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Prey Selection and Hunting Behaviors of Steppe Polecat *Mustela eversmanni* in Laboratory Studies

[1]Shiping Li, [1]Baofa Yin, [1]Xin Dai, [1]Fengping Yang, [1]Shengmei Yang, [1]Wanhong Wei, [2]Naichang Fan and [3]Wenyang Zhou
[1]College of Bioscience and Biotechnology, Yangzhou University, 225009 Yangzhou, Jiangsu, China
[2]Academy of Life and Environment Science, Zhejiang Normal University, 321004 Jinhua, Zhejiang, China
[3]Northwest Plateau Institute of Biology, Chinese Academy of Sciences, 810001 Xining, Qinghai, China

Abstract: Steppe polecat (*Mustela eversmanni* Lesson, 1827) is the dominant species of mustelids in the alpine meadow ecosystem of the Qinghai-Xizang (Tibetan) plateau in China. Using the live and dead rats as the experimental prey, researchers investigated the effects of prey body masses, numbers and activities on predatory behaviors of the polecat. The results revealed that the prey activity was the most important factor that affected prey selection of the polecat during searching phase. The searching time used for live prey by polecat was significantly longer than that used for dead prey. Also, the prey numbers and body masses significantly affected prey selection of the polecat. When the activities of prey were the same, the polecat always preferred the group with more prey than the one with less prey. When the number and activity of prey were the same, the searching duration was significantly decreased from the lowest weight class to the highest one. In addition, the foraging profitability of polecat is prey dependent which was higher with smaller prey than with larger ones. These results indicated that the polecat could adjust the hunting behaviors to achieve the optimal profitability according to the characteristics of prey.

Key words: Hunting behavior, *Mustela eversmanni*, prey activity, prey body mass, prey number, China

INTRODUCTION

In the field, searching for prey is the most important and costly foraging activity of a predator. Predator uses the size, number and activity of prey as criteria for foraging strategies (Davies, 1977; Griffiths, 1980; Raymond *et al*., 1990; Ille, 1991; Pekkarinen and Heikkila, 1997; Sundell *et al*., 2003; Moreby *et al*., 2006; Canepuccia *et al*., 2007). Large prey is more nutritious and more conspicuous as being food by predators and active prey can provide stronger stimuli that facilitate detection by predators. However, it will take more time, more energy and more risk for a predator in handling large and/or active prey (Kaufman, 1974; Slack, 1975; Griffiths, 1980; Derting, 1989). The decision whether a predator selects large or small and active or inactive prey may depend on the time and energy costs of searching for and handling prey (Davies, 1977; Griffiths, 1980). Another factor that can influence prey selection is the number of prey (Erlinge, 1975; Estabrook and Dunbam, 1976; Langvatn and Hanley, 1993). The distribution of alpine weasel (*Mustela altaica*) is associated with the numbers of its major prey, plateau pika (*Ochotona curzoniae*) (Wanhong *et al*., 1994).

The steppe polecat (*Mustela eversmanni* Lesson, 1827), a medium-sized and slender mustelid is a dominant species in mustelids in the alpine meadow ecosystem. It serves as the major prey for foxes (*Vulpes vulpes* and *V. ferrilata*), upland buzzard (*Buteo hemilasius*) and Tibetan dog and has the significant impact on endemic animal populations (Shengwu *et al*., 1983; Zhou and Wei, 1994). On the other hand, the polecat preys mainly on plateau pika, plateau zokor (*Myospalax baibily*), root vole (*Microtus oeconomus*) and small birds (Shengwu *et al*., 1983; Zhou and Wei, 1994). It has to compete for food with foxes, alpine weasel, desert cat (*Felis bieti* and *F. manul*), upland buzzard, falcons (*Falco cherrug*, *F. tinnunculus* and *F. peregrinus*) and owls (*Bubo bubo*, *Athene noctus* and *Asio otus*) in wild (Wanhong *et al*., 1994; Zhou and Wei, 1994; Wei and Zhou, 1997).

