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RESEARCH ARTICLE

Evidence of Effects of Human Disturbance on Alert Response in Père David's Deer (*Elaphurus davidianus*)

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To understand effects of human disturbance on alert response of Père David's deer, we carried out an experiment in the Dafeng Père David's Deer Reserve (32°59′–33°03′N, 120°47′–120°53′E), China. In the spring and summer, we observed alert responses (including stare, walking away, and flee) of deer and recorded the intensity of tourist disturbance in a small display pen using a laser-range finder to measure the alert distance of a free-ranging group in a large enclosure. We also recorded the pattern of head orientation when deer were resting in these two deer groups. After statistical analysis, we found that: 1) in small pen, the frequency of alert response was significantly different among different intensities of human disturbance; strong disturbance resulted in higher frequency of alert response; 2) stare distance in the free-ranging group in summer was significantly longer than that in spring, but the distance of walking away and the distance of flee showed no significant difference between the two seasons; and 3) in free-ranging group, there was no significant directional difference in head orientation, whereas in display group, there was a significant directional difference in head orientation. We suggest that: 1) under the captive situation, human disturbance may be one of the factors that affect alert response in Père David's deer; and 2) Père David's deer adopted different alert response to adapt

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to human disturbance under different circumstance. We recommended that relationships between alert response and human disturbance should be considered in ex situ conservation of this field extinct deer. Zoo Biol 26:461–470, 2007.

Keywords: *Elaphurus davidianus*; alert distance; head orientation; human stimuli; ex situ conservation

INTRODUCTION

Alert response, as indicated by the position of head, movement, or anti-predator signals, is the behavioral response of later vigilance to the risk or potential risk from environments in which the animal lived [LaGory, 1987; Burger, 1997; Lingle and Wilson, 2001]. Although studies of alert response can be helpful in understanding the trade-off of animals [Lingle and Wilson, 2001], the knowledge of relationships between alert response of animals and human disturbance are limited. As reported in Père David's deer (*Elaphurus davidianus*), when vigilance was increasing, the foraging and resting was decreasing [Tang, 2004]. During studies on the relationships between wild animal and human activities, researchers found that stimuli of human disturbance play the same role as predator intrusion toward animal behaviors, and animals perceive human disturbance similarly to predation risk [Walther, 1969; Burger and Gochfeld, 1990; Steidl and Anthony, 2000; Papouchis et al., 2001; Lingle and Wilson, 2001; Frid and Dill, 2002; Fernández-Juricic and Schroeder, 2003].

When animals are conserved in a small reserve, breeding center, or zoo, predation risk for them is low; the alternative pressure was human disturbance [Carlstead, 1996; Gosling and Sutherland, 2002; Mitchell and Hosey, 2005]. In animal conservation practice, scientists and managers have attached importance to the relationship between animal behavior and human disturbance [Papouchis et al., 2001; Ikuta and Blumstein, 2003]. Many studies showed that human disturbance affect voice communication [Gutzwiller et al., 1994], foraging [Verhulst et al., 2001], breeding [Steidl and Anthony, 2000], parental care [Verhulst et al., 2001], and the reproductive success of animals [Phillips and Alldredge, 2000]. Animals adapt to human activities by alert response and vigilance behavior [Burger and Gochfeld, 1990; Papouchis et al., 2001; Fernández-Juricic and Schroeder, 2003; Wang et al., 2004]. Thus, it is important to study the relationships between alert response in animals and human disturbance.

Père David's deer, which lived originally in northeastern and east-central China, Korea, and Japan, is a typical species that was reintroduced from England to China for ex situ conservation in 1980s [Ohtaishi and Gao, 1990; Jiang et al., 2000]. The last wild Père David's deer population was distributed in areas near middle and lower reaches of Yangtze River [Cao et al., 1990]. Père David's deer living now in captive or free-ranging situation become more close to humans than their ancient ancestors [Jiang et al., 2001a]. Research on the behavioral reaction to human disturbance and captive environment has been studied in Père David's deer. Cao et al. [1990] suggested that the captive history of Père David's deer is >200 years, and what they have had to encounter is not predators as carnivores, but stimuli as human disturbance. Jiang et al. [2001a] described the structure, elasticity, and diversity of behavior in Père David's deer, and discussed the relationships among behavior components and environment factors. Li et al. [2006] conducted experiments on behavioral expression of Père David's deer in an artificial environment.

