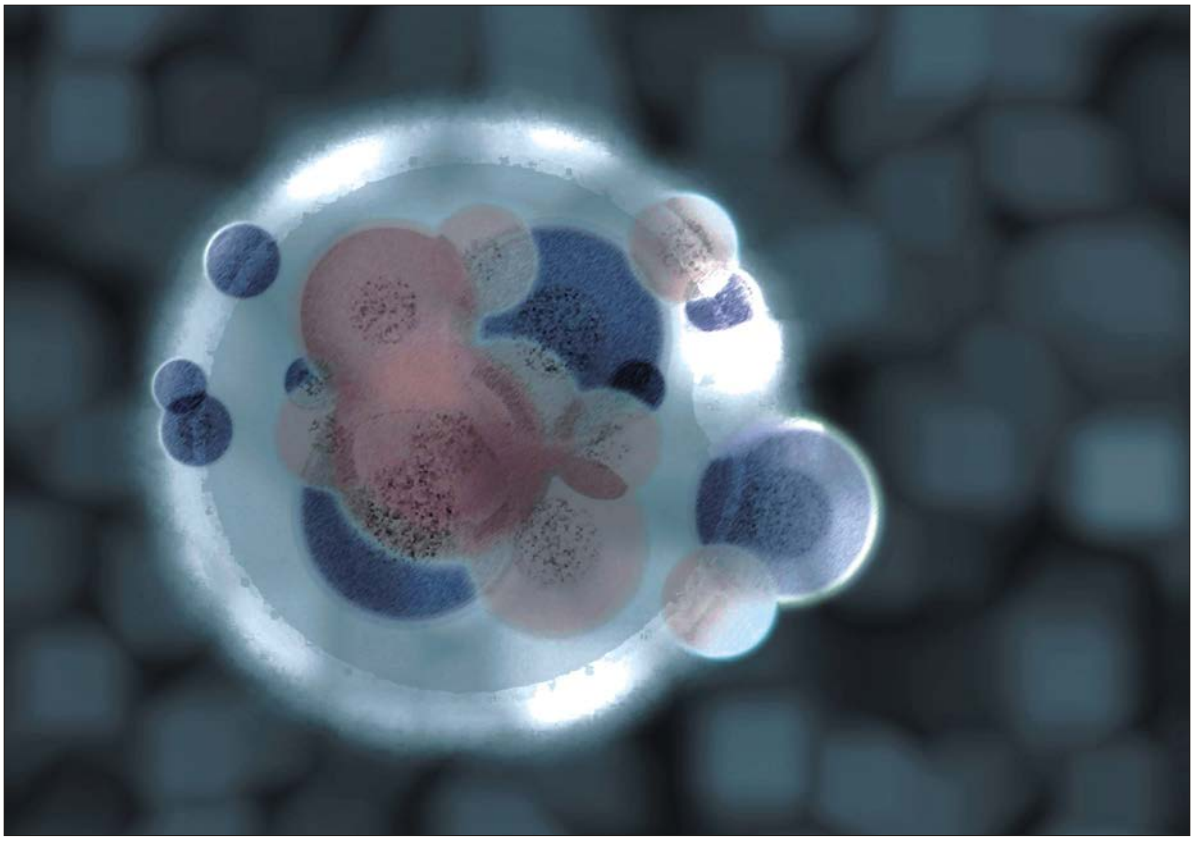

Journal of Biological Sciences

ISSN 1727-3048

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Biological Sciences 6 (2): 370-374, 2006
ISSN 1727-3048

Sex Ratio, Herd Size and Composition and Sexual Segregation in Banteng in the Baluran National Park, Indonesia

Satyawan Pudyatmoko and Djuwantoko
Department of Forest Resources Conservation, Faculty of Forestry,
Gadjah Mada University, Bulaksumur, Yogyakarta, Indonesia

Abstract: This research provided for the first time details observation on sex ratio, herd size and composition as well as the degree of sexual segregation of free ranging banteng. A total of 736 herds were examined from 1996 to 2003 in their natural habitat in the Baluran National Park, Indonesia. Results showed that sex ratio changed from female bias to more equal ratio. It was probably the results of higher predation rate on female than on male by dholes. The herd size varied greatly, with the most herds (76%) consisted of one to ten animals. However, the median was the same for all seasons (5 animals). Mixed sex herds were more frequent than single sex herds. Consequently, differed from the prediction, the degree of sexual segregation was low throughout the year. The responsible factors might include limited food availability and clumped water resources as well as a small population size.

