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Group size, composition and stability of golden takin in Shaanxi Foping Nature Reserve, China

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A b s t r a c t. Golden takin (*Budorcas taxicolor bedfordi;* Bovidae), is found only in the Qinling Mountains of western China. Radio-tracking and direct observations were carried out at Foping Nature Reserve in Shaanxi Province to study social behavior of the takin, including group sizes, group composition and group stability. Golden takins are gregarious. Mean group size among 1,039 takins sighted in groups was 10.82 ± 0.96 (n = 96) individuals excluding solitary individuals. The largest group had 59 animals and 50% of the animals were seen in groups larger than 15 individuals during the study period. The results from this study indicate that the core social unit of golden takin is adult females accompanied by their offspring of more than one generation. 53.1% of all groups included more than one adult female, and 63.3% of all groups had more than one subadult or calf. The mean size of groups formed by adults with subadults or calves was 14.83 ± 2.34 (n = 29) individuals. The ratio of adult females to adult males was 1.0 : 0.49, skewed in favor of females. The results also show that takin groups are unstable and group composition can vary over time. Reproductive activity of adult males, subadult leavings from their mother's group and human disturbance are suggested to be factors responsible for group size variation.

Key words: *Budorcas taxicolor bedfordi*, Foping Nature Reserve, group size, group composition, group stability

Introduction

Takin (*Budorcas taxicolor*), a large mammal belonging to Bovidae, is found in restricted mountainous areas of China, Burma, India and Bhutan (W u 1986, W u et al. 1990). There are four subspecies: Mishmi takin (*B. t. taxicolor*), Bhutan takin (*B. t. whitei*), Sichuan takin (*B. t. tibetana*) and Golden takin (*B. t. bedfordi*). With an estimated population of more than 3,000, golden takins are confined to the Qinling Mountains in Shaanxi Province of China (W u et al. 1990, S o n g & Z e n g 2001). There they inhabit forests at elevations ranging from 1,200–3,500 m (S o n g et al. 1995, M a 1999). With a large body size estimated as 250–350 kg, golden takin is sensitive to hunting and deforestation. As a result, this subspecies has been listed as a first class protected species by the Chinese government.

Research conducted in the field or in Chinese zoos on golden takins has been launched since the 1960's (W u et al. 1966, 1990). W u et al. (1990) summarized all information on takin either gathered from systematic studies or from casual observations on taxonomy, anatomy, habitats, activities, reproduction and diet. More recently, further observations on breeding and parturition behavior and mother/offspring relationships of golden takin have been made in Chinese zoos (Y u et al. 1995, L i u & Z h a o 1999, K a n g & Z h a n g 2001). Beginning in the late 1980's, information on habitat selection and population size of golden takin inhabiting nature reserves in the Qinling Mountains was collected (X i a o et al. 1991, S o n g 1994, S o n g et al. 1995, M a 1999, M a et al. 2001). Population

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characteristics, anti-predator behavior, food habits, feeding behavior, home range, daily activity rhythm and time budget were also studied (Z e n g & S o n g 1998, 1999, 2001, Z e n g et al. 1998, 2001a, 2001b, S o n g et al. 2000).

Until this study, group characteristics of takin in forest have been poorly understood. There is some information about group size, group structure or composition on Sichuan takin (S c h a l l e r 1985, S c h a l l e r et al. 1986, G e et al. 1989, Z h a n g & H u a n g 1995), and little information about group size on golden takin (W u et al. 1966, 1986, 1990, X i a o et al. 1991, S o n g 1994). Information on takin group behavior is essential to understanding the relationship between environmental conditions and social systems of the Bovidae living in forest. In this paper we present information on group size, composition and stability either from direct observations or from radio-collared animals in Foping Nature Reserve. Our results provide basic data for further studies on ungulate social behavior and contribute to the development of grouping theory of ungulates.