There were, however, no systematical reports on alert response of Père David's deer and the relationship between alert response of Père David's deer and human disturbance. Before their extinction in the wild, Père David's deer were the main animals being hunted by humans [Cao et al., 1990]. We do not know if contemporary Père David's deer adopt anti-predator strategy to response to human disturbance. Moreover, when establishing a new captive population or releasing animals to the field, the effect of human disturbance on behavioral response of Père David's deer was not considered. In this study, we compared the alert response of Père David's deer under different intensity of disturbance between spring and summer in a small pen and a large enclosure. We also investigated the distribution of head orientations when Père David's deer was resting. We focused on the following issues: 1) the relationship between alert response in Père David's deer and intensity of human disturbance; 2) alert distance and its relations to human disturbance in two different seasons; and 3) whether the free-ranging group and display group share the same tactics of head orientation for early detection of intruders. We discuss the implications for ex situ conservation of Père David's deer.

MATERIALS AND METHODS

Study Area and Animals

Dafeng Père David's Deer Nature Reserve (32°59′–33°03′N, 120°47′–120°53′E) was established in 1986. Thirty-nine Père David's deer were reintroduced from England and transferred to the Yellow Sea coastal area of the Dafeng, Jiangsu, China [Jiang et al., 2000]. The area of this reserve was enlarged from 1,000 hectares in 1986 to 2,660 hectares in 1996. Altitude ranges from 2–5 m. Annual average temperature is 14.1°C, with mean temperature of 0.8°C in January and 27°C in July. Average annual precipitation is about 1,068 mm. There are now >700 deer in the reserve that forms a free ranging population and a wild population.

During the summer of 2002 and the spring of 2004, we chose two groups of deer that lived in Dafeng Pére David's Deer Nature Reserve to form our observing objects. One free-ranging group of deer has been living in a large enclosure of 200 hectares since 1986; another was a display group that has been in a small pen of 0.75 hectares for 4 years. Père David's deer in the large enclosure graze on natural vegetation in the summer and autumn and they rely on supplementary feeds in winter and spring. Père David's deer in the small pen are fed daily. Tourists can see the deer in the display pen outside the east and the north side of the fence. In the large enclosure there were 97 deer (27 stags, 41 hinds, 12 sub-adults, and 17 calves) in 2002, and 131 deer (36 stags, 53 hinds, 18 sub-adults, and 24 calves) in 2004. In the small pen, there were 16 deer (5 stags, 6 hinds, 2 sub-adults, and 3 calves) in 2002, and 19 deer (7 stags, 6 hinds, 3 sub-adults, and 3 calves) in 2004.

Behavioral Observation

Alert response and intensity of human disturbance

From February 1–April 30 in 2004, we observed the display group from 06:00–18:00 in the small pen. After 1 day of observation, we took a break for 3 days, and then resumed a new bout of observations. Each observation day, we used scan observation and continuous sampling method to record the alert responses of deer every 15 min from 06:00–18:00 with SJ-1 Event Recorder [Jiang, 1999]. Alert responses we recorded including stare, walking away, and flee [Jiang, 2000]. The total number of observation days for the display group was 22. When we observed the alert response, we also recorded the status of human disturbance. Base on the intensity, we divided human disturbance into:

1. Light disturbance. There were <10 persons near the pen, including observer, feeder, or few visitors who were quiet.
2. Moderate disturbance. There were ≥ 10 persons or quiet visitors near the pen.
3. Strong disturbance. There were ≥ 10 persons or noisy visitors near the pen.