Key words: *Bos javanicus*, sexual segregation, dholes, activity budget hypothesis

INTRODUCTION

Banteng (*Bos javanicus* d'Alton, 1823) is classified as an endangered species by IUCN Red List as well as by the US Endangered Species Act. The global population is unlikely to be more than 8,000 and is quite possibly fewer than 5,000 animals (The IUCN Species Survival Commission, 2004). Banteng is a sexually dimorphic species with mature males being dark brown or black and the cow and young, reddish-brown. Both sexes have a slight ridge on the back, a white rump and white stocking on the legs. Bulls of 8-10 years can reach a shoulder height of more than 170 cm, while females of the same age will stand 20 cm lower at the shoulder (Hoogerwerf, 1970). The frequency of ecological segregation, sexual differences in diet or habitat use, is significantly higher among herbivores with sexual body size dimorphism (Mysterud, 2000). In ungulate species, outside the mating season individuals tend to group with other of their own sex. However, sexual segregation is widespread not only in ungulate but also in other species (Ruckstuhl and Neuhaus, 2000, 2002) and occurs in temperate as well as in tropical species, for example in polecats *Mustella putorius* (Lóde, 1996), red-billed choughs *Pyrrhocorax pyrrhocorax* (Blanco and Tella, 1999), red deer *Cervus elaphus* and soay sheep *Ovis aries* (Conradt, 1999; Conradt *et al*., 2000; Conradt *et al*., 2001), mouflon sheep *Ovis gmelini* (Cransac *et al*., 1998; Le Pendu *et al*., 2000), African buffalo *Syncerus caffer* (Prins, 1988), bighorn sheep *Ovis canadensis* (Ruckstuhl, 1998), African elephant *Loxodonta africana* (Stokke and du Toit, 2002) and humpback whales *Megaptera novaeangliae* (Stevick *et al*., 2003).

As a basic component of the animal's social organisation, sexual segregation is very interesting from the behavioural ecology point of view (Ruckstuhl and Neuhaus, 2000). The problem of sexual segregation is also a relevant topic in management and conservation of animals, because it is often accompanied by sex differences in reproductive performance and survival (Conradt *et al*., 2000). However, theory of the evolution of sexual segregation is still controversial and why it is widespread in dimorphism ungulate has not been fully understood. These are three widely hypotheses cited that explain this behaviour: the predation risk hypothesis, the forage selection hypothesis and the activity budget hypothesis (Ruckstuhl and Neuhaus, 2000, 2002; Conradt, 1999; Main *et al*., 1996).

The first hypothesis predicts that females would choose habitats that firstly increase security of offspring and only secondly include nutrition in their habitat choice. Males are less vulnerable to predation and tend to exploit areas where nutritious resources are abundant. The rational of the second hypothesis is that sexual differences of body size lead to different energy requirement and hence habitat selection. According to

Corresponding Author: Dr. Satyawan Pudyatmoko, Department of Forest Resources Conservation, Faculty of Forestry, Gadjah Mada University, Bulaksumur, Yogyakarta, Indonesia

Jarman-Bell Principle (Bell, 1971; Geist, 1974; Jarman, 1974) larger males can survive on lower quality diet and more efficient at extracting energy from fibber than smaller females. Consequently, females need to compensate for this digestive inferiority by either increasing foraging efficiency or selecting higher quality forage. The activity-budget hypothesis explains that sexual segregation between male and female is not by-product of habitat segregation but driven by differences in foraging behaviour (Ruckstuhl and Neuhaus, 2002; Conradt, 1999). Both sex may forage in the same habitat and eat the same plant species (not segregated by habitat) but they fail to establish a mixed-sex group due to differences in time budget and increased cost of synchrony (Ruckstuhl, 1998).