Study Area

Foping Nature Reserve (107°40′–107°55′ E, 33°32′–33°43′ N) is geographically located on the southern slope of the middle range of the Qinling Mountains in Shaanxi Province of China. The reserve covers 29,240 hectare and encompasses rugged mountains with an elevation range of 1,080–2,094 m. Climate there is warm in summer and cold in winter. Temperature varies from 37 °C to – 10 °C, with mean daily temperatures of 27 °C in July and -2 °C in January. Annual precipitation is 950–1,200 mm, with most rain occurring from July to September. Normally first snowfall occurs in early November, with accumulation at low elevations (below 1,500 m) not occurring until December. Snow melt beings in early March and completes at higher elevations by late March, with shaded slopes keeping snow until late April.

Forests are dominant habitats at the reserve and forest types are characterized by vertical zonation. A mixed coniferous and broadleaf deciduous forest occurs between 1,080 m and 2,200 m dominated by trees of *Quercus* spp., *Populus* spp., *Betula* spp., *Toxicodendron* spp., *Salix* spp., *Acer* spp., *Tsuga chinensis* and *Pinus* spp. A bamboo species, *Bashania fargesii*, together with other shrubs, forms the understory of this forest. A subalpine coniferous zone grows from 2,200 m to 2,904 m, dominated by *Abies fargesii* and *Larix chinensis*. *Betula* spp. is the principal broadleafed tree. *Rhododendron* spp., *Lonicera* spp., *Spiraea* spp. and the bamboo *Fargesia spathacea* are common in the understory. At approximately 2,750 m near the mountainous tops, the forest is replaced by meadows. Although roads terminate at the boundaries of Foping Nature Reserve, no roads occur within the reserve. As a result, habitats in the reserve are almost pristine, and the influence of human activity is negligible. In 1996, the population size of golden takin in the reserve was estimated at 435–527 individuals (Z e n g et al. 1998). Other mammals found within the study area include giant panda *Ailuropoda melanoleuca*, golden monkey *Pygathrix roxellana*, serow *Capricornis sumatraensis*, goral *Naemorhedus goral*, forest musk deer *Moschus berezovskii*, Asiatic black bear *Ursus thibetanus* and leopard *Panthera pardus*.

Material and Methods

Golden takin is a robust and cow-like animal with sturdy legs, a bulging convex muzzle and short massive horns that sweep out and back, inhabiting at elevations of 1,200–2,900 m in the study area. Three age-classes, adults (>4 yrs, male or female), subadults (1–4 yrs) and calves

(< 1yrs) were identified in the field by body size, hair color, and shape, size and length of horns. Adult males can weigh over 350 kg and stand from 130 to 140 cm high at the shoulder, while females are smaller and weigh about 250 kg. The horns of adults are over 25 cm in length and twisted obviously for both sexes although horns in females are less massive. Body hairs of golden takin are white or off-white, but the hairs in neck and fore-chest are golden in adult males. Therefore, it is not difficult to distinguish adult males from females in the study area. Subadults can be recognized by their smaller body size and thinner horns. The horns of subadults are about 10–25 cm, either pointing straightforward or appreciably twisted. Calves are easily identified by their smaller body size and brown hair. Horns of the calf do not appear until it is six month-old (W u et al. 1990).

Radio-tracking and direct observation were employed in this study. Four takins (2 adult males, 1 adult female and 1 subadult female) were immobilized with anesthetic fired from a dart gun and radio-collars (Polyethylene collars equipped with radio-transmitters, MOD-500, Telonics Inc. Mesa Ariz., frequency 150–152MHZ) with different frequencies were attached to their necks during May–June 1995. Estimated life of the radio-transmitters was 36 months. Collared animals were located using a tracking system consisting of a TR-2 receiver and 2-element "H antenna". Efforts at locating and tracking the collared animals were made during daytime hours whenever possible. When the collared animals were found, the numbers, sex and age-classes of takins associated with the collared animals were recorded. During the study period, we had more opportunity to obtain the grouping data of a collared adult female (F1). F1 was in a group of 12 takins when immobilized.

Data were collected from July to November 1995 and from February to August 1996. Rutting season of golden takin is from June to August. We used binoculars (8 × 30) to observe radio-collared takins or to spot uncollared animals. Telescopes (15–45 zoom × 60) were used to identify sex and age-classes for each individual from a far distance. All takin sightings in the study area occurred from 0800 h to 1800 h. Number of takin, time, location, habitat type, elevation and activity (eg. feeding, resting, walking) were recorded and efforts were made to identify sex and age-classes for each member in a group. Individuals were considered as members of the same group if the distance between an individual and at least one other member of the group was less than 100 m. Golden takins were conspicuous in forests due to their white and golden hairs. Therefore, it was not easy to miss takin once a group was spotted in the field.