Alert distance in different seasons

From July 1–August 30 (the summer months) in 2002 and from February 1–April 30 (the spring months) in 2004, we recorded alert distances of free-ranging group in the large enclosure. For minimizing habituation of animals to frequent disturbance, we maintained a minimum 6-day interval between consecutive observations on the same group. In each sampling day, we approached deer group twice (one in the morning, another in the afternoon.) and used a laser range finder (Yardagepro 400, Bushnell Performance Optics, Richmond Hill, Ontario) to monitor alert distance of Père David's deer. The total number of approaches was 22 in the summer of 2002 and 30 in the spring of 2004, respectively. When slowly approaching the deer, we recorded the stare distance when 50% individuals in the group noticed us and started to stare. After recording the stare distance, we continued to approach the deer and recorded the distance of walking away when 50% individuals of the deer group we observed started to walk way. The same recording procedure was taken for measuring distance of flee. To avoid group effects, we selected deer group of 30–50 individuals.

Head orientation of resting deer

From February 1 to April 30, 2004, we conducted behavioral observations in the large enclosure and the small pen. We observed each group from 06:00–18:00 daily. After 2 days of observation (one for free-ranging group, another for display group), we suspended the experiment for 2 days and then resumed a new bout of observation. When we found the Père David's deer were resting, we recorded the distribution of their head orientations (i.e., numbers of deer facing the same direction of east, west, south, and north).

Data Analysis

We pooled the frequency of alert responses per 15-min and presented the data as mean $\pm$ SE. When the distribution of behavioral frequencies differed significantly from the normal distribution (one sample Kolmogorov-Smirnov test, $P<0.05$), we used Kruskal-Wallis H-test to check the differences in the frequency of alert response among different intensity of disturbance. The distribution of alert distance was in accord with the normal distribution (one sample Kolmogorov-Smirnov test, $P>0.05$). We used independent sample T-tests to check the difference in alert distance between the spring and summer. In this statistics procedure, we use Levene's test to estimate the equality of variances (when $P > 0.05$, variances were equal, when $P < 0.05$, variances were unequal). The difference at $P < 0.05$ was taken as significant for all statistical tests. When $P > 0.05$, the difference was taken as no significance (NS).

We transferred the data of the head orientation to percentage of deer facing the same direction. We then obtained the variable of the distribution of head orientation that was in accord with the normal distribution (one sample Kolmogorov-Smirnov test, $P > 0.05$). We used one-way ANOVA to check head orientation of Père David's deer in each group among four directions. We then looked into the difference in head orientations between the two groups. If there was no significant difference in head orientations among four directions, we used index of dispersion (i.e., where S^2 is the variance of the variable, is the mean of the variable) to estimate the distribution pattern of head orientation of those group [Pielou, 1960]. When α value was close to 0, the distribution pattern was uniform, and when α value was close to 1, the distribution pattern was random.

RESULTS

Alert Response and Intensity of Human Disturbance

In small pen, behavioral frequencies of stare, walking away, and flee differed significantly among different intensity of disturbance (Kruskal-Wallis *H*-test, for stare, $\chi^2 = 74.748$, $df = 2$, $P < 0.05$; for walking away, $\chi^2 = 35.334$, $df = 2$, $P < 0.05$; for flee, $\chi^2 = 20.565$, $df = 2$, $P < 0.05$) (Fig. 1). The highest value of frequencies of stare, walking away, and flee were all found in intensity of strong disturbance and the lowest value of these three behavior were found in light disturbance (Fig. 1).