It is expected from the theory that sexual segregation should occur in banteng due to different of foraging behaviour of different sex. The paper provided for the first time the relationship between seasons and change of frequency of herd composition and size and the degree of sexual segregation in banteng and came up with possible explanation for the underlying factors. We predict that sexual segregation occurs in all season even the both sexes used the same habitat, but it should be most pronounced when females have offspring.

MATERIALS AND METHODS

Study site: The study was carried out in the Baluran National Park (25000 ha). It is located in the northeast of Java, in the province of East Java, Indonesia. The observations were conducted in the feeding ground in Bekol (about 350 ha) in the northern part of the park. The study area is characterized by monsoon climate with a long dry season from April to November. Most precipitations fall in December till February. Baluran area is composed by mosaic of several vegetation formations. The zonal vegetation includes grassland, semi open lowland monsoon forest and forests of the mountain slopes. The azonal forest formations consist of mangrove forests, swamp forests and coast forests. In this dry landscape grasslands were dominant. These cover approximately 50% of the area. However, most of the grasslands important for banteng were fully covered by an exotic tree species *Acacia nilotica*. Some treatments have been applied to control the propagation of this species, but up to now no sufficient success was reached. Regular eradications of this invasive species were carried out in Bekol. Besides banteng, other herbivores occur in here are feral buffalo (*Bubalus bubalis* Linnaeus, 1758), rusa deer (*Cervus timorensis* Blainville, 1822), Indian muntjac (*Muntiacus muntjac* Zimmermann, 1870) and wild pig (*Sus scrofa* Linnaeus, 1758). The main predator of banteng is dhole (*Cuon alpinus* Pallas, 1811), although leopard (*Panthera pardus* ssp. *mellas* Cuvier, 1809) is also present here.

Animal survey: Data from 1996 to 2001 on group composition (including information of age classes and sex of individuals) were provided by the National Park. In addition regular observations from 2002 to 2003 were conducted. Banteng were observed from the tower in Bekol, which is approx. 6 m high. It is located on a hill from which the surrounding area to a large extent was visible. The observations of banteng took place at the morning (up 05.00 o'clock) and at the late afternoon (up 14.30), in between normally banteng leaved feeding ground and moved to the forest. A detail classification of the banteng according to their age was hardly possible, because the distance between the observer and the objects was too large. Banteng were then divided into three age classes on the basis of clear differences of the body size. These age classes included juvenile, sub-adult and adult. Juvenile is approximately 75 to 50% smaller than an adult cow and sub adult is approximately 25% smaller. Herd membership for individual animals was easy to determine, since groups were distinctly separated from each other.

Degree of sexual segregation: The degree of sexual segregation was calculated using a Segregation Coefficient (SC) (Conradt, 1998) in a slightly modified form (Conradt, 1999):

$$SC = \sqrt{\left(1 - \frac{N-1}{X.Y} \cdot \sum_{i=1}^{k} \frac{xi \cdot yi}{ni - 1}\right)}$$

Where, N = total number of animals (males+females), X = total number of males, Y = total number of females, ni = number of animals (males+females) in the ith herd, xi = number of males in the ith herd, yi = number of females in the i th herd. The value of SC ranges from 0 that indicates no segregation to 1 for complete segregation. Sub adults and juveniles were excluded from the analysis, since they are still strongly dependent on their mother, thus their social segregation are not fully developed. In order to facilitate data comparison between seasons, we distinguished between four seasons of equal length: January to March (rainy season), April to June (dry season, calving season), July to September (dry season, rut season) and October-December (rainy season).

