Habitat Selection and Flock Size of Tibetan Partridge *Perdix hodgsoniae* during Autumn–Winter

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Abstract. Habitat selection and flock size of Tibetan Partridge (*Perdix hodgsoniae*) were investigated in Lhasa mountains, Tibet, from November 1995 to February 1996. The habitats constituted the study area were divided into seven types. Partridge flocks used all the seven types of habitat in late-autumn to early-winter. However, during late-winter the birds were only found in three types of habitat on the south-facing slopes or open fields. Stream belts with scrub dominated by Rose *Rosa sericea* and Barberry *Berberis hemleyana* were the most preferable throughout autumn–winter. Food availability was considered to be a main factor affecting habitat selection. Partridges performed day-roosting behavior around mid day under dense bushes in the stream belts. Their night-roosting sites were mostly located under dense scrub vegetation on the ground at higher altitudes, especially habitats on the north-facing slopes. As the season progressed, frequencies of encountering partridge flocks decreased from 0.78 in late-autumn to early-winter to 0.37 per h in late-winter, with change of mean flock size from 7.41 to 5.21.

Key words: Tibetan Partridge, *Perdix hodgsoniae*, Habitat selection, Roosting behavior, Scrub vegetation, Flock size.

キーワード: チベットヤマウズラ (*Perdix hodgsoniae*), ハビタット選択, 就鳩行動, 低木植生, 群れサイズ.

Introduction

Birds are often found in specific habitats and studies on bird-habitat relationship are necessary for understanding how species are adapted to their environments (Cody 1985). Tibetan Partridge (*Perdix hodgsoniae*) is endemic to Qinghai-Tibet plateau and widely occurs in scrub-meadow mountains of its range (Johnsgard 1988). So far, the alpine ecosystem, with the partridge as one of the representative species, has been subject to relatively less influence by human land utilization, compared to the habitats of its two relative species, Daurian Partridge (*P. dauuricae*) (Zhang & Wu 1992, X. Lu personal observation) and Gray Partridge (*P. perdix*) (Tucker & Heath 1994, Potts & Adbischer 1995). However, little historical information about ecological traits of this species is available (Johnsgard 1988). This paper presents the first data on general habitat selection, microhabitat requirements, population status and flock size of Tibetan Partridges during autumn-winter in Lhasa mountains, Tibet. These data will provide a necessary foundation for predicting possible change of the alpine ecosystem in the future and making conservation decisions, as well as comparing ecological traits between partridge species.

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Study Area and Methods

Fieldwork was carried out in Jia-ma (91°40' E, 29°40' N) near Lhasa, Tibet, from November 1995 to February 1996. Located in the middle Nianqing-Tanggula mountains, the study area has an annual average temperature of 6.5°C and annual precipitation of about 480 mm, less than 10% of which takes place during the period of October to May. Seven types of vegetation, according to physical characteristic and species diversity, were recognized (Table 1).

Golden Eagles (*Aquila chrysaetos*) and Sparrow Hawks (*Accipiter nisus*) are two major species of avian predators. Siberian Weasels (*Mustela sibirica*) are common mammals. From distribution range and habitats, Tibetan Foxes (*Vulpes ferrilata*) should have occurred in the areas, but during the study period we failed to find the animals anywhere. Tibetan Snow Cocks (*Tetragallus tibetanus*) occupy higher altitude and Tibetan Eared Pheasants (*Crossoptilon harmani*) have overlapping home range with Tibetan Partridge. No hunting activity took place in the study area. Grazing by yaks and sheep mostly staying on alpine meadow had less heavy influence on partridges.

Line transect sampling (Bibby *et al.* 1992) was used to estimate relative abundance of partridges. Within each type of habitat, we randomly established 2–4 census routes (their

Table 1. Types of habitat and their features in the study area.

