Sexual/aggressive behavior of wild yak (*Bos mutus* Prejevalsky, 1883) during the rut: implications for female choice

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Abstract

Wild yaks (*Bos mutus*) ranged across the Tibetan plateau in large herds before over-hunting greatly reduced populations. Wild yaks are endangered and have been forced to remote areas. Little has been published about their behavioral ecology, and here we present the first extensive study on wild yak behavior during the rut. We gathered data on activity budgets, aggressive/sexual behaviors, and the behavior of bulls inside and outside mixed groups. Yaks ate less and were more social during the rut than during the summer. Males ate less than females and socialized more during the rut. We observed yaks for 234.25 hours and recorded 2078 aggressive/sexual behaviors. Yak behavior was closer to bison (genus *Bison*) than wild cattle (genus *Bos*). Yak bulls inspected and tended cows in mixed sex herds showing off their profiles during lateral displays, the most common type of indirect aggression. Direct horn to horn fights could be intense. Yak bulls inside mixed sex groups rested less and socialized more than bulls outside groups. Females initiated intense intra-sexual competition leading at least 25 bulls on chases and inciting fight frenzies of numerous bulls before copulations. We discuss female choice selecting for large size and fighting ability in males.

Keywords: *Bos mutus*, wild yaks, female choice, mating behavior
Introduction

In the past, wild yaks (*Bos mutus* Prejevalsky, 1883) ranged across the Tibetan plateau of China in large numbers and often associated in herds of hundreds and even thousands (Prejevalsky 1876; Rockhill 1891). The worldwide yak population has been greatly reduced, however, to as low as 10,000 because of competition with livestock, loss of habitat and especially over-hunting (Harris and Leslie 2008). The remaining wild yaks have been forced to remote areas of the plateau, and consequently, there has been little information published on wild yak behavioral ecology and almost nothing published on their behavior during the rut (Schaller 1998). In this paper, we provide the first extensive study of the sexual and aggressive behavior of wild yak during the rut to contribute to the understanding of yak behavioral ecology, ungulate mating systems and the importance of female choice.

Traditionally, studies of sexually selected behaviors in ungulates and other mammals have focused on intra-sexual male competition (Darwin 1871; Clutton-Brock and McAuliffe 2009), and the mating systems of ungulates are characterized by monogamy, resource defense polygyny, female defense polygyny or most rarely lekking (Clutton-Brock 1989; Höglund and Alatalo 1995). Recently, however, there has been much interest in the importance of female choice as well as cooperative and competitive interactions between and within the sexes for a complete understanding of ungulate mating systems (Bro-Jørgensen 2011). Female choice can be for the stamina and competitive ability of males as well as auditory or olfactory status signals (Clutton-Brock and McAuliffe 2009). For example, pronghorn (*Antilocapra americana* Ord, 1815) females test the stamina of males and incite fights among them while red deer (*Cervus elaphus* Linnaeus, 1758) and fallow deer (*Dama dama* Linnaeus, 1758) does prefer higher roaring rates of stags (McComb 1991; Byers et al. 1994; McElligot and Hayden 2001; Byers et al. 2005).

Wild cattle (genus *Bos*), bison (genus *Bison*) and buffaloes (genera *Syncerus* and *Bubalus*) of the tribe Bovini (subfamily Bovinae family Bovidae) generally use a tend-bond mating system in mixed sex herds where bulls guard or tend cows for varying periods of time with indirect and direct aggressive behaviors (Caboń-Raczyńska et al. 1987; Prins 1989; Wolff 1998). In these mixed sex herds there is often much sexual dimorphism, and fighting ability is related to the number of copulations with a great skew in mating success. For example, in American bison (*Bison bison* Linnaeus, 1758) male/female body weight ratios range from 1.6-1.8 (Berger and Peacock 1988; Weckerly 1998; Wolff 1998), and high ranking bulls sire at least 70% of calves (Roden et al. 2003). Despite the prevalence of intra-sexual competition and mating skew among Bovini bulls, female choice also occurs. For example, American bison cows approach high-ranking bulls and run to incite chases and fights among bulls (Wolff 1998). Cows most often end up with higher ranking bulls after the runs and run more often if challenging bulls have a higher rank than the tending bull.

