Chinese Birds 2011, 2(2):94–100
DOI 10.5122/cbirds.2011.0014

ORIGINAL ARTICLE

Home range, population density, and habitat utilization of the Sichuan Jay (*Perisoreus internigrans*)

Yu JING, Nan LÜ, Yun FANG, Yue-Hua SUN ✉

Institute of Zoology, Chinese Academy of Sciences, Beijing 100080, China

Abstract We assessed habitat preference and population status of the Sichuan Jay (*Perisoreus internigrans*), a poorly known Chinese endemic bird, at two sites (Zhuoni and Jiuzhaigou) in the Qinghai-Tibetan plateau between 2001 and 2004. Mean group size was 3.8 jays. Each group occupied a mean home range of 42.0 ha during the breeding season, and the mean internest distance was 2.7 km. These data indicated that the jays used less than ten percent of the available habitats and occurred at an overall density of only 0.6 jays per km^2. Radio-tracked Sichuan Jays had a strong preference for mature montane coniferous forests and avoided areas dominated by shrubs, while the utilization of young conifers, grassland, and human residential habitat types did not differ significantly from the values expected from the home-range availabilities of these habitats generally.

Keywords Sichuan Jay, Qinghai-Tibetan plateau, home range, population density, habitat utilization

Introduction

The Sichuan Jay (*Perisoreus internigrans,* Fig. 1) is a Chinese endemic designated as vulnerable and decreasing by the IUCN (BirdLife International, 2008). This species is apparently restricted to the southeastern portion of the Qinghai-Tibetan plateau and associated with high-altitude old-growth coniferous forests (Sun et al., 2001). However, nearly all the potential habitats within this restricted range have been fragmented in the past 30–40 years due to logging activity (Jing et al., 2009). Compared to its two congeners, the palearctic Siberian Jay (*P. infaustus*) and the nearctic Gray Jay (*P. canadensis*), the Sichuan Jay breeds in cold, snowy conditions in late March and early April so that the birds have a low nesting success in spite of receiving assistance from nonbreeders during the nestling period (Jing et al., 2009). All *Perisoreus* species rely on stored food for winter survival and to some extent for the feeding of nestlings in their late winter breeding seasons (Waite and Reeve, 1992; Ekman et al., 1996; Jing et al., 2003). Since the stored food items are highly perishable, these species may be vulnerable to climate warming (Waite and Strickland, 2006). Given this vulnerability to direct and indirect habitat destruction and climate change, conservation for this species is urgently needed. To aid conservation, here we assessed the population density, home range size, and habitat utilization of the Sichuan Jay.

Study Area

Field studies were carried out at the Kache Forestry Farm in Zhuoni County of southern Gansu Province (34°27′N, 103°26′E) and the Hongyan Forestry Farm in Jiuzhaigou County of northern Sichuan Province (34°27′N, 103°26′E). See Jing et al. (2009) for full details on the topography, climate, vegetation, and disturbance history of these sites.

Methods

Population estimates

We used two methods to estimate jay population density. (1) At Jiuzhaigou, we established a grid of 264 bait stations at the centers of imaginary contiguous 200 m square blocks covering 10.56 km^2 of the study area. Captures with

Received 11 March 2011; accepted 20 May 2011

✉ Author for correspondence (**Yue-Hua Sun**)
E-mail: **sunyh@ioz.ac.cn**

Fig. 1 The Sichuan Jay (*Perisoreus internigrans*)

mist nets or walk-in traps of jays encountered at bait stations were continued until all individuals detected in the study area were color-banded and usually fitted with radio transmitters (Jing et al., 2009). (2) Following Strickland and Ouellet (1993), we used the mean, GPS-derived distance (d) between adjacent nests to calculate the land area per nest in our study area by the formula $3/2(d^2\tan 30)$ on the assumption that nests were located at the centers of adjacent equal hexagons. Nest density was equal to the reciprocal of this ratio and, knowing the mean number of birds in each breeding group, we were then able to calculate an estimate of jay density in our study area.