Habitat type	Altitude (m)	Location	Dominant plant	Scrub species diversity	% vegetation cover	
					High scrub	Low scrub
I	< 4000	Farmland in the foot of mountain	Sandliving Sophora (<i>Sophora moorcroftiana</i>), Lhasa Ceratostigma (<i>Ceratostigma minus</i>), highland barley	1.11	10.5	14.7
II	4000–4500	South-facing slopes	Rose (<i>Rosa sericea</i>), Barberry (<i>Berberis hemleyana</i>)	1.11	30.2	38.2
III	4000–4500	Stream belts on south-facing slopes	Rose, Barberry, Little-leaf Peashrub (<i>Caragana microphylla</i>), Shagspine Peashrub (<i>C. jubata</i>), Bush Cinquefoil (<i>Potentilla fruticosa</i>)	1.74	43.4	41.5
IV	4500–4900	South-facing slopes	Wilson Juniper (<i>Sabina pingi</i>)	0.77	4.3	51.6
V	4000–4200	North-facing slopes	Spiraea (<i>Spiraea alpina</i>)	0.69	5.2	40.8
VI	4200–4900	North-facing slopes	Willow (<i>Salix sclerophylla</i>), Rhododendron (<i>Rhododendron nivale</i>)	0.69	44.1	75.9
VII	4900–5200	Alpine	meadow, no scrub vegetation	0.0	0.0	0.0

lengths varied from 4 to 8 km), which ran up obliquely to the upper limit of investigated vegetation and then obliquely down. We walked at a speed 2 km/h along each line in the morning (not later than 4 h after sunrise) and noted the number of flock and flock size of partridges encountered within 50 m of each side of the track walked. A counting bout lasted 2–4 h and was alternated among habitats during the study period. Totally 138.8 h were spent in walking transects of about 280 km in total length. Because partridge flocks were found in separate sites and flock sizes were small, their abundance could easily be estimated by line census method. The birds were highly sensitive to disturbance (often giving sharp calls) and very easy to be flushed. Thus, vegetation covers, in spite of relatively great difference among types of habitat, had little effect on detectability of the birds. Also, attempt was made to search systematically for day- and night-roost sites over the study area.

For each type of habitat, some quadrates (15–25) of 4×4 m were located at sites where partridges foraged and then five sub-samples of 1×1 m quadrate were taken from each larger quadrate, four at the corners and one at the center, to measure (with a sighting tube) percent covers of high (over 150 cm) and low (below 150 cm) shrubs (Goldsmith *et al.* 1986). The frequencies of common scrub species were measured for each large quadrate to estimate species diversity (Shannon-Weiner index). In this study the data on vegetation parameters were collected from 136 quadrates of 4×4 m.

The data were divided into two periods, late-autumn to early-winter (November to December) and late-winter (January to February). Habitat preferences by the birds for each period were evaluated using Ivlev's selectivity index (Ivlev's 1961, cited from Morrison *et al.* 1992): $E_i = (r_i - p_i) / (r_i + p_i)$, where E_i = selectivity index, r_i = the proportions of actual number of encountered flocks in habitat i , p_i = the proportion of habitat i in the whole study area. Nonparametric procedures, Kruskal-Wallis, Mann-Whitney U and Chi-square tests, were used to examine significance of difference between variables, and Spearman's correlation to assess relationship between two variables. All expressions in the text were given as mean $\pm$ SE.

Results and Discussion

Diurnal habitat

Field observation showed that daily activity range of each partridge flock included different types of habitat. In late-autumn to early-winter period, the flocks were found in all the seven habitats over the study area (Table 2), but rates of encountering flock significantly differed between them (Kruskal-Wallis test, $H = 20.02$, $df = 6$, $P = 0.003$), with habitats III and I being most favorable. In late-winter period, partridges only used habitats I, II and III (among which habitat III and I still were most suitable) and avoided others (Kruskal-Wallis test, $H = 14.60$, $df = 6$, $P = 0.024$).