Corresponding Author: Wanhong Wei, College of Bioscience and Biotechnology, Yangzhou University, 225009 Yangzhou, Jiangsu, China

Sheng-Mei *et al.* (2006) observed that both male and female polecats first selected Plateau pika then Plateau zokor and root vole when these three preys were offered simultaneously. Field observations showed that the polecat spends most of the daily time (about 8 h) in searching for food although, it also needs to spend time for other activities such as finding mates, caring for the young and guiding the territory (Zhou and Wei, 1994). However, little is known about the predatory behaviors of the polecat including prey selection and hunting behavior. How the polecat effectively searching for prey remains unknown and becomes an important and very interesting topic.

In this study, researchers applied different experimental approaches to investigate the foraging strategies of the polecat. Using laboratory rats (*Rattus norvegicus*) as prey, researchers measured the effects of prey body mass (size), activity and number on prey selection and hunting behaviors of the polecat and examined how the polecat adjusts its hunting behaviors to achieve the optimal profitability according to the characteristics of prey.

MATERIALS AND METHODS

Animals: Three male (733.3±7.5 g) and two female (646.0±9.9 g) steppe polecats were trapped in the region of Haibei Alpine Meadow Ecosystem Research Station of the Chinese Academy of Sciences (37°29'-37°45' N, 101°12'-101°33' E). Each polecat was kept in an outdoor wire meshed enclosure with dimensions of 140×120×180 cm. A wooden nest cage (25×25×39 cm) and several plastic tubes (20 cm in diameter and 100 cm in length) were placed in each enclosure for the purposes of animal sleeping and concealment. The food (Live or dead laboratory rats) was provided at 7:00 pm each day and water was available *ad libitum*.

Because it is difficult to get enough natural prey such as plateau pika, plateau zokor and root vole, laboratory rats were used in experiments which were supplied by the Laboratory Animal Centre of Northwest Plateau Institute of Biology, the Chinese Academy of Sciences. All rats were under 10 months old and had no previous reproductive experience. Both the live and dead rats (Dead rats were killed immediately before the beginning of an experiment and kept at -4°C until use) were divided into four weight classes based on the body mass: Class SW (Small-sized prey) with body mass <100 g; Class MW (Medium-sized prey) with body mass between 100 and 200 g; Class LW (Large-sized prey) with body mass between 200 and 300 g; Class MLW (largest-sized prey) with body mass >300 g. All procedures involving animals were licensed and conducted according to the guidelines of the Institutional Animal Care and Use Committee of Northwest Plateau Institute of Biology, the Chinese Academy of Sciences.

Trial procedure in experiments: All trials were performed in a room (260×490×180 cm) without windows. Two boxes of transparent and close plexiglass hexahedron (0.65 m^2 in area and 60 cm in height) for settling prey were put in the center of the room with 70 cm apart from each other. A nest cage with one polecat was set in the middle of a wall with 300 cm apart from the two boxes. An infrared camera connected to a video-recorder was set above the boxes to record the searching and handling behaviors of the polecat.

In each trial, matched prey from four different weight classes including two active levels and different numbers were put into the two boxes. In each trial, researchers first settled the prey in the boxes, then opened the door of the nest cage and turned lights off. After the polecat came out of the nest cage and moved in the room at will for 10 min, the searching behaviors of the polecat within the next 20 min were recorded. In this period, the polecat could move around or scratched the two boxes but could not come into the boxes to capture prey at will. Next, the door of one box was opened to allow the polecat to come into the box and the handling behaviors of the polecat were recorded until the polecat carried one prey to its nest cage. The time interval between trials was 20 min based on the preliminary results (Fig. 1).

Because polecats were nocturnal and were active only from 7:00-10:00 am and 5:00-8:00 pm, all trials were conducted within the 2 time periods. Each polecat was used only once in any given day and twice in the similar trials. Each trial was performed 10 times for statistical purpose. In all experiments except for experiment 5, the same experimental process and the numbers of prey in each trial was applied to the live and dead prey, respectively.