Habitat utilization

In both study areas we trapped and color-banded jays and affixed radio transmitters to some or all individuals in each social group (Jing et al., 2009). We then re-located focal groups twice daily throughout the breeding season (March–May) and used GPS to record group locations. Home range sizes were calculated by the 100% minimum convex polygon (MCP, Lawson and Rodgers, 1997) and fixed kernel methods (Worton, 1989; Seaman et al., 1998) based on all sample locations, and using ARCVIEW GIS, version 3.2, in combination with the Animal Movement Extension (Hooge, 1998). For the 95% fixed kernel methods we used the Least Squares Cross Validation (LSCV) smoothing parameter selection (Seaman et al., 1999; Ackerman et al., 2007; Pattishall and Cundall, 2008). We then defined the utilization frequencies of five habitat classes (mature coniferous forest (trees 10–20 m in height), newly planted replacement forest (trees 2–5 m in height), scrub, grassland, and human residential) as the number of observations made in each habitat type divided by the total number of observations made in all five habitats. Then, using the 95% confidence intervals (CI) around the observed frequencies (Manly et al., 2002), we compared the observed utilization frequencies with those expected from the proportion of each habitat type within their 95% fixed kernel home ranges (Graves et al., 2007).

Results

Population assessment

We obtained two indications of population density. First, through the 10.56 km^2 bait grids at Jiuzhaigou in 2003, we detected 11 Sichuan Jays in three social groups within 20 days (i.e. suggesting a population density of 1.04 jays per km^2). Second, in 2003 at Jiuzhaigou we found the nests

on all three territories and in 2004 we found the nests on two of them (Fig. 2). Giving equal weight to the two observed distances between successive nests on the same two territories, the overall mean value for the three internest distances (*d*; Table 1) was 2706 m. Using the formula $1/(3/2d^2\tan 30)$, we calculated the nest density to be 0.16 nests per km^2 and, since the mean group size was known to be 3.8 (Jing et al., 2009), the population density was therefore estimated to be 0.60 jays per km^2.

Home range and habitat utilization

We radio-tracked two family groups at Zhuoni (F1 and F2) in 2001 and two groups at Jiuzhaigou (F3 in the years 2002–2004 and F4 in 2003–2004). Mean home range size was 42.0 ha (SD = 19.5, $n = 7$) using the 100% minimum convex polygon method and 34.6 ha (SD=19.0) using the 95% fixed kernel method (Table 2). The home ranges of seven cases and the vegetation base map are shown in Fig. 3. Assuming a mean home range size of 42.0 ha, only 8.4% of the Jiuzhaigou survey area was utilized by Sichuan Jay.

Our estimates of habitat utilization frequencies revealed a strongly significant preference for mature conifers and a significant avoidance of shrub areas in all years within the home ranges of the five groups (Fig. 4a, b). Utilization of young conifers, grassland, and human residential habitat types did not generally differ significantly from the values expected from the home-range availabilities of these habitats (Fig. 4c, d, e).

Discussion

The two direct methods we used to calculate Sichuan Jay density in Jiuzhaigou gave quite different results (1.04 vs. 0.60 jays per km^2 respectively for the "grid" and "internest distance" methods). We suggest that the latter approach yields the more accurate result because, unlike the grid method, it is insensitive to how close home ranges or nests are to study area boundaries. In our study, home ranges were invariably located closer to study area boundaries than they were to each other. This means that areas "assignable" to the pairs we observed lay beyond the 10.56 km^2 grid at Jiuzhaigou and this must have led to an overestimate of jay density. Both methods, however, strongly indicated that the density of Sichuan Jays in our study area was far below that of the Gray Jay in North America (3.2–