By detecting crops of several shot specimens and lots of feces of the partridges, we found a larger proportion of Rose fruits and Little-leaf Peashrub pods in the bird's diets during late-autumn to early-winter. But as the season progressed, those foods became rare whereas the roots and seeds of plant predominate, partly because Tibetan Eared Pheasants

and Woolly Hares (*Lepus oisstolus*) strongly contested the fruits with partridges. This change in abundance of plant fruits seemingly could explain a high rate of utilization for habitat II in late-autumn to early-winter and a declined rate in late-winter. Well-developed bushes in habitat III (plant species diversity was 1.74, compared to 0.69–1.11 in others) and loose soil led a better food availability and thus higher preference throughout autumn-winter period.

Partridges are typically dry-resistant birds (Ali & Ripley 1978, Johnsgard 1988). Therefore favorable habitats of the birds under study were on the south-facing slopes or open fields. Frequencies of encountering flock were not correlated with vegetation covers (Spearman's rank correlation coefficient, higher scrub: late-autumn to early-winter, $r_s = 0.11$, $P = 0.82$; late-winter, $r_s = -0.43$, $P = 0.34$. lower scrub: late-autumn to early-winter, $r_s = 0.45$, $P = 0.31$; late-winter, $r_s = 0.20$, $P = 0.67$). In fact, the dark spotted plumage of the birds allowed them to emerge in habitats I and VII with poor vegetation covers. Partridges could reach the habitats at higher altitudes in late-autumn to early-winter. But in late-winter, 69 (94.5%) out of all 73 records of encountering flocks were below 4500 m a.s.l. We believe that better food availability of habitats I and VII in late-autumn to early-winter could be attractive to partridges, meanwhile pressure of high population density in the period (Table 2) probably forced some individuals to move into those habitats for foraging.

From late-autumn to late-winter, partridge flock encounter rate significantly decreased in all the habitats (Table 2). For the whole study area, average encounter rate changed from 0.78 in late-autumn to early-winter to 0.37 in late-winter (Mann-Whitney U test, $z = -2.08$, $n_1 = 25$, $n_2 = 22$, $P = 0.038$). Predation could be responsible for the decline. During the study period, 5 bodies of partridge were found under the denser bushes in habitat III, possibly killed by predators especially Siberian Weasel. The fact that feathers of partridge were most often used as nesting materials by several passerines such as Stoliczka's Tit Warbler (*Leptopoecile sophiae*) and willow warblers (*Phylloscopus* spp.) (X. Lu personal observation) further suggested a high winter mortality of partridges. The

Table 2. Preference of partridge flocks for different types of habitat during autumn-winter.

Habitat type	Habitat area (ha)	Proportion of each habitat (p)	Late-autumn to early-winter			Late-winter		
			Flock encounter rate (flock/h)	Proportion of flock (r)	Selectivity index ^a	Flock encounter rate (flock/h)	Proportion of flock (r)	Selectivity index ^a
I	51.6	0.068	0.58	0.130	+0.31	0.58	0.278	+0.61
II	201.3	0.266	1.15	0.315	+0.08	0.48	0.278	+0.02
III	52.2	0.069	1.83	0.444	+0.73	0.80	0.444	+0.73
IV	67.0	0.088	0.21	0.037	-0.41	0.00	0.000	-1.00
V	54.1	0.071	0.15	0.019	-0.58	0.00	0.000	-1.00
VI	149.8	0.198	0.13	0.019	-0.82	0.00	0.000	-1.00
VII	181.5	0.240	0.29	0.037	-0.73	0.00	0.000	-1.00

^asee text for method of calculation.

heavier covers in the habitat, although providing better shelter for the birds from detectability of avian predators, could make it difficult for them to escape from mammals.