Thus, it seems that female choice and potential cooperation with high-ranking males has been a strong evolutionary force in American bison favoring large body size, fighting ability and stamina in this tend-bond mating species. The benefits to female choice can be direct or indirect, however, so it can be difficult to
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To provide more insight into female and male sexually selected behaviors it is necessary to study more species, especially those in different ecological environments (Bro-Jørgensen 2011). The environment of the wild yak is particularly harsh in terms of high altitude and a short growing season providing just such an opportunity. Wild yak sexes are primarily segregated with bulls living alone or in bachelor groups and joining groups for the rut in September (Prejevalski 1876; Schaller 1998). Schaller (1977) observed aggressive behavior in domestic yaks and recorded indirect threats such as lateral displays with males standing broadside showing off their profiles and direct aggression such as charges and horn to horn fights that lasted 15 minutes. Aggression is likely more intense in wild herds. For example, Prejevalski (1876) reported that many wild yak bulls had scars, injuries and horn damage. Other yak behaviors during the rut include wallowing in dust accompanied with urinating/defecating, bellowing and hornung the ground (Schaller 1998).

In this paper, we describe the timing, changes in activity budgets and group compositions for wild yak during the 2010 and 2011 ruts. Data on activity budgets are important for understanding the ecological influences on social behavior (Isbell and Young 1993), and we compare activity budgets over the course of the rut with data from summer 2004. We also provide data on aggressive/sexual behaviors during the rut. We predicted that in mixed sex groups wild yak bulls would tend cows and intensely guard them from other bulls as implied by the large degree of sexual dimorphism (male/female body weight ratios ranging from 1.6-2.7, Schaller 1998) and preliminary observations on social grouping and male injuries (Prejevalski 1876; Schaller 1998). We also observed yak bulls in and outside of mixed sex groups to determine if group bulls would engage in more activity behaviors (standing, walking and social) and less comfort behaviors (lying and feeding) than bulls outside of mixed sex groups. The same has been found in American bison and Cape buffalo (Syncerus caffer Sparrman, 1779) where males leave herds to recover (Komers et al. 1992; Turner et al. 2005).

Study area

Arjinshan Nature Reserve (ANR), Xinjiang is a national-level reserve and one of the largest nature reserves in China (45,000 km²). ANR is on the northern edge of the Tibetan Plateau and protects a unique ecosystem in transition from plateau to desert (Figure 1). There are steppes at 4,000–4,600 m and mountains with permanent snow above 5,500 m. The climate of the area is continental, dry and cold. Precipitation is rare and sparse and frequently falls as snow or sleet even in summer (Achuff and Petocz 1988).

Materials and methods

The largest concentration of wild yak in ANR is in the northeast (Buzzard et al. 2010), and from September 11-21, 2010 and September 19-28, 2011 we observed several groups of wild yak at a small herder community of Yishakipati and at a camp 15 km to the southeast of Yishakipati in ANR (Figure 1). We defined a group as ≥1 animal that was ≤ 75 m from one another and tended to move as a
cohesive unit. Group membership was variable especially with regard to bulls because they would often range just outside groups and join groups in the evenings. Because of the observation distances and topography it was difficult at times to obtain robust counts of age/sex classes. We made minimum counts only for the number of bulls and calves per group and made group counts in the evening (16:30-20:30) because many bulls joined groups at this time and visibility was better.

We observed yaks generally from dawn (07:30) until dusk (20:30) from a distance of 0.5-2 km with a 20-60x spotting scope and 25-40x binoculars. We conducted scan samples every half hour beginning at the hour or half past the hour, and between scans we conducted all occurrence focal scans for 10 minutes (Altmann 1974). We also monitored the group between scans/focals to record ad libitum all sexual/aggressive behaviors. From September 16-20, 2010 and September 20-26, 2011 two observers recorded behaviors concurrently in the mornings (07:30-10:30) and evenings (16:30-20:30) because social behaviors were most common at this time. If observers watched the same large group (>100 animals) each observer monitored one half of the group spread and used local landmarks to demarcate the boundaries.