RESULTS

The estimated number of banteng was about 200 animals. During the research the total number of 736 herds

was observed. The population sex ratio of banteng changed considerably from the periods of 1999-2001 to 2002. It was female bias during the periods of 1999 to 2001. In 1999 the sex ratio was 1:3.75 ($n = 95$; $\chi^2 = 36.76$; $df = 1$; $p<0.01$), in 2000 1:3 ($n = 40$; $\chi^2 = 10.00$; $df = 1$; $p<0.01$) and in 2001 1:2.92 ($n = 47$; $\chi^2 = 11.25$; $df = 1$; $p<0.01$). However, in 2002 the sex ratio was near to 1:1 ($n = 116$; $\chi^2 = 0.31$; $df = 1$; ns). Unfortunately, the sex ratio of animals in 2003 could not be estimated because too few banteng could be observed in the park.

Table 1 showed seasonal variation of herd size. As a whole there was a dependency between the frequency of each herd classes with the seasons ($\chi^2 = 40.78$; $df = 15$; $p<0.01$) and the total frequency of each herd classes in a year differed very significantly ($\chi_r^2 = 514$; $df = 5$; $p<0.01$). A congregation of banteng appeared for the first time in early April already. However, this animal was easiest to be encountered in the rut season from July to September. The frequency of banteng visiting the feeding ground declined after the rut season. In the rainy season from November to March banteng were hardly to be observed in the grassland. They preferred to stay in the monsoon forest, where forage and water were also abundant. The herd size ranged from a single to 101 animals with a median of 5 animals. Most herds consisted of 1-5 animals (50,12%), of 6-10 animals (20.83%), of 11-15 animals (16.16%) and of 16 animals and above (12.88%).

Banteng formed a very loose herd (fission-fusion group). Usually, the members of herd were able to keep the togetherness for no longer than a day. Animals were frequently leaved it original group and joined other herd. Only cows and their calves formed a permanent herd. The total frequency of each herd composition among seasons in a year differed also very significantly ($\chi_r^2 = 866$, $df = 4$, $p<0.01$) (Table 2). Most herds were mixed group (57.74%). However, the frequency of solitary male was unexpectedly high (18.21%). The frequency of male herd (11.68%) was slightly higher than those of female (9.92%). The solitary female had the lowest frequency with only 2.44%. Adult males were living in three different social environment, namely in the mixed and the male herd (bachelor herd) or solitary. The solitary male could enter mixed herds temporarily in the mating season. On the other hand, male of mixed herd could also leave the herd to joint other herds or went alone. We never observed adult females that separated from their herd and went alone.

Degree of sexual segregation was low through out the year. It differed with the expectation that sexual segregation should be most pronounced during calving season (April to June) and less obvious during the mating season (July to September). Present data showed that the highest degree of sexual segregation took place from

Table 1: The absolute observed frequency of herd classes of banteng in each season. Juveniles were excluded

Herd classes	Seasons				
	Jan.-March	April-June	July-Sept.	Oct.-Dec.	Total
1-5	7	144	188	59	398
6-10	5	55	72	36	165
11-15	5	19	32	12	68
16-20	1	10	26	6	43
21-25	0	5	9	1	15
>25	6	5	28	5	44
Total	24	238	355	119	736

Table 2: The absolute observed frequency of herd composition of banteng in each season. Juveniles were excluded

Herd composition	Season				
	Jan.-March	April-June	July-Sept.	Oct.-Dec.	Total
Solitary male	4	43	73	14	144
Solitary female	2	9	4	3	20
Mixed herd	17	128	201	79	455
Male herd	0	18	55	13	91
Female herd	1	40	22	10	82
Total	24	238	355	119	736

October to December (SC = 0.461) that was slightly higher than those from April to June (SC = 0.410). The degree of sexual segregation was low after the rut from July to September (SC = 0.369) and reached the lowest degree in January to March (SC = 0.315).

