near the reserve during 1988–89; this is the only source of background information for that area (Ding 1990).

Most of the study animals were caught by the local trappers with traditional bamboo foothold snares (Han 1960); only one masked

1616-5047/01/66/04-251 $ 15.00/0.

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palm civet was captured in a cage-type live trap. Captured animals were weighed to calculate drug dose, then immobilized with Telezol (Tiletamine HCL and Zolazepam HCL) or Ketaset (Ketamine HCI) at a dosage of 10 mg/kg body weight. After sex was determined and body measurements recorded, each animal was fitted with radiocollar (with 15-cm whip antennas) weighing < 5% of their body weight. All immobilized animals were held in cages then released after full recovery from the drugs' effects.

Activity of marked animals was determined by listening for changes in radio signal strength during a 60-second period. Consecutive readings were taken with an interval of at least 30 minutes. The activity level (% active) was calculated as the number of active readings divided by the total number of readings. Collared animals were generally located a minimum of 3 times a week by walking in on the animals' resting site during periods of inactivity. The term "daybed" is used to designate those resting sites (RABINOWITZ 1991). The general external characteristics of daybeds were recorded to categorize them. Daily movements were calculated as the linear distances between 2 consecutive daybeds. Re-use rates of daybeds were calculated as the total number of locations divided by the number of different daybeds (PALOMARES and DELIBES 1993, 1994). The resting home ranges of the marked animals were calculated as minimum convex polygons (MOHR 1947) with the RANGES V program (KENWARD and HODDER 1996), based on the locations of daybeds and capture sites (PALOMARES and DELIBES 1994).

Masked palm civets were active > 50% of the time between 18.00 and 05.00 hours (Tab. 1). Their activity declined throughout

Table 1. Percent of checks indicating activity for radio-marked carnivores studied near Taohong Village, southeastern China during April 1993–November 1994

	Masked palm civet		Small Indian civet		Crab-eating mongoose	
Hour	No. of checks	Percent active	No. of checks	Percent active	No. of checks	Percent active
01.00	1	100	2	100	–	–
02.00	7	57	–	–	–	–
03.00	8	100	2	100	–	–
04.00	19	53	–	–	–	–
05.00	40	68	1	100	–	–
06.00	94	45	3	33	–	–
07.00	101	39	2	0	–	–
08.00	104	21	–	–	1	0
09.00	135	15	1	0	–	–
10.00	144	22	–	–	4	25
11.00	112	9	–	–	4	25
12.00	90	3	–	–	3	100
13.00	48	14	2	0	3	67
14.00	51	14	2	0	–	–
15.00	66	17	2	0	3	67
16.00	137	14	6	17	4	100
17.00	178	33	12	42	2	100
18.00	167	74	20	85	2	50
19.00	60	88	6	100	–	–
20.00	45	89	4	100	–	–
21.00	42	93	–	–	–	–
22.00	27	89	4	100	–	–
23.00	13	93	1	100	–	–
24.00	6	83	–	–	–	–

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the morning, with a nadir at 12.00 hours, then remained moderately low until 18.00 hours. Limited data for small Indian civets seemed to mirror that of masked palm civets, but the crab-eating mongoose was clearly very active (56% of 25 readings) when monitored between 10.00 and 18.00 hours (Tab. 1). Masked palm civets have been reported elsewhere to have 2 nocturnal peaks of activity (Zhang et al. 1991), and small Indian civets apparently have either 1 (Wang et al. 1976; Rabinowitz 1991) or 2 (Sheng and Xu 1990). Like we found, Gao (1987) indicated that crab-eating mongooses were diurnal.

All the daybeds of the masked palm civets were underground burrows, mainly the abandoned dens of porcupines (*Hystrix brachyura* Cuvier, 1822). In contrast, all the daybeds of the small Indian civets we examined were on the ground, usually under dense bushes or among tall grass. In some cases adjacent daybeds were located so close to each other (e. g., 4 daybeds with an area of 2 m^2) as to practically form daybed groups. The few daybeds used by the crab-eating mongoose were underground dens. Rabinowitz (1991) reported that the small civets (including small Indian civet and masked palm civet in his study) were located in tree beds 86% of the time; we did not find use of tree beds by the masked palm civets though there were enough big trees within their habitat. Gao (1987) observed that masked palm civets commonly rest in dens in winter and spring and often use the dense bush in the hot summer. Thus, factors other than the availability of proper-sized trees would seem to affect civet daybed selection.

All 3 species did not use permanent dens but moved among numerous daybeds. The average daybed reuse rate was 2.5 times for the 5 masked palm civets (range 1.2–4.2), but increased with the total number of locations obtained ($r^2 = 0.86$, 4.d.f., $P = 0.005$), as might be expected. The reuse rate was 3.6 for the small Indian civet. However, the animals did not use their daybeds randomly but showed strong preferences. Overall, masked palm civets used their daybeds only once (59% of 124), twice (14%) or 3 times (11%), but some daybeds were frequently used; 7 were used 6–10 times each and 5 were used 10–17 times each. Similarly, small Indian civets often used their daybeds only once (43% of 14) or twice (29%), but 4 were used 6–10 times each.