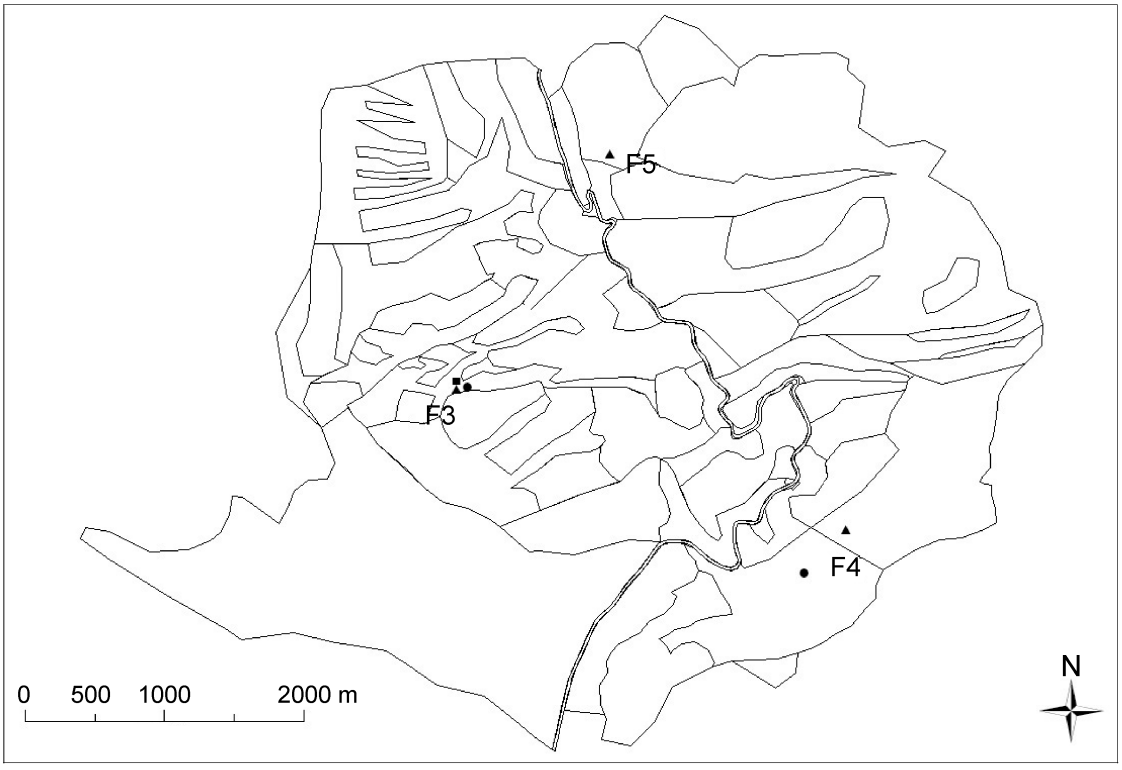

Fig. 2 Nest sites of three Sichuan Jay family groups (F3, F4 and F5) in Jiuzhaigou between 2002 and 2004 (■2002, ▲2003, ●2004).

Table 1 Internest distances of Sichuan Jay

Territories involved[a]	2003	2004	Mean of 2003–2004
"F3-F4"	2032 m		2032 m
"F4-F5"	3206 m		3206 m
"F3-F5"	2988 m	2770 m	2879 m

[a] Specific locations of these three families were indicated in Fig. 2.
Grand mean (d) = 2706 m;
Corresponding area = $(3/2)d^2\tan 30$ = 634 ha;
Nest density = 10^6/area = 0.16 nests/km^2.

Table 2 Home range sizes of Sichuan Jay families, estimated by 100% minimum convex polygon (MCP) method, 95% and 50% fixed kernel method

Family[a]	Number of radio location points	Minimum convex polygon method	Fixed kernel method (95%)
F1	108	82.3	76.4
F2	98	51.2	29.2
F3 (2002)	59	33.6	23.8
F3 (2003)	72	33.3	32.0
F3 (2004)	95	33.1	22.1
F4 (2003)	85	36.0	34.7
F4 (2004)	103	24.4	23.9
Mean ± SD	89 ± 18	42.0 ± 19.5	34.6 ± 19.0

[a] Radio location data of F1 an F2 were collected in Zhuoni in 2001, while F3 and F4 were collected in Jiuzhaigou.