DISCUSSION

Findings of the research suggested that predation pressure by dholes could alter the demographic structure of banteng. Changes of adult sexual ratio of banteng were obvious in Baluran. Sex ratio of banteng at birth was near 1:1 (Choquenot, 1993) and under low predation pressure adult sex ratio skewed toward female. Normally, male had a higher mortality rate, because it was more susceptible to malnutrition (Owen-Smith, 1993). The number of dholes increased since 2000 and after that the proportion of females in the population decreased. Present records showed that females were more vulnerable to predation than males. During April 2002 to April 2003 we observed 6 cows were preyed, among them three were pregnant. But no single adult bull was being a victim of dholes. This carnivore preferentially killed females, sub adult and calves. It could have far reaching consequence for the long-term survival of banteng population (Pudyatmoko, 2005). The challenge was how to reduce the pack size of dholes sufficiently, so that this predator avoids banteng and prefers smaller prey species. This is further complicated because the ecology and behavioural correlates to predation by dholes were poorly understood.

Herd size might be influenced by season and habitat (Fischer and Linsenmair, 2000; Leuthold, 1976). The number of a big herds observed was highest during the

rut in the open habitat with good visibility. The congregation of animals might benefit animals in the mating choice. The function of grassland was not only providing banteng with foods, but more important with sufficient space. The eradications of *A. nilotica* in the grassland were important measures to ensure the availability of open habitat. In this research, a quantitative comparison of herd size between habitats could not be performed. Too few banteng were observed in the forest. The animals in the forest were wary of people and did not allow close approach. We could not estimate the herd size from tracks they leaved. However, we never saw a herd of banteng consisted of more than 20 animals in the forest. A weak bond of herds could be caused by frequent disturbance of human including tourists. Many local peoples gathered grasses, fuel woods and other forest products for their livelihood in the forest. Herd began to split as the animals fled to avoid human or predator.

Present finding showed that banteng was an exception among the polygynous ungulates with sexual body size dimorphism. The activity budget hypotheses could not explain the sexual segregation in banteng and the relationship between sexual segregation and sexual body size dimorphism was weak. It might be not necessary to find a common underlying cause of sexual segregation and more reasonable to assume that combination of factors acted at the same or different level (Ruckstuhl and Neuhaus, 2002). The low degree of sexual segregation in banteng could be caused by multiple factors. First, the high frequency of mixed herd could be caused by limited food availability and clumped water resources (example *Capra ibex sibirica*) (Fox *et al*., 1992). Bekol grassland was the only large open habitat available in Baluran. In addition, most all ponds located in the surrounding of Bekol. During dry season a large number of banteng independent of their sex visited Bekol to take freshwater provided by park management. Second, there was relationship between sexual segregation and population size. In a small population the degree of sexual segregation could be very low or absent (Mysterud, 2000). The number of males and females was too low to form segregate herd. These factors override effect of the sexual body size dimorphism and lead to the low degree of sexual segregation in banteng.

ACKNOWLEDGMENTS

The study was carried out under the sponsorship of DAAD (German Educational Exchange Service). We would like to thank the head of Baluran National Park for granting us for permission to conduct research in Baluran. We wish also to thank Pak Saidi and Pak Kusdiyana for their field assistant and to Dr. Soemardi for his comment on the first draft of the manuscript.

REFERENCES

Bell, R.H.V., 1971. A grazing ecosystem in the Serengeti. Sci. Am., 225: 86-89.

Blanco, G. and J.L. Tella, 1999. Temporal, spatial and social segregation of red-billed choughs between two types of communal roost: A role for mating and territory acquisition. Anim. Behav., 57: 1219-1227.

Choquenot, D., 1993. Growth, body condition and demography of wild banteng (*Bos javanicus*) on Couburg Peninsula, Northern Australia. J. Zool. Lond., 231: 533-542.

Conradt, L., 1998. Measuring the degree of sexual segregation in groupliving animals. J. Anim. Ecol., 67: 217-226.

Cransac, N., J.F. Gerard, M.L. Maublanc and D. Pépin, 1998. An example of segregation between age and sex only weakly related to habitat use in Mouflon sheep (*Ovis gmelini*). J. Zool. Lond., 244: 371-378.