The daybeds of the small Indian civet and crab-eating mongoose were located solely in the foothill region adjacent to the farmland. Some daybeds of masked palm civets were located in the low bushes and tall grass that covered the hilly region bordering farmland, but many were also farther above in the woods. This difference in habi-

Table 2. Altitude (m asl) of daybeds used, distance (m) between consecutive daily locations, and resting home range sizes (ha) of radio-marked sympatric small carnivores studied near Taohong Village, southeastern China during April 1993–November 1994

Species	Sex	No. of locations	No. of different daybeds	Daybed altitude			Distance between locations		Tracking period	Home range size
				x ± SD[2]	Min.[b]	Max.[c]	x ± SD	Max.		
Masked palm civet	F	104	25	92 ± 23	45	145	560 ± 448	1960	04/93–11/93	288
	F	89	31	85 ± 17	46	125	248 ± 313	1155	06/93–12/93	190
	M	21	17	151 ± 91	53	363			12/93–07/94	410
	M	39	23	122 ± 31	65	170	681 ± 414	1450	03/94–11/94	182
	M	64	28	97 ± 66	30	363	177 ± 223	805	10/93–07/94	346
Small Indian civet	M	47	13	86 ± 18	40	108	613 ± 686	2395	03/94–06/94	227
	M	3	3	59 ± 14	43	70			06/94–07/94	7
Crab-eating mongoose	F	7	6	78 ± 33	30	105			02/94–03/94	100

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tat use was showed clearly by the altitudes of the locations of the tracked animals (Tab. 2). Although many daybeds of these 3 species occurred in close proximity to farmland and trails used by humans, most marked carnivores that were resting were not disturbed by nearby human activity. Elsewhere, masked palm civets prefer dense forest (Rabinowitz 1991), and small Indian civets prefer disturbed habitats or forest/agricultural edges (Wemmer and Watling 1986; Sheng and Xu 1990; Wang 1990), similar to our results and indicating an important difference in overall habitat use between those 2 species.

The average distance moved between consecutively used daybeds ranged from 177–681 m (max. = 1 960 m) for masked palm civets, and 613 m for the small Indian civet (max. = 2 395; Tab. 2). Although masked palm civets and small Indian civets returned to their previous daybeds with similar frequency (32% of 203 movements vs. 38% of 37 movements, respectively), movements to different daybeds were usually shorter for masked palm civets (53% vs. 15% of moves < 500 m to different daybeds; $X^2 = 9.37$, 1 d.f., $P < 0.01$).

The resting home ranges of the 5 masked palm civets located 20–104 times ranged from 182–410 ha (Tab. 2) and did not vary with number of locations ($P > 0.56$). The resting home range for the small Indian civet located 47 times was similar in size (227 ha). The monthly home range for the small Indian civet was 158 ha (n = 24) in April and 156 ha (n = 20) in May. Although the crab-eating mongoose was only located 7 times, its home range was at least 100 ha.

The home ranges of the 2 small Indian civets overlapped, and they and 4 other individuals were caught in the same area. Local hunters told us that both masked palm civets and crab-eating mongooses were seen in packs of 3 to 4 individuals. Two marked masked palm civets were found sharing the same daybeds more than 20 times. In addition, footprints showed that small Indian civets were usually solitary while crab-eating mongooses often moved in small packs or family groups.

In spite of their dietary similarity (Wang 1999), the resting home ranges of these 3 species overlapped extensively. Even though only an unknown portion of all individuals of any 1 species were marked in the study area, daytime home ranges of crab-eating mongooses overlapped 35% and 36%, those of small Indian civets overlapped 60% and 82%, and those of masked palm civets overlapped 76% and 99% with those of other species. However, none of the radio-marked individuals of any 1 species used the same daybed simultaneously with any other marked individual of another species.

In the only other telemetry study of masked palm civets, Rabinowitz (1991) radio-tracked a single adult female for 12 months. Its total home range was 370 ha, the average daily movement distance was 620 m, and the longest daily movement was 1 800 m, figures rather close to those we recorded. Rabinowitz (1991) also reported that an adult male small Indian civet followed for 6 months had an overall home range of 310 ha, an average daily movement of 500 m, and the longest distance of 2 400 m, findings that were again, similar to ours. The home ranges we calculated, however, were certainly minimums because they were calculated solely from daybed locations and capture sites, while Rabinowitz (1991) used both the daybeds and locations obtained by triangulation at night.

Acknowledgements

We are grateful for the field assistance of Tang Daxong and the logistical assistance of J. Qing, S. Meng, W. Wang, B. Wang, J. Zhang, and G. Li.

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Zeitschrift/Journal: Mammalian Biology (früher Zeitschrift für Säugetierkunde)

Jahr/Year: 2001

Band/Volume: 66

Autor(en)/Author(s): Wang H., Fuller Todd K.

Artikel/Article: Notes on the ecology of sympatric small carnivores in southeastern China 251-255