3.5 jays per km^2, Strickland and Ouellet, 1993).

In our analysis of the Sichuan Jay's habitat preferences, we found a strong association with mature montane coniferous forest (Fig. 4a), at least during the breeding season. This may be partially attributed to the relatively higher food quality and less predation risk (Sjöberg and Danell, 2001), but it is also possible that mature forests are important as places to store food. The fact that the social groups in both our study areas centered their activities in smaller fragments of mature forest, rather than in more extensive stands nearby (Fig. 3), suggests that a heterogeneous home range may be nutritionally most productive for Sichuan Jays provided, of course, that some mature coniferous forest is available for food storage and nesting. All seven nests we observed were in mature conifers (mean height 15 m

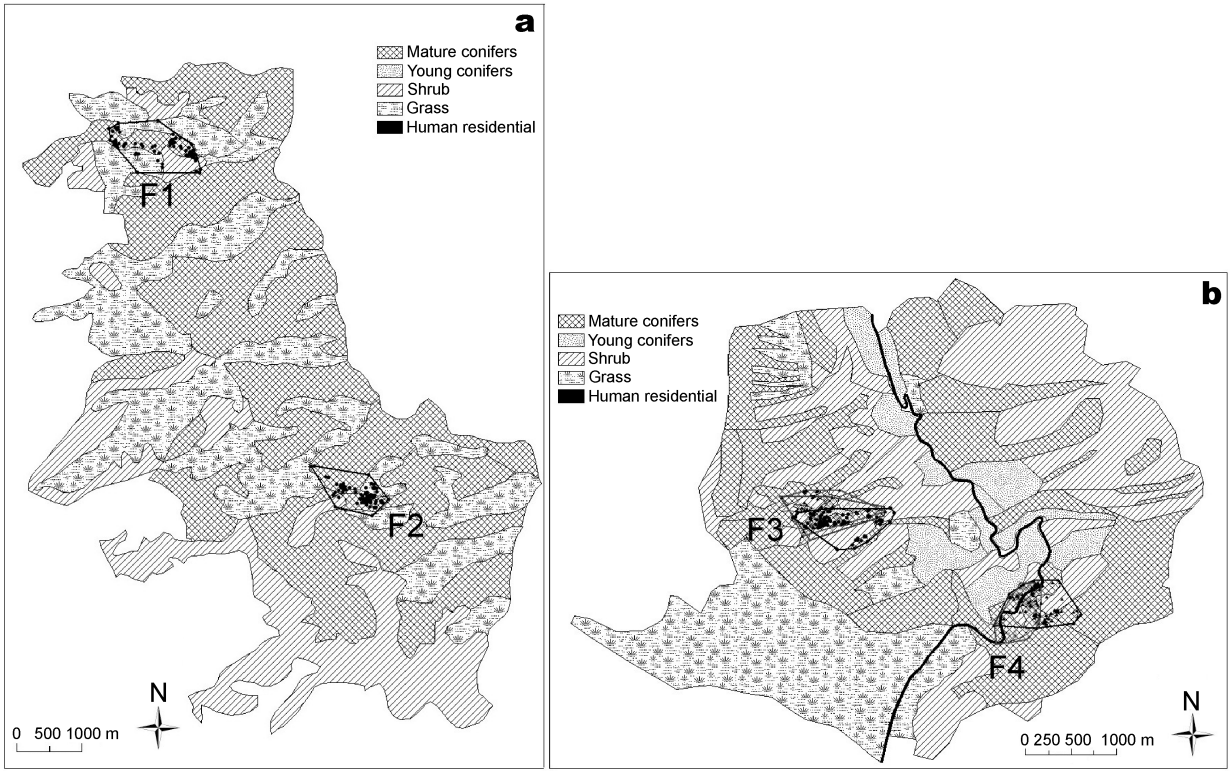

Fig. 3 Home ranges of four Sichuan Jay family groups (F1, F2, F3 and F4) showing radio-location data and the corresponding 100% minimum convex polygons. (**a**) F1 and F2 at Zhuoni in 2001, (**b**) F3 at Jiuzhaigou in 2002**–2004; F4 at Jiuzhaigou in 2003–2004.**