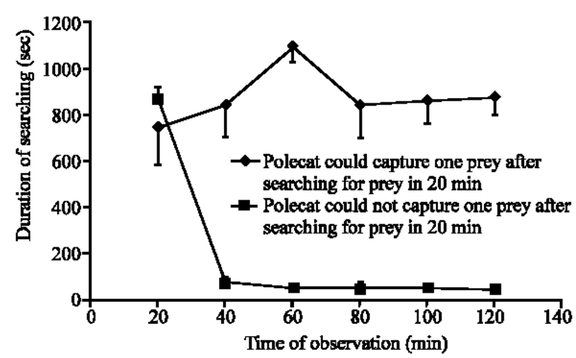

Fig. 1: Duration of the polecat searching for prey under different conditions

Experiment 1: As a control group, this experiment was to investigate how the prey with the same body masses (sizes), total biomasses, numbers and activities to affect the prey selection of polecat. For each of the weight classes, the prey were settled in the two boxes with a ratio of 1:1, 2:2 and 4:4.

Experiment 2: To evaluate how the body masses of prey affected the prey selection of polecat, one prey from different weight classes were settled to the two boxes, respectively.

Experiment 3: This experiment was to determine the effect of the number of prey from different weight classes on the prey selection of polecat. The two boxes were provided with the same total biomasses but with different numbers of prey in each trial. The numbers of prey for the two boxes were 1:7, 1:5 and 1:3 from the weight classes of MLW:SW, LW:SW and MW:SW, respectively.

Experiment 4: This experiment was to observe the prey selection of polecat when different numbers of prey with the same activities but from different weight classes were provided in different combinations. Prey from four weight classes were matched in pairs. For each trial, one prey from one weight class was put into the first box and 2 or 4 prey from another weight class were put into the second box.

Experiment 5: This experiment was performed to determine how the prey activities affected the prey selection of polecat. In one set of trials, the live prey and dead prey from the same weight class were respectively settled in the two boxes with a ratio of 1:1, 2:2 or 4:4. In another set of trials, one live prey from each of the four weight classes was put into one box and 1, 2 or 4 dead prey from each of the four weight classes were put into another box.

Data collection and statistical analyses: The hunting behaviors could be divided into searching, pursuing, killing, carrying and eating phases. The pursuing, killing, carrying and eating phases are combined as the handling phase in the laboratory studies. The prey selection of polecat was determined by the searching time that was defined as the total time of the polecat touching one box with any part of its body within 20 min. The profitability of catching prey was calculated by the handling time. Because eating occurred in the nest cage, the handling time in this study was the total time for pursuing, killing and carrying prey. The pursuing time was the duration from polecat getting into a box to touching a prey. The killing time was the duration from the prey being captured to being dropped or carried away. The carrying time was the duration from the prey being moved to being taken back to the nest cage. If the polecat dropped the killed or dead prey or did not carry the prey back to the nest cage, the trial was excluded from analysis.

In all experiments, the number of the prey supplied was the total number in each box in each trial and the total biomass in each trial was the total body masses of all prey offered in each box. The profitability of catching prey was measured in net nutritive value which was the energy (KJ) gained per unit time for handling one prey (Energy/handling time).

The statistical significance of the polecat searching for prey in each comparison was determined using the nonparametric tests of Wilcoxon matched pairs. The relationships between the prey's body masses and the time of polecat for searching and handling (Pursuing, killing and carrying) prey were measured by multiple regression methods. The related data were presented as mean±SE and the $p<0.05$ level was considered statistically significant.

RESULTS AND DISCUSSION

During the control tests, no significant differences were observed for the searching time when the prey, either live or dead with the same body masses, numbers and activities were provided in the two boxes ($n = 10$, $p>0.05$) (Fig. 2).

Preference of the prey body masses (sizes): Table 1 and Fig. 3 shows the effects of the prey body masses on the prey selection of the polecat. Significant influence of the prey body masses on the polecat searching behaviors was observed ($p<0.05$). The prey body masses and the searching time showed negative correlations in all trials using the dead ($r = -0.97$, $F_{1,2} = 30.67$, $p = 0.03$) and live prey ($r = -0.97$, $F_{1,2} = 21.97$, $p = 0.04$). In addition, the data indicated that the polecat preferred the small preys rather than the large prey and the live preys rather than the dead preys (Fig. 3).