Statistical analyses were conducted using the Mann-Whitney U method in two-independent-samples nonparametric tests. The method was applied to compare mean group sizes between two areas. Statistical results are considered to be significant when $p<0.05$. The standard error (*SE*) is given for each mean group size.

Results

Group size

Golden takins were encountered 146 times and a total of 1,089 individuals were sighted in the study area. Solitary animals were observed 50 times forming 34.3% of all observations. However, solitary animals composed only a small percentage (4.6%) of the total observed individuals. The rest of the animals were observed in groups ranging from 2 to 59 with 50 percent of the animals observed in groups larger than 15 individuals (Fig. 1, Fig. 2). Mean group size recorded was 10.82 ± 0.96 ($n = 96$) individuals if solitary animals were excluded.

One group with 13 individuals occurred in February, but the largest group, with 59 members, was seen in June. The small sample size of data from September to March of the next year made it unsuitable to compare with differences of group size among months or seasons.

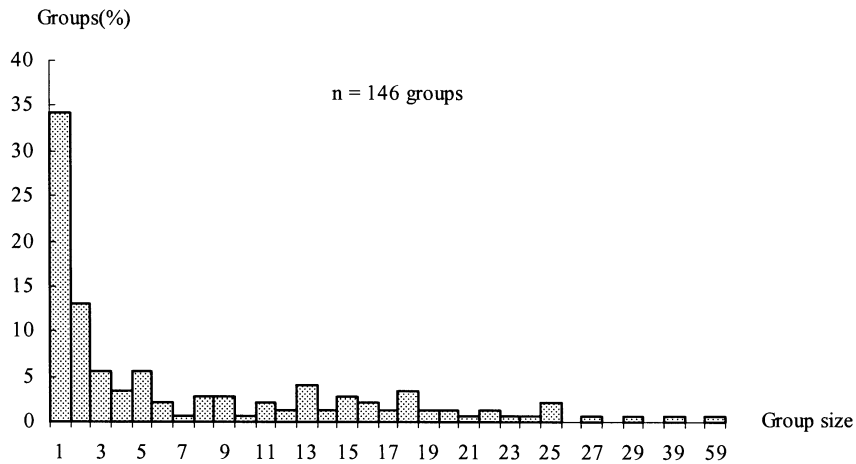

Fig. 1. Group size frequency of golden takin.

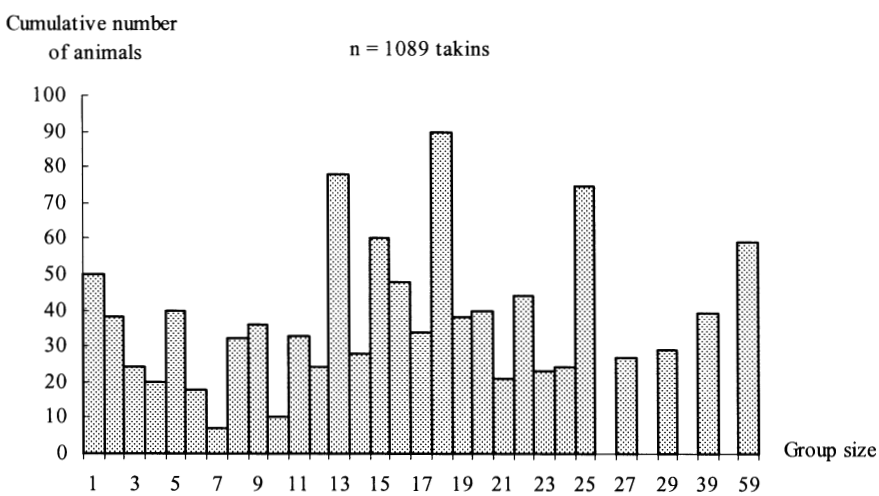

Fig. 2. Number of animals encountered in different group sizes of golden takin.