We recorded four age/sex categories during scans: females (> 3 years old), males (> 3 years old), young (calves less than one year old) and other (yearlings and unidentified individuals). We recorded six behaviors: (1) feed, (2) lie prone, (3) stand, (4) walk, (5) social behaviors and (6) other. Walking individuals moved between feeding or resting places. The category social included aggressive or sexual behaviors between two individuals. The category other included additional behaviors such as reactions to a wolf (*Canis lupus*) in one case. We compared these scan data with scan samples collected by DX with the same methods from July 14-16, 18, 2004. We tested the frequencies of scan categories with G-tests (Sokal and Rohlf 1995).

We conducted focal samples on bulls in and outside mixed sex groups uniformly during the day. We recorded the time spent in the six behaviors from above during focal samples. We compared the average times that bulls performed these behaviors by first transforming the data with arcsinh then performing z-tests of means after F tests confirmed the variances were comparable (Fowler et al. 2008).

Aggressive behaviors could be indirect or direct. Lateral displays were indirect aggressive displays where males showed off their profiles and stood within 5 m of each other oriented head to head or tail to tail (Schaller 1977). Another indirect display, the "pass-by", occurred when one male walked slowly in front of another male and passed within 1 m. Head to head face offs occurred when males stood directly opposite each other within 1 meter. At this time males sometimes rotated/shook their heads and this often led to direct aggression in the form of horn to horn fights. Males charged towards other males in another show of direct aggression. Direct aggression was often indicated by males raising their tails. A "fight frenzy" was the engagement of at least five to 25 or more males in aggressive displays and fights (Berger and Cunningham 1994). Individuals rolled in dust during the wallow behavior, and before using wallows they often pawed the ground with a front hoof or horned the ground. Males also extended their neck to vocalize with bellows.

Sexual behaviors included male inspection of females. During inspection, males smelled and at times licked the genital region of females often followed by the stereotypic lip curl or flehmen response (Wolff 1998). If the female moved
off, the males would often follow. Males also tended or guarded females from
other males by standing next to them and blocking their escape. Males often
reached back to make head to head contact with the female while tending the
female. Mounts occurred within and between the sexes, and copulations lasted for
at least 5 sec.

Results

Timing of the rut

On September 11, 2010 from 0800 to 1530 we observed a mixed sex group of c.
200 individuals for 15 minutes every half hour. We observed a bull using the
flehmen response indicating that the early rut had begun. On September 12 we
continuously watched a group of 40-50 individuals at the camp east of Yishakipati
from 11:45-20:30 and observed a large increase in rutting activity. On September
14 we observed for the first time a bull tending or guarding a cow from other
bulls. We observed the first copulation on September 19 and observed bulls
guarding cows from many other bulls until the end of September. Based on the
behavior of bulls we considered September 11-13 as the early rut, September 14-
18 the mid-rut and September 19-28 the main rut.

Activity Budgets

We compared activity budgets for wild yak bulls, cows and unknown individuals
during the rut to activity budgets from summer 2004. We found that during the
summer yak ate more than during the rut while lying prone, socializing and
walking less (Table 1, G = 155 p<0.01). We then compared the activity budgets
of yak bulls and cows during the rut. We found that bulls fed less than cows
during the rut while engaging in every other behavioral category more than cows
(Table 1, G = 2082 p<0.01). We then compared the activity budgets for yak bulls
over the course of the rut from the early rut to the mid-rut to the main rut. The
time spent feeding by bulls decreased significantly over the course of the rut, and
the time spent in social activities increased (Table 1, G = 158 p < 0.01).