Preference of the prey numbers: The prey number, both live and dead, significantly affected the prey selection of the polecat. In all trials, the polecat preferred the box containing more prey than the one containing fewer ones ($p<0.05$) (Table 2 and Fig. 4) but there was no significant effect of the total biomass of the prey on the predatory behaviors of polecat.

Table 1: Duration (in seconds) of the polecat searching for prey from different weight classes in trials (n = 10). Class SW: average body mass 49.2±0.8 g; Class MW: average body mass 153.6±1.5 g; Class LW: average body mass 249.3±0.5 g; Class MLW: average body mass 350.5±1.3 g (n = 20 prey in each class). Results of statistical comparisons in rows (by Wilcoxon tests) are shown

	Searching for dead prey				Searching for live prey			
Paired weight classes	For larger prey	For smaller prey	Z	p	For larger prey	For smaller prey	Z	p
MLW:LW	10.5±2.9	46.0±4.20	2.80	0.01	33.2±2.90	74.0±8.20	2.67	0.01
MLW:MW	18.2±6.7	41.1±7.30	2.80	0.01	41.9±6.70	78.0±10.3	2.70	0.01
MLW:SW	12.2±2.6	43.0±6.80	2.80	0.01	39.0±8.60	91.5±13.5	2.80	0.01
LW:MW	20.4±4.6	48.3±8.50	2.40	0.02	50.4±10.5	58.4±8.10	2.40	0.02
LW:SW	13.3±4.9	35.4±11.4	1.99	0.05	30.4±3.20	88.2±17.5	2.80	0.01
MW:SW	11.5±0.3	34.9±9.20	2.19	0.03	27.9±4.20	59.1±6.60	2.80	0.01

