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Short Communication

Vigilance of the Demoiselle Crane *Antropoides virgo*: The Effects of Group Size, Human Disturbance, and Predation Vulnerability

Feng Xu[1,2,3]*, Weikang Yang[1,2,3]*, Ming Ma[1,2,3] and David A. Blank[4]

[1]CAS Key Laboratory of Biogeography and Bioresource in Arid Land, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi, 830011, China
[2]Mori Wildlife Monitoring and Experimentation Station, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Mori, 831900, China
[3]University of Chinese Academy of Sciences, Beijing, 100049, China
[4]CAS Research Center for Ecology and Environment of Central Asia, Bishkek, 720001, Kyrgyzstan

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FX, MM and WYK conceived and designed the experiments. FX performed the experiments. FX and DB analyzed the data. FX, MM, WYK and DB wrote the paper.

Key words
***Antropoides virgo*, Group size effect, Group scan level, Group scan frequency, Vigilance.**

ABSTRACT

Vigilance was defined as the behavior for increasing probability of detecting and recognizing a predator before being detected themselves. Group size, human disturbance, environment factors, body size of a prey and a predator, season, traits of species and numbers of others factors were thought to have significant impacts on vigilance. Here, in this study we considered only three of them: group size, disturbance, and predation vulnerability and their impact on the vigilance of the Demoiselle crane (*Antropoides virgo*). Our results showed that group size, human disturbance, and predation vulnerability significantly affect Demoiselle crane's vigilance. With increasing of group size, the percentage of scanning time by one individual at least in the group increased, while the proportion of vigilant individuals in the group decreased. The group size effect was supported by our study of vigilance in Demoiselle crane and the cranes gained vigilance benefits from increasing their group size. And when the cranes in strong human disturbance area closer to the road, they devoted significantly more time to their vigilance. The significant relationship between crane vigilance and group size might be explained by the high population density and big intraspecific competitions for resources.

Vigilance is often directed towards detecting predators and assessment of the threat level (Krause and Ruxton, 2002). Many social and environmental factors were assumed to have impacts on the vigilance behavior, such as group size, predation vulnerability, habitat type (open, closed), forage strategy, social status, proximity of refuge area, time of day, season and ambient temperature and even distance to the nearest neighbor, as well as human disturbance (Underwood, 1982; Quenette, 1990; Eby and Ritchie, 2013). The negative relationship between group size and vigilance is one of the most discussed topics in antipredator behavior of many species of birds and mammals, and this relationship has been termed as the group size effect (Elgar, 1989; Roberts, 1996; Xu *et al*., 2010, 2013; Wang *et al*., 2015). There are three main hypotheses proposed to explain this effect: the scramble competition hypothesis (Beauchamp and Ruxton, 2003; Clark and Mangel, 1986), the many-eyes hypothesis (Pulliam, 1973), and the safety in numbers hypothesis (Foster and Treherne, 1981). The scramble competition hypothesis emphasizes the impact of food competition on vigilance level. Living individuals in large groups should allocate more time for food competition than other behaviours such as vigilance. While the many-eyes hypothesis and safety in number hypothesis emphasize the role of predation risk in shaping vigilance levels. Although the group size effect has been demonstrated for many birds and mammals, it was not found in the Rock Mountain elk *Cervus elaphus* (Laundre *et al*., 2001) and Giraffes *Giraffa camelopardalis* (Cameron and Du Toit, 2005). Therefore, it is still not everything clear in the impact of group size on vigilance behavior.

Black-Necked Crane *Grus nigricollis*, increased their vigilance level under high predation risk (Xu *et al*., 2013), and the mother Przewalski's gazelle *Procapra przewalskii* also increased their scanning behavior when they stay with the lambs (Li *et al*., 2009). However, the relationship between vigilance and predation vulnerability is not always consistent (Berger and Cunningham, 1988; Cameron and Du Toit, 2005). Thus, more researches are

* Corresponding authors: xufeng@ms.xjb.ac.cn; yangwk@ms.xjb.ac.cn
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needed to explore whether predation vulnerability affects vigilance.

In addition to group size and predation risk, human disturbance also plays an important role in shaping vigilance behavior (Wang *et al*., 2011; Li *et al*., 2015; Wang *et al*., 2016). In Hooded Crane *Grus monacha* and Red-crowned Crane *Grus japonensis*, individuals, living in buffer zone outside of the core area of the nature reserve had significant high vigilance level (Wang *et al*., 2011; Li *et al*., 2015). The research in Khulan *Equus hemionus* found the similar results (Wang *et al*., 2016). So the human disturbance should also be considered when studying vigilance behavior.

Demoiselle crane *Anthropoides virgo* is a species which has an extremely large range and big population (BirdLife, 2016) throughout the world, but its population and distribution range in China is limited. It is a Category II National Protected Wild Animal Species in China since 1989. There are some studies addressing the biology and ecology of this species (Goncharova *et al*., 2015; BirdLife, 2016; Klenova *et al*., 2014; Sarwar *et al*., 2013), but until now there were no studies related with vigilance behavior of the Demoiselle crane. Understanding the vigilance behavior of Demoiselle crane will not only help us to protect this species, but also help us to understand how the social and environmental factors affect animal vigilance behavior.