Group composition

Forty-nine groups with 531 takins were clearly aged and sexed out of the 96 groups. Among those animals there were 92 adult males, 188 adult females, 186 subadults and 65 calves (Table 1). The ratio of adults to subadults to calves was 1.0 : 0.66 : 0.23. Adult individuals in the 49 groups were obviously favored to females, the ratio of adult females to adult males was 1.0 : 0.49. The participation of adult females varied from 0 to 25 individuals in groups,

Table 1. Group types and compositions of golden takins.

Group types	Groups observed	Mean±SE	Adult males	Adult females	Subadults	Calves
Adults only	10	2.30±0.30	11	12	0	0
Adult females with subadults/calves	9	8.33±1.83	0	21	44	10
Adults with subadults/calves	29	14.83±2.34	78	155	142	55
Adult males only	1	3	3	0	0	0
Total	49	10.84±1.60	92	188	186	65

averaged 3.84 ± 0.66 (n = 49). The participation of adult males varied from 0 to 13 individuals in groups, averaged 1.88 ± 0.31 (n = 49). Only one group (2.0%) observed did not include at least one adult female, and 53.1% of all groups included more than one adult female. Only one adult male was encountered in 42.9% groups. There was no adult male in 18.4% groups, no subadult or calf in 22.4% groups. More than half of all groups (63.3%) included more than one subadult or calf (Fig.3).

Majority of the 49 groups (59.2%) were formed by adult takins with subadults or calves, mean size was 14.83 ± 2.34 individuals (n = 29, ranging from 3 to 59; Table 1). Relationships between group members loosened as the group size increased. Smaller groups often split off from a large group as animals were feeding and moving. The second most common group (20.4%) consisted only of adults, mean size was 2.30 ± 0.30 individuals (n = 10). In these all-adult groups, nine groups were composed of 1 male and 1 female, one group consisted of 2 males and 3 females. Groups formed by adult females with subadults or calves averaged 8.33 ± 1.83 individuals (n = 9, ranging from 2 to 16) and were the third most common group type. The group of adult male (n = 3 males) was observed on only one occasion, April 26, 1996.

Fifty solitary takins (34.3% of observations), including adult males (n = 36), adult females (n = 9), subadults (n = 3) and calves (n = 2), were observed in the study area.

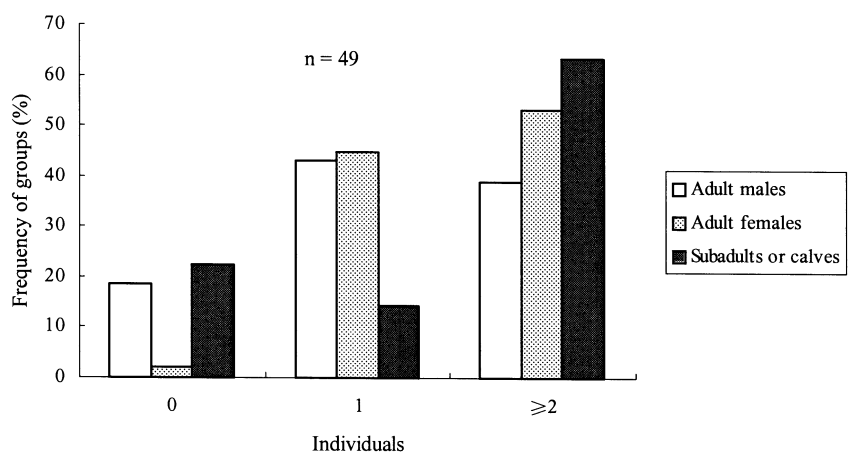

Fig. 3. Number of golden takins in groups.

Solitary adult males were more likely to be found during the rutting season from June to August (26 of 36 solitary males observed).