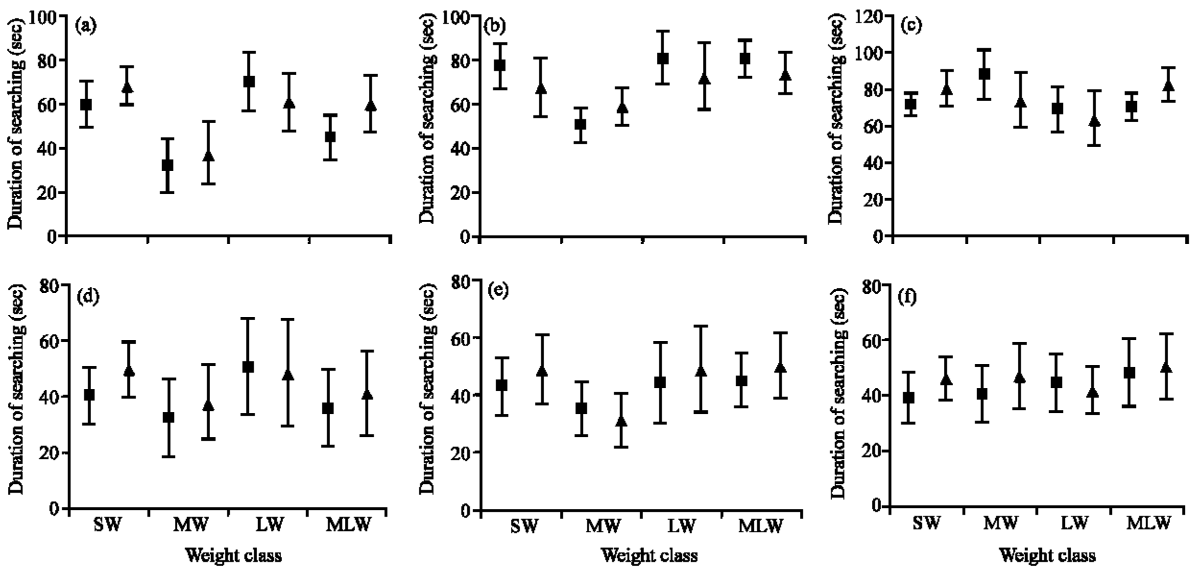

Fig. 2: Duration (mean±SE) of the polecat searching for one live prey ;a) two live prey ;b) four live prey ;c) one dead prey ;d) two dead prey ;e) or four dead prey and f) from the same weight class in each box in trials (n = 10 trials in each combination). Symbol ■ indicates prey in one box and ▲ indicates prey in another box in each trial. The average body masses of dead or live prey used in the experiment were 74.4±1.1 g in class SW, 129.9±0.5 g in class MW, 242.3±0.5 g in class LW and 312.8±2.1 g in class MLW (n = 20 prey items in each class)

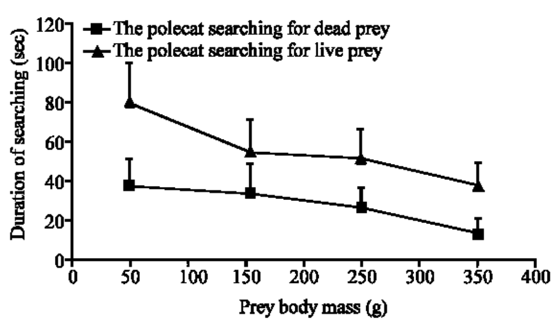

Fig. 3: The relationships between the prey body mass and the searching time (mean±SE) of the live and dead prey by polecats

Preference of the prey activity: The prey activity was a major factor affecting the prey selection of the polecat. When the same numbers of prey from the same weight class with equal total biomass were used in the trials, the searching time used for live prey by polecat was longer than that used for dead ones ($p<0.05$) (Table 3). The same results were also observed in the trials when more numbers and higher total biomass of dead prey were provided over those of live prey ($p<0.05$) (Fig. 5).

Handling behavior of polecat: Table 4 shows the profitability of the polecat hunting for prey from different weight classes. The observations showed that the prey body masses were significantly correlated with the pursuing time ($r = 0.36$, $F_{1, 224} = 5.96$, $p = 0.02$) and the killing time ($r = 0.77$, $F_{1, 224} = 81.00$, $p = 0.00$) but not related to the carrying time ($r = 0.16$, $F_{1, 224} = 1.54$, $p = 0.22$) (Fig. 6).

Using the live and dead rats as the experimental prey, the prey preferences of the polecat were examined in different ways. The results suggested that the prey's body masses, numbers and activities could significantly

Table 2: Duration (in seconds) of the polecat searching for prey with the same total biomass and activity but different prey numbers in trials (n =10). The average body masses of dead or live prey used in the experiment were 50.4±0.3 g (n = 70) for class SW, 151.2±2.5 g (n = 10) for class MW, 250.7±1.7 g (n = 10) for class LW and 349.0±2.7 g (n = 10) for class MLW. Results of statistical comparisons in rows (by Wilcoxon tests) are shown

Activity of prey	Paired weight classes	Paired numbers	Searching for 1 prey	Searching for 3, 5 or 7 prey	Z	p
	MLW:SW	1:7	39.2±11.5	160.6±20.00	2.80	0.01
Dead	LW:SW	1:5	30.70±7.5	139.60±58.8	2.80	0.01
	MW:SW	1:3	18.00±2.4	51.25±22.7	2.29	0.02
	MLW:SW	1:7	38.00±4.8	194.00±92.3	2.80	0.01
Live	LW:SW	1:5	30.35±3.0	125.15±12.7	2.80	0.01
	MW:SW	1:3	25.25±3.3	101.42±13.0	2.80	0.01

Table 3: Duration (in seconds) of the polecat searching for live and dead prey with the same number and total biomass in trials (n = 10). Class SW: average body mass 74.5±1.8 g; Class MW: average body mass 145.8±2.2 g; Class LW: average body mass 259.3±1.4 g; Class MLW: average body mass 360.1±2.9 g (n = 50 rats in each class). Results of statistical comparisons in rows (by Wilcoxon tests) are shown