Day-roost habitats

Around mid day partridges often had a roost on the ground under the denser bushes, during which the birds often dusted. Among 6 day-roost sites noted, 5 were located in habitat III and one in habitat I. Those sites were next to (less than 20 m, 3 cases) or at the same plot (one case) of Tibetan Eared Pheasants. There were 2.5 ± 0.2 (range=2-3) dusting hollows in a day-roost site, significantly less than mean flock size (Mann-Whitney U test, $z = -3.58$, $n_1 = 6$, $n_2 = 54$, $P = 0.00$, Fig. 1), suggesting that not all individuals dust during a day-roost bout, or more than 2 individuals use the same hollow. The average dimensions of 12 day-roost hollows were 22.8 ± 0.6 cm in length, 22.4 ± 0.5 cm in width and 3.1 ± 0.4 cm in depth. The mean distance between hollows at the same day-roost site was 1.1 ± 0.3 m ($n = 12$, range=0.2-3.2).

Fig. 1. Frequency distribution of partridge flock sizes during autumn-winter.

Night-roost habitat

We observed that partridge flocks always moved at dusk toward higher altitudes and at dawn directly flew down to daily foraging habitats. During the study we located 14 night-roost sites, 10 (71.4%) of which lay in habitat VI, 3 (21.4%) in habitat II and 1 (7.2%) in habitat III, showing an uneven distribution among habitats (Chi-square test, $\chi^2 = 41.00$, $df=6$, $P=0.00$). Of the 14 sites, 12 were near the top of mountain (4600–4700 m a.s.l., i.e. the upper limit of habitats II and IV), and 2 in middle altitude (4290 m a.s.l. in habitat VI and 4300 m a.s.l. in habitat III), showing that the birds preferred to roost at higher altitudes (Chi-square test, $\chi^2 = 7.14$, $df=1$, $P=0.01$). Low rate of encountering night-roost site appeared to indicate that partridge flocks were faithful to the sites. The mean number of hollows at a night-roost site was 3.0 ± 0.3 ($n=8$, range=2–4), smaller than mean flock size (Mann–Whitney U test, $z = -3.90$, $n_1=8$, $n_2=54$, $P=0.00$, Fig. 1). In addition, there were a lot of fecal pellets deposited in each hollow (63.9 ± 24.2 items, $n=12$, range=12–200). This suggested that probably 2–3 individuals have sat in the same hollow together throughout night, as observed in Gray Partridges (Jenkins 1961). The average dimensions of 16 night-roost hollows were 20.4 ± 0.8 cm in length, 19.9 ± 0.9 cm in width and 2.9 ± 0.3 cm in depth. The mean distance between hollows at the same night-roost site was 0.8 ± 0.2 ($n=16$, range=0.2–2.5 m), smaller than that between day-roost hollows (Mann–Whitney U test, $z = -1.07$, $n_1=12$, $n_2=16$, $P=0.30$).

Why did partridges take high locations far away their daily range as night-roost sites? Field observation showed that all the night-roost sites were associated with dense bushes occurring in habitat VI and III, or with cliff in habitat II. It has been urged that dense vegetation at night-roost site is responsible for protecting birds against winter wind that can have body heat radiated quickly (Cody 1985). Therefore, reducing energy cost should be a prior decision when partridges choose their night-roost habitat in colder season. Six of 10 partridge night-roost sites on the upper mountain in habitat VI were close (2.6–60.0 m) to those of Tibetan Eared Pheasant flocks, one close (4.7 m) to that of a Tibetan Snow Cock flock. This indicated that Galliforme species in the study area use some similar cues to select night-roost habitats (Lu 1997). As mentioned above, the partridges probably arranged themselves in “roosting rings” during night to benefit from sharing body heat. Johnsgard (1988) also noted the similar strategy of behavioral thermoregulation in other partridge species.