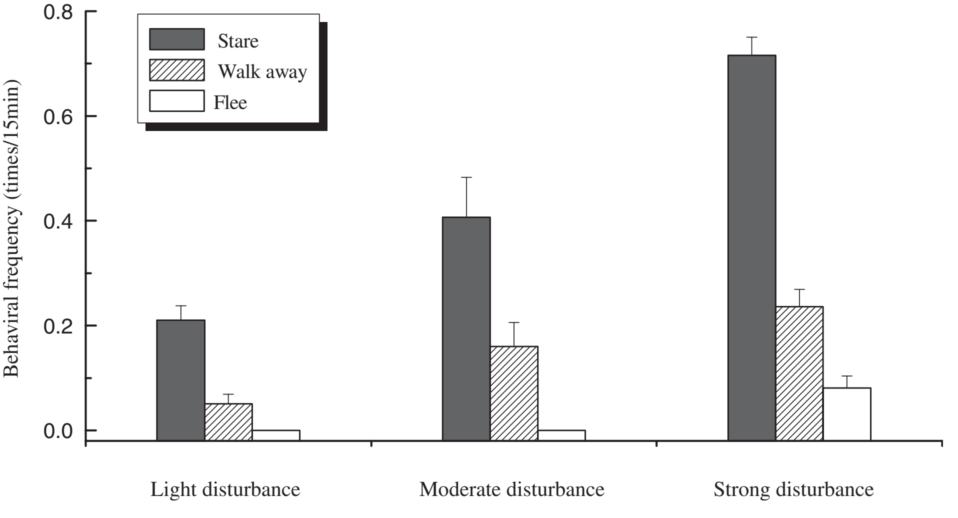

Fig. 1. Alert responses distribution in Père David's deer in small pen under different intensity of disturbance (mean ± SE). Behavioral frequencies of stare, walking away and flee differed significantly among different intensity of disturbance (Kruskal-Wallis *H*-test, for stare, $\chi^2 = 74.748$, $df = 2$, $P < 0.05$; for walking away, $\chi^2 = 35.334$, $df = 2$, $P < 0.05$; for flee, $\chi^2 = 20.565$, $df = 2$, $P < 0.05$).

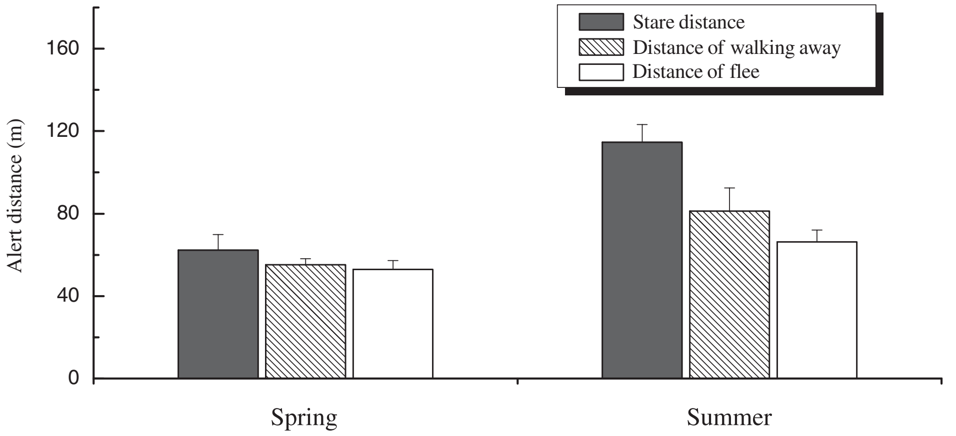

Fig. 2. Alert distances of free-ranging Père David's deer in the spring and the summer (mean $\pm$ SE). Average stare distance in summer was significantly longer than that in spring (independent samples *t*-test, $t = -3.905$, $df = 21$, $P < 0.05$). There were no significant differences of distance of walking away and distance of flee in spring and summer (independent samples *t*-test, for distance of walking, $t = -2.221$, $df = 15.627$, *NS*; for distance of flee, $t = -1.875$, $df = 25$, *NS*).

Alert Distance in Different Seasons

Average stare distance in the summer was significantly longer than that in the spring (independent samples *t*-test, $t = -3.905$, $df = 21$, $P < 0.05$) (Fig. 2). There were no significant differences of distance of walking away and distance of flee between spring and summer (independent samples *t*-test, for distance of walking, $t = -2.221$, $df = 15.627$, *NS*; for distance of flee, $t = -1.875$, $df = 25$, *NS*) (Fig. 2).

Head Orientation in Free-Ranging and Display Group

In the free-ranging group, there was no significant difference in head orientation among four directions (one-way ANOVA, $F_{3,143} = 2.498$, $P > 0.05$) (Fig. 3), whereas there was significant difference in head orientation among four directions in the display group (one-way ANOVA, $F_{3,62} = 7.864$, $P < 0.05$) (Fig. 3). The value of a (0.026) was close to 0 in the free-ranging group, that means the distribution of head orientation is not in accord with random but in accord with uniform.