Live prey	Dead prey	Paired numbers of live vs. dead prey	Searching for dead prey	Searching for live prey	Z	p
SW	SW	1:1	5.3±2.6	194.6±37.6	2.80	0.01
SW	SW	2:2	10.2±3.2	218.4±39.6	2.80	0.01
SW	SW	4:4	6.5±2.8	170.7±26.7	2.80	0.01
MW	MW	1:1	4.5±1.3	168.5±21.7	2.80	0.01
MW	MW	2:2	6.8±2.9	154.8±19.7	2.80	0.01
MW	MW	4:4	7.8±3.8	131.9±17.5	2.80	0.01
LW	LW	1:1	4.8±2.0	89.1±14.1	2.80	0.01
LW	LW	2:2	9.7±5.0	92.8±25.8	2.80	0.01
LW	LW	4:4	6.9±3.5	117.8±18.4	2.65	0.01
MLW	MLW	1:1	5.1±2.3	148.4±29.5	2.80	0.01
MLW	MLW	2:2	8.8±3.9	168.9±23.5	2.80	0.01
MLW	MLW	4:4	4.5±2.0	185.2±28.4	2.80	0.01

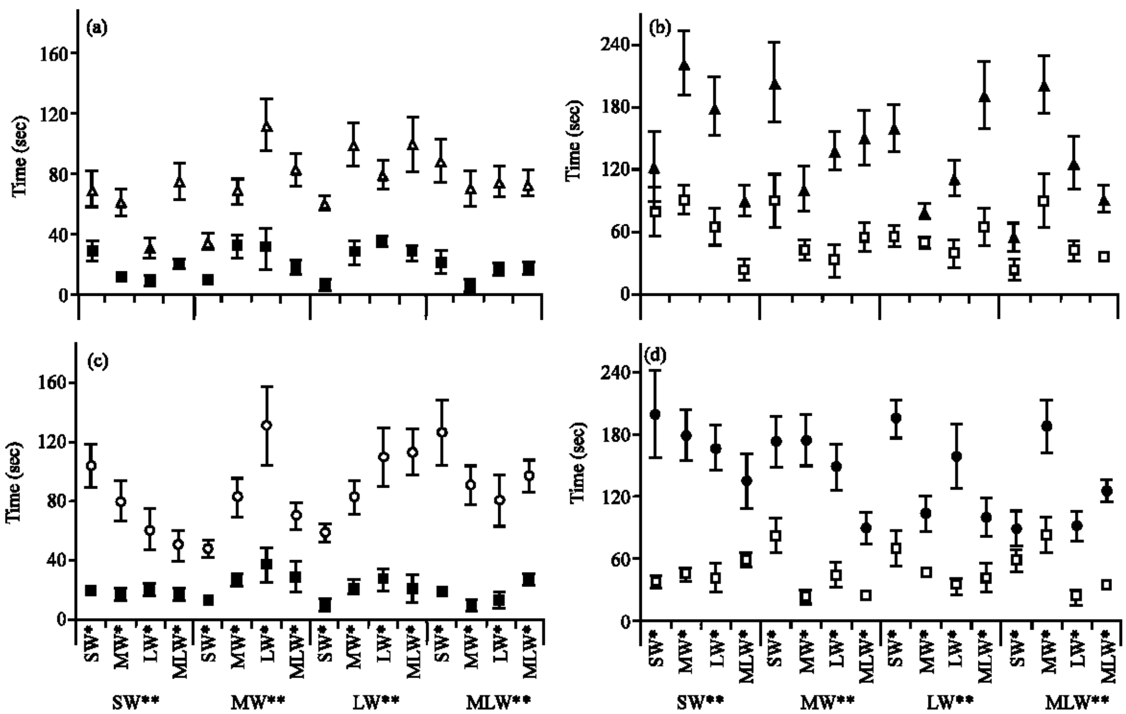

Fig. 4: The searching behaviors of the polecat when one dead prey in one box and two dead prey in another box ;a) or one live prey in one box and two live prey in another box ;b) or one dead prey in one box and four dead prey in another box ;c) or one live prey in one box and four live prey in another box ;d) were provided in different trials (n =10). Symbols ■, □, ▵, ▲, ○, ● indicate prey for one dead, one live, two dead, two live, four dead and four live, respectively. Class SW: average body mass 66.8±0.7 g; Class MW: average body mass 166.8±0.2 g; Class LW: average body mass 253.5±0.5 g; Class MLW: average body mass 348.2±0.5 g (n = 50 prey items in each class); *(Two or four prey); **(One preys)