Flocking behavior

After hatching (June–July) partridges in the study area had lived in flock until early-spring (late-March) (X. Lu personal observation). The flocks were larger in size in late-autumn to early-winter than in late-winter (Mann–Whitney U test, $z = -2.99$, $n_1=54$, $n_2=19$, $P=0.003$, Fig. 1). The seasonal decline in flock size was probably due to death of some individuals. It also showed that partridge flocks did not combine into larger winter aggregations. Many authors have demonstrated that bird flock often increase owing to lower temperature and snowing in mid winter (e.g. Caraco 1979, Hogstad 1988). That Daurian Partridges establish larger flocks (as many as 200 birds) in winter has been reported (Johnsgard 1988). In northern China where mean January temperature is less

than -10°C and snowing takes place frequently (total precipitation from November to February = 80–125 mm), Danrion Partridge flocks consisting of 30–100 individuals are common (X. Lu personal observation). In our study area, the mean temperature of November to February is -1.7°C and the lowest -3.7°C (in December). There is less snowing (total precipitation during the study period was 32 mm) and snow cover cannot accumulate due to strong sunlight in the plateau. The modest weather conditions did not cause partridge flocks to assemble.

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References

- Ali, S. & Ripley, S. D. 1978. *Handbook of the birds of India and Pakistan (revised edn)* vol. 2. Oxford University Press, Oxford.
- Bibby, C. J., Burgess, N. D. & Hill, D. A. 1992. *Bird census techniques*. Academic Press, London.
- Caraco, T. 1979. Time budgeting and group size: a test of theory. *Ecology* **60**: 618–627.
- Cody, M. L. 1985. *Habitat selection in birds*. Academic Press, Orlando.
- Goldsmith, F. B., Harrison, C. M. & Morton, A. J. 1986. Description and analysis of vegetation. In Moore, P. D. & Chapman, S. B. (eds.) *Methods in plant ecology (2nd edn)* pp. 437–524. Blackwell Scientific Publications, Oxford.
- Hogstad, O. 1988. Advantages of social foraging of Willow Tits *Parus montanus*. *Ibis* **130**: 275–283.
- Jenkins, D. 1961. Social behaviour in the Partridge *Perdix perdix*. *Ibis* **103**: 155–188.
- Johnsgard, P. A. 1988. *The quails, partridges and francolins of the world*. Oxford University Press, Oxford.
- Lu, X. 1997. *Study on habitat selection and behavior of the Tibetan Eared Pheasant Crossoptilon harmani*. Ph.D. thesis, Beijing Normal University.
- Morrison, M. L., Marcot, B. G. & Mannan, R. W. 1992. *Wildlife-habitat relationship*. University of Wisconsin Press, Madison.
- Potts, G. R. & Adbischer, N. J. 1995. Population dynamics of the Grey Partridge (*Perdix perdix*) 1793–1993: monitoring modelling and management. *Ibis* **137** (suppl.): 29–37.
- Tucker, G. M. & Heath, M. F. 1994. *Birds in Europe: Their conservation status*. BirdLife International, Cambridge.
- Zhang, Z. W. & Wu, Y. C. 1992. The Daurian Partridge (*Perdix dauuricae*) in north-central China. *Gibier Faune Sauvage, Game wildl.* **9**: 591–595.

秋冬季におけるチベットヤマウズラのハビタット選択と群れサイズ

チベットヤマウズラ (*Perdix hodgsoniae*) のハビタット選択と群れサイズの変化を、チベットのラサ山地において 1995 年 11 月から 1996 年 2 月にかけて調査した。調査地内のハビタットは 7 タイプに分類され、晩秋から初冬 (11–12 月) にはチベットヤマウズラの群れは全てのタ

イプを利用していた。しかし晩冬（1～2月）になると、群れは南向きの斜面や農地に見られる3タイプのみでしか観察されなかった。バラ属の1種 (*Rosa sericea*) やメギ属の1種 (*Berberis hemleyana*) の優占したやぶのある川沿いが、秋冬を通じてもっとも好まれていた。ハビタット選択に影響している主要な要因は餌の利用可能量であると考えられた。チベットヤマウズラは日中にも川沿いの密なやぶの中で昼ねぐらをとっていた。また夜間のねぐらの多くはより標高の高い場所の、とりわけ北向き斜面の密な低木植生下の地上にあった。群れが観察される頻度は、晩秋から初冬には1時間あたり0.78羽であったが、晩冬には0.37羽と季節の進行とともに減少し、平均群れサイズも7.41羽から5.21羽へと変化した。

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