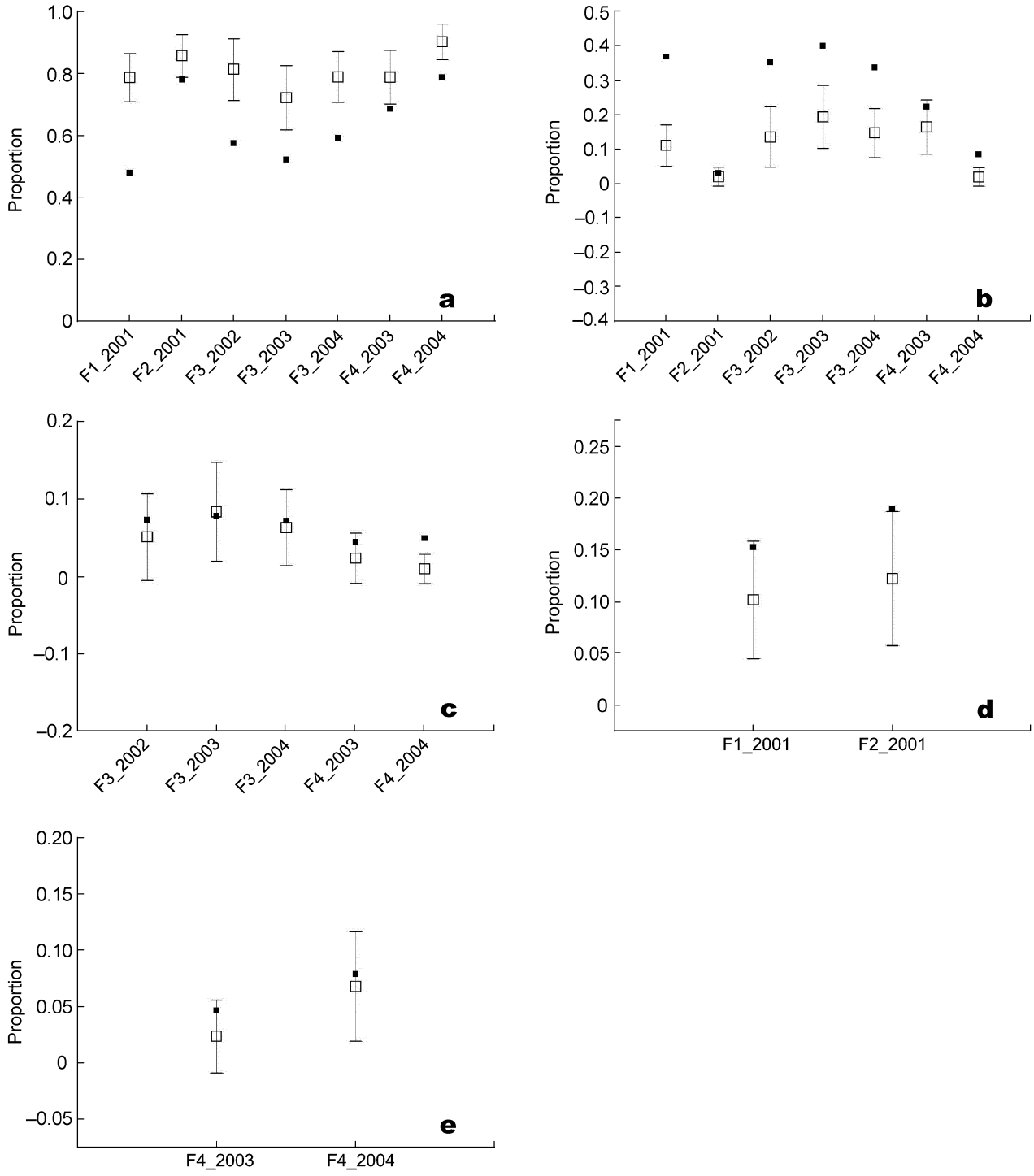

Fig. 4 Utilization of three Sichuan Jay family groups for (**a**) mature conifers, (**b**) shrub, (**c**) young conifers, (**d**) grassland, (**e**) human residential habitat types in four study territories in different years (F1 and F2 are in Zhuoni, while F3 and F4 are in Jiuzhaigou). Open squares represent observed utilization frequencies and the whiskers are the upper and lower 95% confidence intervals (CI), and the black rectangles represent the expected utilization frequencies.

above the ground in trees with a mean diameter at breast height of 32 cm (unpublished data)).

Our observations suggest that even the Sichuan Jay population in Jiuzhaigou, close to the center of the species' known historic range (Sun et al., 2001), was also in some difficulty. First, the population seemed to be far below "saturation" levels. In spite of the large distances between neighbors, radio tracking nevertheless indicated occupation of small home ranges (i.e. mean 42.0 ha) amounting to less than ten percent of the available, seemingly suitable land through the survey area. Second, the invariable presence and long-term persistence of nonbreeders compared to the other two congener jays (Jing et al., 2009), suggests a serious constraint on independent breeding and/or a powerful benefit accruing to delayed dispersers. Third, only 22.2% of the nestlings at 6 nests survived to fledging, and chicks from half of these nests died from a cause other than predation, including at two where allofeeding was observed intensively (Jing et al., 2009). The relative high nestling death rate indicates that the alloparenting behavior of nonbreeders was clearly even unsuccessful in achieving high production of young. It may be relevant here that both of our study sites experienced heavily commercial deforestation before 1998, with the resulting fragmented habitats possibly contributing to the abnormally low productivity. Additionally, we also speculate that the extremely stable membership in the family groups (Jing et al., 2009), i.e. the