Conradt, L., 1999. Social segregation is not a consequence of habitat segregation in red deer and feral soay sheep. Anim. Behav., 57: 1151-1157.

Conradt, L, T.H. Clutton-Brock and F.E. Guinness, 2000. Sex differences in weather sensitivity can cause habitat segregation: red deer as an example. Anim. Behav., 59: 1049-1060.

Conradt, L., T.H. Clutton-Brock, D. Thomson and F.E. Guinness, 2001. Could the indirect competition hypothesis explain inter-sexual site segregation in red deer (*Cervus elaphus* L)? J. Zool. Lond., 254: 185-193.

Fox, J.L., S.P. Sinha and R.S. Chundawat, 1992. Activity pattern and habitat use of ibex in the Himalaya Mountains of India. J. Mammal., 73: 527-534.

Fischer, F. and K.E. Linsenmair., 2000. Changes in group size in *Kobus kob kob* (Bovidae) in the Comóe National Park, Ivory Coast (West Africa). Z. Säugetierkunde, 65: 232-242.

Geist, V., 1974. On the relationship of social evolution and ecology in ungulates. Am. Zool., 14: 205-220.

Hoogerwerf, A., 1970. Udjung Kulon, the Land of the Last Javan Rhinocheros. E.J. Brill, Leiden, Netherlands, pp: 168.

Jarman, P.J., 1974. The social organisation of antelope in relation to their ecology. Behaviour, 48: 215-266.

Leuthold, W., 1976. Group size in elephant of Tsavo National Park and possible factors influencing it. J. Anim. Ecol., 45: 425-439.

Lóde, T., 1996. Conspecific tolerance and sexual segregation in the use of space and habitats in the European polecat. Acta Theriol., 41: 171-176.

Le Pendu, Y., C. Guilhem, L. Briedermann, M.L. Maublanc and J.F. Gerard, 2000. Interaction and association between age and sex classes in mouflon sheep (*Ovis gmelini*) during winter. Behav. Proc., 52: 97-107.

Main, M.B., F.W. Weckerley and V.C. Bleich, 1996. Sexual segregation in ungulates. new direction for research. J. Mammal., 77: 449-461.

Mysterud, A., 2000. The relationship between ecological segregation and sexual body size dimorphism in large herbivores. Oecologia, 124: 40-54.

Owen-Smith, N., 1993. Comparative mortality rate of male and female kudus: the cost of sexual dimorphism. J. Anim. Ecol., 62: 428-440.

Prins, H.H.T., 1988. Condition changes and choice of social environment in African buffalo bulls. Behaviour, 108: 297-323.

Pudyatmoko, S., 2005. Does banteng (*Bos javanicus*) have a future in Java? Challenges of the conservation of a large herbivore in the densely populated island. Proceedings of the 3rd IUCN World Conservation Congress-Knowledge Market Place, Bangkok, pp: 1-6.

Ruckstuhl, K.E., 1998. Foraging behaviour and sexual segregation in bighorn sheep. Anim. Behav., 56: 99-106.

Ruckstuhl, K.E. and P. Neuhaus, 2000. Sexual segregation in ungulates: A new approach. Behaviour, 137: 361-377.

Ruckstuhl, K.E. and P. Neuhaus, 2002. Sexual segregation in ungulates: A comparative test of three hypothesisnew approach. Biol. Rev., 77: 77-96.

Stokke, S and J.T. du Toit, 2002. Sexual segregation in habitat use by elephants in Chobe National Park, Botswana. Afr. J. Ecol., 40: 360-371.

Stevick, P.T., J. Allen, M. Bérubé, P.J. Clapham and S.K. Katona *et al*., 2003. Segregation of migration by feeding ground origin in North Atlantic humpback whales (*Megaptera novaeangliae*). J. Zool. Lond., 259: 231-237.

The IUCN Species Survival Commission, 2004. 2004 the IUCN Red List of Threatened Species. www.redlist.org.