DISCUSSION

Alert Response and Intensity of Human Disturbance

Our data showed that the occurrence of alert response of Père David's deer (including stare, walking away, and flee) increased with increasing intensity of human disturbance. This result indicates that human disturbance may be one of the factors that affect alert response in display group of Père David's deer. Similar results were also found in other ungulates [Walther, 1969; LaGory, 1987; Del Thompson, 1989; Carlstead et al., 1999; Lingle and Wilson, 2001]. For example, when man approaches Thomson's gazelles (*Gazella thomsoni*), accompanying with

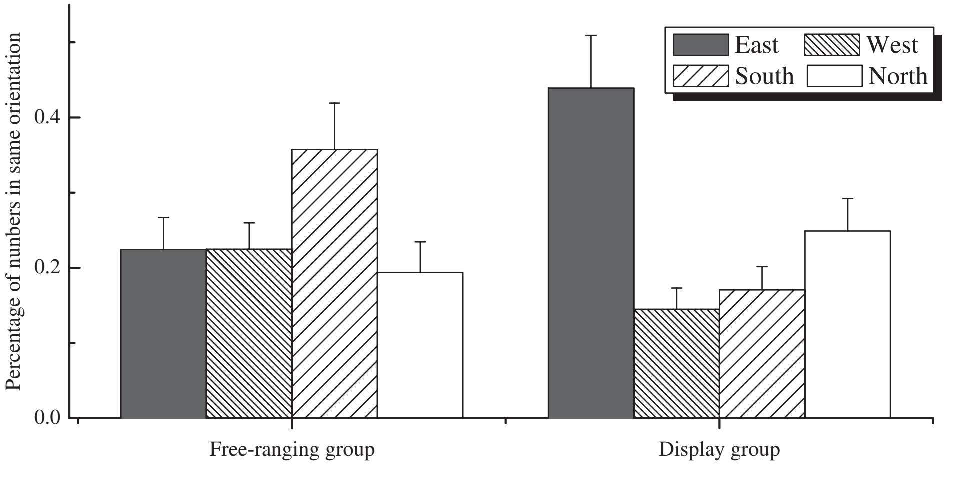

Fig. 3. Head orientation of Père David's deer in free-ranging group and display group (mean $\pm$ SE). In the free-ranging group, there was no significant difference of percentage of numbers in same orientation among for directions (one-way ANOVA, $F_{3,143} = 2.498$, $P > 0.05$), whereas in the display group, it showed significant difference of percentage of numbers in same orientation among for directions (one-way ANOVA, $F_{3,62} = 7.864$, $P < 0.05$).

decrease of distance between human and animals, gazelles modulate their behavioral pattern to alert response sequentially: stare, walk away and flight [Walther, 1969].

It was reported that after estimating intensity of disturbance stimuli, animals reduce effects of human disturbance by corresponding alert [Burger and Gochfeld, 1990]. Wang et al. [2004] did an experiment in Hangzhou, China to investigate the adaptation of local birds to human intrusion and found that most birds change their alert pattern to adapt to different intensity of human intrusion. Frid and Dill [2002] suggested that animals perceive human disturbance similarly to predation risk. When they have detected an intruding human (a potential predator), the animal changes their behavioral pattern to alert response. Our data suggested that Père David's deer adopt the behavioral tactics to response to human disturbance accordingly.

Alert Distance in Different Seasons

With the same experimental treatment (Materials and Methods), we found that stare distance of Père David's deer in the summer was significantly greater than that in the spring. In addition, the interval between two seasons is >5 months. It seems unlikely that this difference is due to habituation. Presumably, the reason for this result was because Père David's deer in the large enclosure graze on supplementary feeds in the spring, whereas they graze on natural vegetation in summer. Therefore, they keep their stare distance farther in the summer than in the spring. Taylor and Knight [2003] found that alert distances in bison (*Bison bison*), mule deer (*Odocoileus hemionus*), and pronghorn antelope (*Antilocapra americana*) were greater during morning than during evening. Similar results were also found in moose (*Alces alces*) and elk (*Cervus elephus*) [Altmann, 1958]. Taylor and Knight [2003] suggested that greater tolerance of human disturbance during the evening is related to the importance of evening as a feeding period during the hot summer. Based on our result, we drew a similar conclusion: For obtaining supplied food from humans, Père David's deer reduce alert distance to human stimuli.