Group composition

At Yishakipati and at the camp 15 km to the southeast we watched groups with 9
to 283 yaks. We observed a lot of variety in group sizes within and between days,
and the largest groups formed during the main rut especially on days with fight
frenzies when small groups joined together. There were from 2 to at least 25
calves making up 7-27% of group totals and 8-54% of cows/others (Figure 2).
Groups had from 2 to at least 25 bulls making up 8-26% of group totals (Figure
2). For an additional 16 groups during the main rut we only counted total group
sizes; these groups ranged in size from 15 to 283 with an average group size of
101.4 ± 67.6.

Aggressive/sexual behaviors

We observed the yaks for 234.25 observer-hours and observed 2078
aggressive/sexual behaviors. Aggressive behaviors typically occurred between
bulls. The most common indirect aggression was the lateral display (N = 196) followed by pass-bys (N = 34). Direct aggression occurred in the form of charges (N = 43) and horn to horn fights (N = 151). Fights lasted from 15 seconds to over 20 minutes. Fights varied in intensity from long bouts (> 20 minutes) of low intensity sparring among small bulls to more intense fights between large bulls forcing each other to the ground. In one instance this involved three bulls; while two bulls were fighting a third bull charged into one of the combatants forcing it to the ground. We could not confirm any injuries. We also observed one brief fight between cows.

Bulls bellowed rarely during aggressive situations such as during lateral displays or with tail up and walking through the group (N = 12). At other times, bulls bellowed while alone (N = 20) or in uncertain situations (N = 12).

Wallowing occurred 156 times in both aggressive and sexual situations and up to 7 times in one 10 minute focal sample. During wallows, primarily bulls rolled in sandy patches usually after pawing and/or horning the ground. Bulls most often wallowed during aggressive situations such as lateral displays, before fights, or when alone but with tail up in an aggressive posture (65 %, N = 155). When wallowing alone with or without tail up they wallowed at a prominent position often higher in elevation than most other group members. Rarely, bulls wallowed while interacting with females (5 %, N = 155). We only observed a female wallowing once and this occurred before fighting with another female.

Indirect aggressive behaviors between bulls were more common than direct aggressive behaviors and wallowing during the early and mid-rut (Figure 3). The first day of the main rut (19th) there was a large fight frenzy with a lot of lateral displays, and indirect aggressive behaviors were still more common than direct aggressive behaviors and wallowing (Figure 3). By the end of the main rut direct aggressive behaviors and wallowing were as common as indirect aggressive behaviors (Figure 3).

The most common behavior we observed between the sexes was when males smelled/inspected the genital region of females (N = 834) often leading to female urination. After the urination and at other times males often performed the flehmen response (n = 123). After smelling and inspecting the female the male would often stand next to and tend the female guarding her from 1-10 other males (n = 477). The guarding often involved males reaching back and touching the head of the female while standing next to her. We observed several mounts within the sexes and among young. We observed seven copulations, and all were brief (<10 seconds).

The three most common intersexual behaviors (inspecting or smelling females, guarding or standing by females as well as following females) were most common during the main rut and most common during the days with a fight frenzy (Figure 4). Bulls more often inspected cows during the early and mid-rut and more often guarded and followed cows as the rut progressed (Figure 4).

**Comparison of group and outside bulls**

Bulls in mixed sex groups socialized more and rested less than bulls outside mixed sex groups (Figure 5). Group bulls spent on average 4.1 ±1.5 minutes (N = 64) in social behaviors per focal sample compared to an average of 0.4 ±1.1 minutes (N = 83) for bulls outside mixed sex groups (z test = 9.4, p<0.01). Group bulls spent on average 0.7 ±1.6 minutes (N = 64) resting per focal samples compared to an average of 3.2 ±1.9 minutes (N = 83) for bulls outside groups (z
test = 5.7, p<0.01). Feeding, walking and standing rates were similar for bulls inside and outside groups (Figure 5).

Female Choice

After males smelled females the females often left and forced males to follow (N = 233). At times this led to an extended sequence where males would smell then females would leave. Males would then follow the females who would stop. The males would smell again, and this could go on for several more times. Nine times we also saw females fight with males to elude guarding males or attempted mountings.