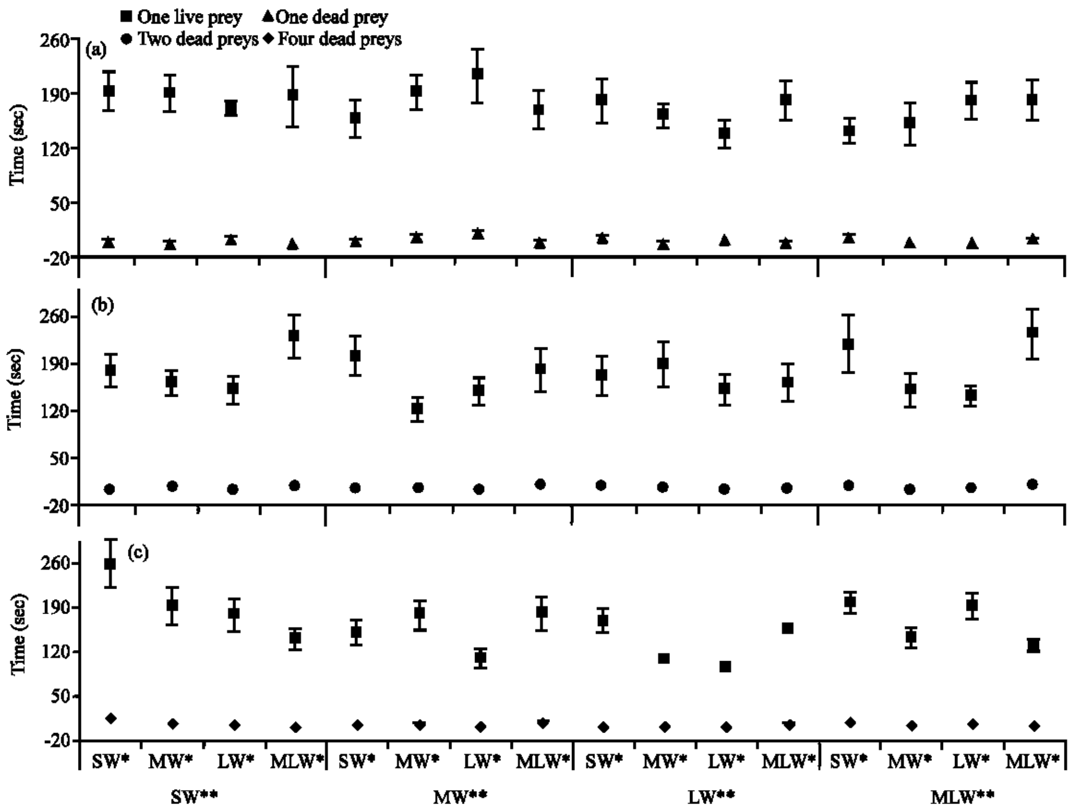

Fig. 5: The searching behaviors of the polecat when one live prey was provided in one box and one dead prey ;a) or two dead prey ;b) or four dead prey and c) were provided in another box in different trials (n =10). Class SW: average body mass 74.5±1.8 g; Class MW: average body mass 145.8±2.2 g; Class LW: average body mass 259.3±1.4 g; Class MLW: average body mass 360.1±2.9 g (n = 50 prey items in each class), *(Dead prey); **(Live prey)