Group stability

Group composition of golden takins was fluid. Radio-collared female F1 with her group (F1 group) was observed 21 times (Table 2). F1 had a calf in 1995 and gave birth again the following year. The size of F1 group ranged from 2 to 20 with a mean size of 6.57 ± 1.25 (n = 21) individuals. Seventeen of the 21 observations of F1 occurred within less than three months in the summer of 1996. F1 and her calf were always seen together, but her yearling offspring did not always associate with her over time (Table 2). F1 group had four individuals on 1 July 1996, including a 4-year subadult, a 2-year subadult (the offspring of F1 born in 1995) and a calf. However, the 4-year subadult was not in F1 group when the group was found again 23 days later. On 26 July 1996 F1 group was only composed of F1 and her calf; her 2-year offspring was not found. On six occasions only F1 and her calf were observed. In addition, there were 3 times that the composition of F1 group was stable for some days. First, F1 was seen in a group of 3 takins including her calf and an adult female from 31 July to 2 August. Then, during 6–11 August F1 and her calf associated with an

Table 2. Membership and its changes in the F1 groups.

Date	Group size	Group members				Description
		AM	AF	SA	Calves	
14 Jun. 1995	12	0	4	5	3	Animals associated when captured.
7 Jul. 1995	20	5	5	8	3	
18 Aug. 1995	>5	?	>3	>1	1	
28 Apr. 1996	13	3	4	4	2	
29 Jun. 1996	>10	1	2	2	1	A single adult male sniffing and following F1 group. Running away in two groups when they were disturbed by observers.
29 Jun. 1996	5	1	1	2	1	Splitting from the group of >10; two sub-adults in the group were one 2-year female and one 4-year male.
1 Jul. 1996	4		1	2	1	An adult male left when disturbed.
23 Jul. 1996	10		2	7	1	The 4-year sub-adult male found on 1 Jul. 1996 was not in this group.
26 Jul. 1996	2		1		1	F1 with her calf.
27 Jul. 1996	2		1		1	F1 with her calf.
29 Jul. 1996	2		1		1	F1 with her calf.
*31 Jul. 1996	3		2		1	A adult female was with F1 group.
*1 Aug. 1996	3		2		1	
*2 Aug. 1996	3		2		1	The adult female associated with F1 group left.
**6 Aug. 1996	3	1	1		1	A single adult male joined F1 group.
**11 Aug. 1996	3	1	1		1	The same adult male was with F1 and showed sexual interest in F1.
11 Aug. 1996	2		1		1	The adult male left after disturbance.
#13 Aug. 1996	16		5	10	1	
#14 Aug. 1996	16		5	10	1	
14 Aug. 1996	2		1		1	F1 with her calf had left the group of 16 takins.
15 Aug. 1996	2		1		1	F1 with her calf.

Here, AM: Adult males; AF: Adult females; SA: Sub-adults.
Groups marked by *, ** and # are sequences of observations with equal members within some days.

adult male. On 13–14 August F1 and her calf were part of a group of 16 takin, before leaving the group on 14 August and moving several kilometers away. Therefore, except for the calf and her mother, the other membership of the group was often unstable.

Fission or fusion took place quite often for the F1 group. F1 left groups on 5 occasions and joined groups on 4 occasions from 29 June to 15 August (Table 2). Leaving from groups was due to disturbance of observers on 3 occasions (29 June, 1 July and 11 August). Two additional cases of the leaving happened spontaneously on 2 August and 14 August. The former occurred when an adult female left F1 group to become a single takin. The latter occurred when F1 leading her calf spontaneously left the other group members. In addition to these 5 cases of fission actually observed, F1 group had split from a large group with 10 individuals on 23 July to form a small group with only 2 individuals by 26 July. F1 group was observed four times to have fused into a large group on 23 July, 31 July, 6 August and 13 August.

Discussion

The data presented in this paper indicate that golden takin is gregarious. More than half of the total individuals observed in this study appeared in groups of larger than 15 takins. While sociality among ungulates is uncommon in dense forests, a few species such as bison (*Bison bison*), European bison (*Bison bonasus*) and bongo (*Tragelaphus eurycerus*) also live in dense forest habitats and are gregarious, forming groups of more than 10 animals (Van Vuren 1983, Krasińska et al. 1987, Krasiński & Krasińska 1992, Turkalo & Klaus-Hügi 1999). Their group sizes are similar to those of the golden takin.

Grouping characteristics of golden takins in this study agree with the results from the Pingheliang region on the northern slope of the middle range of the Qinling Mountains (Xiao et al. 1991). The mean group size for golden takins at Foping Nature Reserve (10.82 ± 0.96, $n = 96$) was larger than that recorded in Pingheliang region (8.97 ± 1.70, $n = 34$). However, the difference in group size of takins between the two areas was not significant ($Z = -0.997$, $P = 0.319$, $n_1 = 96$, $n_2 = 34$).