failure of nonbreeders to establish new breeding territories, might be related to the relative likelihood that dispersing individuals may encounter each other in places and at times suitable for pair formation, territory establishment and sufficient food storage effort to ensure subsequent winter survival. Therefore, we suggest that more intensive and specific work should be conducted to evaluate the habitat fragmentation effects on Sichuan Jay' s behavior and population dynamics. Although the Chinese government stopped logging in such forests in 1998, some illegal logging has continued (Sun et al., 2006). We recommend that conservation of the montane coniferous forest conservation in Qinghai-Tibetan plateau be given the highest priority. For the effective conservation of this rare endemic species, we believe that a thorough inventory should be undertaken to determine the location and status of all remaining populations, and that nature reserves be established to protect them.

Acknowledgements This study was supported by grants of the National Natural Science Foundation of China (30270202, 39870103), and Chinese Academy of Sciences (kscx2-yw-z-1021). We thank the Taohe and Nanping Forestry Bureaus and especially Mr. Xianguang Pan and Mr. Dengwei Li for facilitating this study. Field work was assisted by Wenhu Huang, Yongzhi Zhu, Yingxin Jiang, and Rizhan Bao. We also thank Dan Strickland and reviewers for many helpful comments and improvements to our English.

References

Ackerman JT, Eagles-Smith CA, Takekawa JY, Demers SC, Adelsbach TL, Bluso JD, Miles AK, Warnock N, Suchanek TH, Schwarzbach SE. 2007. Mercury concentrations and space use of pre-breeding American avocets and black-necked stilts in San Francisco Bay. Sci Total Environ, 384:452–466.

BirdLife International. 2008. Perisoreus internigrans. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. http://www.iucnredlist.org. Accessed 1 May 2011.

Ekman J, Brodin A, Bylin A, Sklepkovych B. 1996. Selfish long-term benefits of hoarding in the Siberian jay. Behav Ecol, 7:140–144.