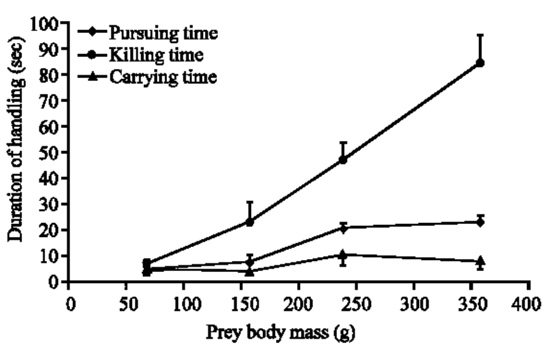

Fig. 6: The relationship between prey body mass and the duration (mean+SE) of different phases of prey handling by polecats

Table 4: The profitability of the polecat hunting for prey of different weight classes. The energy used here was 8.29 kJ g^{-1} (Wijnandts, 1984). Handling time-total time spent by polecat for pursuing+killing+carrying of a given prey. Class SW: body mass<100 g; Class MW: body mass between 100 and 200 g; Class LW: body mass between 200 and 300 g; Class MLW: body mass >300 g

Weight class	Number of prey	Average body mass of prey (g)	Energy of prey (kJ g^{-1})	Handling time (sec)	Profitability (kJ sec^{-1})
SW	61	68.1	564.6	17.4	32.5
MW	45	156.8	1299.9	35.6	36.5
LW	64	238.4	1976.3	79.4	24.9
MLW	56	357.1	2960.4	116.3	25.5

influence the prey selection and hunting behaviors of the polecat. In the field, searching for prey is probably the most important and time-consuming activity in polecat's foraging behaviors. An optimal forager should select preys that contribute the most gain and least cost. The present study suggested that the polecat is a selective forager that prefers to feed on small prey. As handling time increases with the increases of the size and body mass, the polecat chose prey that minimizes handling time per energy input. The prey activity seemed to be the most important factor influencing the prey selection of the polecat suggesting that the live prey can provide more stimuli for polecat than the dead ones (Derting, 1989).

Many predators, especially those having higher basal energetic expenditure usually have the risk-aversion foraging behaviors but they tend to be risk-prone when they suffer from starvation or food shortage (Stephens, 1981; Barnard and Brown, 1985). The present study showed that when the same number of the live or dead prey was offered in the experiments, the polecat always tried to catch the small prey rather than large ones. Similar behaviors were observed in least weasel (*Mustela nivalis*) and marbled polecat (*Vormela peregsna syriaca*) (Derting, 1989; Ben-David *et al*., 1991). These observations suggested that an increased risk involved with handling large or live prey should affect prey size selectivity in the polecat implying avoidance of large prey might be the use of risk-aversion strategy by the polecat.

The average food intake of a polecat is about 250 g per day in laboratory (Shengwu *et al*., 1983). The plateau pika and the plateau zokor constitute 90.5 and 76.2% of the polecat food components, respectively (Shengwu *et al*., 1983). One zokor or two pikas could support the daily energetic expenditure of an adult polecat but the predation risk to capture one zokor for polecat is higher than that of capturing two pikas. Compared to an adult pika (about 125 g), an adult zokor (about 250 g) shows stronger aggressive behaviors, sometimes even killing a polecat. Field radio tracking found the dead polecat in the burrow of the plateau zokor but not in the burrow of the plateau pika (Zhou and Wei, 1994). Moreover, during experiments, the escaped small prey usually fled and hid in corners while the large prey frequently displayed aggressive behaviors facing towards the attacking polecat. The findings demonstrated that although, a large prey yields higher caloric rewards, the polecat faces more risk and more energy expenditure.

Previous studies showed that the prey number significantly influenced the distribution of predators such as Geoffory's cat (*Leopardus geoffroyi*) (Canepuccia *et al*., 2007), polecat (Zhou and Wei, 1994) and alpine weasel (Wanhong *et al*., 1994). The results were consistent with the above observations indicating that the number of the prey is another important factor for prey selection of polecat.

CONCLUSION

In this study, the results showed that prey activity, prey size and prey number had significant influence on the predatory behaviors of the polecat in searching phase and the polecat selected the prey with higher energy yield in handling phase.

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