On the other hand, our study indicates that there are differences in group size and composition between golden takin and Sichuan takin. For example, during our study we observed only 1 group of adult males and there are no other historic observations on record for golden takin (Wu et al. 1986, 1990, Xiao et al. 1991). Bachelor groups are common, however, among Sichuan takin males (Schaller et al. 1986, Ge et al. 1989, Yuan et al. 1990). Sichuan takins tended to form larger groups than those of golden takins. The mean group size of Sichuan takin was 39.63 ± 4.69 ($n = 35$) and ranged as high as 105 individuals at Tangjiahe Nature Reserve, Sichuan Province (Ge et al. 1989). The difference in group size between the two subspecies of takin was significant ($Z = -6.203$, $P<0.001$, $n_1 = 96$, $n_2 = 35$).

Group size in ungulates often varies with habitat openness (Hirth 1977, Wirtz & Lörscher 1983, Lagory 1986, Borkowski & Furubayashi 1998, Silva 1999). Group size of ungulates, affected by sensory contact among conspecific individuals, is positively correlated to body size and negatively correlated to habitat cover (Jarman 1974, Wirtz & Lörscher 1983, Lagory 1986). Both golden takin and Sichuan takin inhabit forest environments and have similar population density (1.29–1.56 vs. 1.2–1.3 ind./ km^2; Ge et al. 1989, Zeng et al. 1998). The golden takin has

larger body size and brighter color than the Sichuan takin (Wu et al. 1990). Theoretically, golden takins should form larger group than that of Sichuan takins, but the result is the opposite. At the present time we cannot explain this apparent deviation from theory.

Our results indicate that the core social unit of golden takin is adult females accompanied by their offspring of more than one generation. Some 98.0% of all groups included adult females and the sum of subadults and calves found in groups exceeded the sum of adult females (Table 1, Fig 3). The sex ratio within groups of adult female to adult male golden takin (1.0 : 0.49) is similar to the Sichuan takin (1.0 : 0.44; Ge et al. 1989). Although takins mainly lived in groups, a few solitary individuals were observed. Having more solitary adult males than solitary adult females in the field might partially explain the sex ratio difference of takins in groups.

The results of radio-tracking collared-takin show that the groups of golden takin are unstable. Many reasons might be responsible for these group changes. Our research indicate that reproductive activity by adult males during the rutting season facilitate the group change. For example, a strong adult male was found to follow F1 group by sniffing the group's scent on 29 June 1996. Another adult male joined the F1 group to form a new group and presented some reproductive behavior toward F1 on 11 August. This male split from the F1 group five days later (Table 2). We have also directly observed that one adult male came into a group, approached and continually sniffed 2 adult females and mounted them, then left the group 10 minutes later. These observations showed that reproductive activity of strong adult males might cause the group change of golden takin. Although strong males of solitary takin occurred throughout the study period, frequency of finding them was higher in the rutting season than other seasons (Zeng & Song 1999). We suggest that strong adult males of takin move alone between groups in search of estrous females and as a result get more mating opportunities. Krasińska (1987) reported the fragility and variance of groups for European bison and believed that reproductive behavior was one of the reasons for these group changes. A positive relationship between reproduction and group size was found in feral sheep (*Ovis aries*) (Bowen & Van Vuren 1999).

Then, subadult leavings from their mother's group also appear to be a factor responsible for group size variation. Tracking F1 group, we observed two subadults (first a 4-year subadult and later the 2-year subadult offspring of F1) permanently leave the group (Table 2). It appears that subadults gradually break off contacts with her mother in the course of maturing. Furthermore, human disturbance may be a factor for the group variation. In our observations, the fission of F1 groups occurred three times due to disturbance by observers (Table 2). Golden takins often run away rapidly when they encountered observers in the field. When the takins took flight, they often ran in different directions by splitting several groups. Then group fission may be expected later in sometimes. The possibilities of group fission will increase as the group size getting larger (Zeng & Song 1998).

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