Graves TA, Farley S, Goldstein MI, Servheen C. 2007. Identification of functional corridors with movement characteristics of brown bears on the Kenai Peninsula, Alaska. Landscape Ecol, 22:765–772.

Hooge PN. 1998. Animal Movement Analysis ARCVIEW Extension. USGS-BRD, Alaska Biological Science Center, Glacier Bay Field Station, Alaska.

Jing Y, Sun YH, Fang Y. 2003. Notes on the Natural History of the Sichuan Jay (*Perisoreus internigrans*). Chin J Zool, 38:91–92.

Jing Y, Fang Y, Strickland D, Lu N, Sun YH. 2009. Alloparenting in the rare Sichuan Jay (*Perisoreus internigrans*). Condor, 111:662–667.

Lawson EJG, Rodgers AR. 1997. Differences in home-range size computed in commonly used software programs. Wildlife Soc B, 25:721–729.

Manly BF, McDonald L, Thomas DL, McDonald TL, Erickson WP. 2002. Resource Selection by Animals: Statistical Design and Analysis for Field Studies. 2nd ed. Hardcover, Springer.

Pattishall A, Cundall D. 2008. Spatial biology of northern watersnakes (*Nerodia sipedon*) living along an urban stream. Copeia, 2008:752–762.

Seaman DE, Millspaugh JJ, Kernohan BJ, Brundige GC, Raedeke KJ, Gitzen RA. 1999. Effects of sample size on kernel home range estimates. J Wildlife Manage, 63:739–747.

Seaman DE, Griffith B, Powell RA. 1998. KERNELHR: a program for estimating animal home ranges. Wildlife Soc B, 26:95–100.

Sjöberg K, Danell K. 2001. Introduction of Lodgepole pine in Sweden — ecological relevance for vertebrates. Forest Ecol Manag, 141:143–153.

Strickland D, Ouellet H. 1993. Gray Jay. In: Poole P, Stettenheim P, Gill F (eds) Birds of North America. No. 40. The Academy of Natural Sciences, Philadelphia, and the American Ornithologists' Union, Washington, D.C.

Sun Y-H, Jia CX, Fang Y. 2001. The distribution and status of Sichuan Grey Jay (*Perisoreus internigrans*). J Ornithol, 142:93–98.

Sun Y-H, Klaus S, Fang Y, Selsam P, Jia CX. 2006. Habitat isolation and fragmentation of the Chinese grouse (*Bonasa sewerzowi*) at Lianhuashan Mountains, Gansu, China. Acta Zool Sinica, 52:S202–S204.

Waite TA, Reeve JD. 1992. Gray Jay scatterhoarding behavior, rate maximization, and the effect of local cache density. Ornis Scand, 23:175–182.

Waite TA, Strickland D. 2006. Climate change and the demographic demise of a hoarding bird living on the edge. P Royal Soc B, 273:2809–2813.

Worton BJ. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology, 70:164–168.

黑头噪鸦的活动区、种群密度和栖息地利用

经宇，吕楠，方昀，孙悦华

（中国科学院动物研究所动物生态与保护生物学院重点实验室，北京，100101）

摘要：黑头噪鸦(*Perisoreus internigrans*)是我国青藏高原高山针叶林的特有鸟类，种群数量稀少，一些基本生活史资料至今依然缺乏。我们于2001–2004年间对该物种在卓尼和九寨沟地区的种群状况和栖息地选择进行了研究。研究表明黑头噪鸦通常以平均3.8只个体构成的“群体”形式活动，平均家域大小为42.0 ha, 平均巢间距为2.7 km。在研究区域，种群密度大小仅0.6 只/km^2，大概只有10%栖息地被利用。我们发现，该鸟对成熟针叶林有着强烈的偏好，不喜好在灌丛活动，而对针叶林幼林、草地和人类居住地没有表现出特别的喜好。

关键词：黑头噪鸦，青藏高原，活动区，种群密度，栖息地利用