Every copulation occurred after females left a guarding male instigating chases and fight frenzies. For example, in one instance, a male guarded a female from at least 10 other bulls for several hours. Then the female led the males on a chase and they were joined by at least 15 other males. At least 50 other individuals from the group joined to watch or engage in the fight frenzy. Three large males from outside the group joined, and after several intense fights involving these three males, one copulated with the female several times.

Discussion

The timing of the wild yak rut and group compositions were generally consistent with previous reports (Prejevalski 1876; Schaller 1998; Miller et al. 1994). Wild yak bulls were sexually segregated most of the year and tended females within mixed sex herds during the rut as predicted. Wild yak ate less and were more social and walked more during the rut compared to the summer. During the rut bulls were more social than females and fed less, and bulls became more social and fed less as the rut progressed.

Female choice, potentially in cooperation with high status males (Bro-Jørgensen 2011) seemed to be an important factor in wild yak selecting for large body size and fighting ability in this tend-bond mating species. In both years, we observed yak cows being tended or guarded for hours and then chased by over 25 bulls, and we only observed mating during or after large fight frenzies with intense fights involving large males. These chases and frenzies together with cows resisting bulls emphasized the importance of intra-sexual competition mediated by female choice.

Wild yak cows in estrus are particularly valuable because yak cows breed every two years or longer (Wiener et al. 2003), and estrus can be very short. In domestic yak, estrus can last from only 0.5 to 6.5 hours, and it mostly lasts less than a day (References in Wiener et al. 2003). In this study, wild yak cows were guarded by multiple bulls for much of the day, and this coercion was likely as costly as it is for other females (Smuts and Smuts 1993) so there are likely large benefits. The benefits to female choice can be direct or indirect, however, so it can be difficult to distinguish female choice from intra-sexual male competition (Clutton-Brock and McAuliffe 2009; Bro-Jørgensen 2011). The costs and benefits to the yak bulls are also substantial given the intense fights and scarring (Prejevalsky 1876). Females incite male competition in a variety of animals, and inter-sexual choice, intra-sexual competition and inter-sexual coercion must be considered together (Cox and Leboeuf 1977; Koprowski 1993; Wolff 1998;
Pizzari 2001; Clarke et al. 2010; Bro-Jørgensen 2011). It is necessary for long
term studies on wild yak groups with individual identification to obtain data on
the length of male tenures in and out of groups and to clarify the costs and benefits
of female and male mating strategies.

The harsh plateau ecology was likely also an important factor that has
selected for large, aggressive males and large fighting frenzies in wild yak.
American bison cows were chased by only 1-4 bulls at Niobrara, Nebraska (Wolff
1998) while at the Badlands of South Dakota bison cows were pursued by up to
19 bulls (Berger and Cunningham 1994). The environment of the Badlands is
harsher than at Niobrara and fewer cows conceived each year. At Arjinshan
where yak cows breed every two years or longer (Wiener et al. 2003) the
environment is harsher still, and yak cows were chased by even more bulls.

Schaller (1977) suggested that yak behavior is intermediate between bison
and wild cattle. Our data, however, showed that yak behavior during the rut more
closely resembled the behavior of bison. For example, males tending females is
an important part of yak as well as American and European bison behavioral
repertoires during the rut. Feral cattle, banteng (*Bos javanicus* d’Alton, 1823) and
gaur (*Bos gaurus* Smith, 1827) males compete for access to females but there is
no extended tending (Hoogerwerf 1970; Halder 1976 referenced in Timmins et al.
2008; Hall 1989; Daycard 1990; Lazo 1995). In addition, tail position is an
important signifier of aggressive nature in wild yak as well as bison (Komers et al.
1992; Caboń-Raczyńska et al.1983) but not for cattle (Boissou et al. 2001). Yaks
also paw the ground before using wallows like in bison but not before fights or
charges like in cattle (Berger and Cunningham 1994; pers. obs.).