Besides the different feeding pattern, the presence of calves in spring was noticeable. The calving season begins in mid-February in the Dafeng Père David's Deer Reserve [Liang et al., 1993]. During spring months in 2004, 24 deer calves were born in the free-ranging group in succession. Some studies showed that deer groups with newborns are more vigilant with greater alert distance than those without newborns [White and Berger, 2001; Wolff and Van Horn, 2003] because hinds tend to be more vigilant but less tolerance of intruder disturbance during the birth period. Stare distance of Père David's deer during birth period was significantly closer than that in the summer. We conclude that the trade-off between anti-predator and parental care are adjusted by animals to match the needs for food.

There were no significant differences of distance of walking away and distance of flee between the spring and the summer. Père David's deer keep the same distance of walking away and flee all the time. Flight distance may be the baseline of tolerance of human stimuli for Père David's deer.

Head Orientation and Human Disturbance

Head orientation, as an estimator of gaze, is considered to be a function for early detection of predators [Formozov, 1966; Land, 1999; Franklin and Lima, 2001; Dawkins, 2002]. Our data indicated that head orientations in resting Père David's deer were different between free-ranging group and display group. When they were resting, Père David's deer in free-ranging group tended to all directions with a uniform distribution. However, more deer were found to face to the east and north directions in the display group. We suggest that for detecting intruders quickly, Père David's deer in the large enclosure oriented their heads evenly in all directions, but when they live in the small display pen, the frequent disturbance of visitors makes them face to the east and the north with high frequency.

Group living in animals is believed to confer advantages related to a decrease in predation risk [Krebs and Davies, 1993]. An interesting viewpoint is that group vigilance can increase eyes or ears of each individual, so that they can detect predators easily [Kenward, 1978; Blumstein and Daniel, 2003]. Père David's deer usually live in groups [Wemmer, 1983; Jiang et al., 2000]. Li et al. [2006] also found that Père David's deer tend to choose bare land and water area with low plant coverage for resting, and suggested that it may relate to the easy detection of intruders. Combining with our present findings, we believe that uniform distribution of head orientation increases the probability of early detection of intruders in Père David's deer. Frequent disturbance from specific fixed directions may affect the distribution pattern of head orientation.

Additionally, there is another variation of distribution of head orientation in grouping animals. In some animals, more individuals prefer to face toward the shelter. For example, more individual harbor seals (*Phoca vitulina*) face the sea, this ensures that they can return to the sea quickly after detection of predators [Terhune and Brillant, 1996].

Implications for Animal Conservation

No matter where they live (natural distributed area, nature reserve, breeding center, or zoo), animals cannot avoid the disturbance of human activities [Carlstead, 1996]. Although there are divergences of opinion on the relation of human disturbance and behavioral response of animals, people take notice of the relation between animal conservation and human disturbance in recent years. Worchel and Shebilske [1986] pointed out that because animals and human were close with each other, their spatial and mental tolerance distance became short, animal would fall into tension status. Previous studies suggested that human disturbance is a type of stimuli that brings such negative effects as stress to animals [Lima and Dill, 1990; Gutzwiller et al., 1994; Steidl and Anthony, 2000; Frid and Dill, 2002]. To protect birds from human disturbance, for example, people have tried to enact a bylaw or build fences for restricting tourist access to the living habitat of birds [Burger and Gochfeld, 1999; Ikuta and Blumstein, 2003]. However, the patterns of alert response are different in various animal species. When people try to build a partition, they should consider this interspecific difference [Fernández-Juricic and Schroeder, 2003].

Reintroduction of Père David's deer was a successful case in ex situ conservation [Jiang et al., 2000], but the growth of captive Père David's deer populations showed density-dependent patterns [Jiang et al., 2001b]. We need to establish new captive populations or release the captive bred Père David's deer to establish wild populations. Our study showed that despite of long-term captive breeding, Père David's deer still carry out alert response to human disturbance. To some extent, difference of alert response between free-ranging group and display group may mirror the differences between animals in artificial environment versus those in the field. We suggest that whether we establish new captive populations or establish wild populations, it is necessary to learn more about human impact on the behavior of Père David's deer and their adaptation of alert response to human disturbance.

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