Fights between yak bulls were common as they are in bison (Lott 1974;
Caboń-Raczyńska et al. 1987; Berger and Cunningham 1994; but see Krasieńska
and Krasieńska 2007 referenced in Ahrestani et al. 2011). In American bison 29%
of bulls were injured in fights (Wolff 1998), and European bison bulls are
frequently wounded and at times die from the wounds (Caboń-Raczyńska et al.
1987). The fights between yak bulls were at times intense especially during the
fight frenzies when bulls sometimes forced other bulls to the ground. We could
not confirm any injuries as noted by Prejevalsky (1876) because we were too far
away. Yak bulls outside mixed sex groups rested much more than bulls inside of
groups, and this is consistent with results from bison and cape buffalo where
outside bulls were recovering and not searching for estrus females (Prins 1989;
Komers et al. 1992; Turner et al. 2005).

Wild yak used wallows during the rut like bison and unlike cattle (Schaller
1998), but there were important differences in context. Yak wallowing was used
more during intrasexual aggressive contexts, for example, with the tail raised
before broadside displays and fighting. Bison wallowing, on the other hand, often
followed urination in the wallow pits and was used primarily for scent marking
and linked more to courtship behavior (Bowyer et al. 2007; Caboń-Raczyńska et
al. 1987 but see Lott 1974). We did not observe wild yaks urinating in the
wallows, but we were likely too far. This behavior has been observed in domestic
yak (Schaller 1977; J. Watson pers. comm.).

Wild yak bellowed during the rut like domestic yak, bison and many
Bovini (Schaller 1998; J. Watson pers. comm.), but again there were important
differences. Bellowing seemed to be much more important in American bison
than in wild yak. Bellowing contests between tending male and 1-4 challenging
bulls occurred in bison not yak and the bellowing is incessant in bison (Berger and
Cunningham 1994; Wolff 1998). Prejevalsky (1876) reported local claims that the
yak bulls constantly made a grunting noise during the rutting season but his party did not hear it once. We were too far to hear any bellows, and in the future closer observations may provide more insight. In addition, in our study some of the bellowing may have been mistaken for flehmen. Nevertheless, these behaviors would have occurred in inter-sexual contexts such as after smelling female and not in bellowing contests.

Our behavioral data support genetic and morphologic studies that show yak are closer to bison than cattle (Groves 1981; Buntjer et al. 2002; Verkaar et al. 2004; Nijman et al. 2008; Wang et al. 2010). Behavioral characters can be very valuable for determining phylogenetic relationships (de Queiroz and Wimberger 1993), and the behavioral data from this paper support Poephagus as the proper genus for yak instead of Bos as suggested by Nijman et al. (2008).

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Table 1. Comparison of activity budgets for (a) wild yak bulls, cows and unknown individuals from scans during summer 2004 vs. the 2010 and 2011 ruts; (b) wild yak bulls and cows during the 2010 and 2011 rut; and (c) yak bulls during the early rut vs. the mid-rut vs. the main rut.

(a)  

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<th>Summer (n = 526)</th>
<th>Rut (n = 15,297)</th>
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<td>Lie</td>
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(b)  

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<td>68%</td>
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<tr>
<td>Social</td>
<td>24%</td>
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</tr>
<tr>
<td>Lie</td>
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<td>Stand</td>
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<td>Walk</td>
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(c)  

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Figure 1. Arjinshan National Nature Reserve, Xinjiang and its position in China.

Figure 2. The numbers of bulls, calves and cows/other individuals for wild yak groups (a) during the early and mid-rut and (b) during the main rut. “+” indicates a fight frenzy.

Figure 3. The number of indirect aggressive behaviors (lateral displays and pass-bys), direct aggressive behaviors (fights and charges) and wallowing (a) during the early and mid-rut and (b) during the main rut. “+” indicates a fight frenzy.

Figure 4. The number of inter-sexual behaviors (inspecting or smelling females (SM), tending or standing by females (STF) and following females (FOL) (a) during the early and mid-rut and (b) during the main rut. “+” indicates a fight frenzy.

Figure 5. The percent of time bulls inside and outside mixed sex groups performed different behaviors during focal samples.