Materials and methods

This study was conducted near the Balikun Lake, Xinjiang Province, Northwestern China. This area is on the migration route of many species of water birds, such as Demoiselle crane, Common crane *Grus grus*, and Whooper swan *Cygnus cygnus* (Ma, 2011). The climate and vegetation here in the study area is the typical central type, its cold in the winter and warm in the summer (Ma, 2011). And the Balikun Lake is a good stopover sites for migration Demoiselle crane. During the migration season, thousands of Demoiselle crane can be found on the grassland around the lake. There is a paved highway about 1 km far away from the lake, and the Demoiselle crane can be easily found on the grassland between the highway and the lake. It provides us the opportunity to carry out this study.

The basic social unit of Demoiselle crane is a family, several of which gather into a group. A family consists of two adults with or without juveniles. Because the males and females Demoiselle crane have similar body size and plumage color, so we did not distinguish the sex. Crane groups were classified into two social categories: adults with young and adults without young. The group of cranes consisted of two or more individuals occurring within 30 m of each other (Wang *et al*., 2011; Xu *et al*., 2013). Young animal are generally more prone to be attacked by predators compared to adults for many species (Li *et al*., 2009), so in this study crane groups consisting of adults with young were defined as high predation risk, and groups from only adults were consisted as low predation risk (Xu *et al*., 2013).

Behavior observation was carried out using the group scan sampling method (Martin and Bateson, 1993) during October 2012 from 8:00 to 20:00 hours. Target groups were randomly selected and observed using a telescope (20-60×85). One session was defined as a period from when a group was first found to when the group size changed or the group disappeared. Observation sessions less than 6 scans were discarded. Crane activities were recorded by scanning groups at 10 min intervals, and all observations were recorded by the same person. We avoided group re-sampling by observing the groups over a long distance, and this allowed us to ensure spatial independence between groups sampled in the same day. Crane behavior was divided into six categories: vigilance, feeding, preening, locomotion, fighting and others (Xu *et al*., 2013; Yang *et al*., 2007). And vigilance refers to a crane stretching the head upwards while standing and walking or scanning (Wang *et al*., 2011). Group vigilance was estimated using group scan level (GSL) and frequency (GSF). Group scan level was calculated as the percentage of individuals within the group that were engaged in scanning behavior during a session. It reflected the level of individual vigilance. Group scan frequency was measured as the proportion of time that at least one bird of the group was vigilant and it reflected the group vigilance or collective detection (Fernandez *et al*., 2003). The group size of Demoiselle crane in this study ranged from 2-26, with a median of 6.48; the duration of the observation session ranged from 30-160 min with a median of 99.2 min. In total, we collected data from 43 groups of Demoiselle crane and conducted 4170 min of observation.

Highway has many negative effects on birds and distance from the highway was an indicator reflecting the human disturbance. In this study we also used the distance to the highway to define the human disturbance, distinguishing 3 levels: high human disturbance (less than 100 m), medium human disturbance (100-300 m), and low human disturbance (more than 300 m).

The data of group scan level and group scan frequency were arcsine square-root transformed, and the data of group size was log transformed, and then all of these data were tested for normality with one-sample Kolmogorov-Smirnov tests. Group scan frequency and group scan level differences of groups between different levels of predator vulnerability were compared using

t-tests, and different levels of distance to the highway were compared using one-way ANOVA. We used ANCOVA to test for effects of group size, distance to the highway, and predator vulnerability on vigilance level (Xu *et al*., 2013). Significant differences were indicated by P≤0.05, and all data were analyzed using the SPSS 19.0 statistical package (SPSS, 2010).

Table I.- Comparison of group scan level and frequency of different level of predation risk of the *Antropoides virgo* and it's distance to highway.

	Group scan level		Group scan frequency	
	Mean±SD	P	Mean±SD	P
Predation vulnerability (t-tests)				
LPV	42.6±9.1	P=0.004*	48.6±13.3	P=0.017*
HPV	50.5±11.3		37.5±5.7	
Distance to highway (one way ANOVA)				
<100 m	56.1±12.1	*F*=0.221, P=0.004*	44.4±9.8	*F*=6.471, P=0.803
100 - 300 m	42.2±7.9		46.3±10.1	
>300 m	43.3±9.2		43.4±15.1	

LPV, Low predation vulnerability; HPV, Low predation vulnerability.

Table II.- Results of ANCOVA to test variation in proportion of individuals scanning (group scan level) and proportion of the time that at least one individual was scanning (group scan frequency) with group size, distance to highway, and predation vulnerability. The models of group scan level and group scan frequency were all highly significant (group scan level: F4,41=8.1, P<0.001, adjusted R2=0.708; group scan frequency: F4,41=10.7, P<0.001, adjusted R2=0.768).

Source	df	Group scan level		Group scan frequency	
		f	P	f	P
Intercept	1	146.6	<0.001*	227.1	<0.001*
Group size	12	-6.6	<0.001*	9.5	<0.001*
Predation vulnerability	1	3.9	= 0.059	0.7	= 0.419
Distance to highway	1	-6.1	= 0.02*	19.1	<0.001*

Results

The results showed that predation risk had significant effects on both group scan level and frequency. Groups with low predation risk had low group scan level (Mean ± SD = 42.6 ± 9.1, P = 0.004) and high group scan frequency (Mean ± SD = 48.6 ± 13.3, P = 0.017) (Table I). Distance to highway only affected group scan level (Mean ± SD = 56.1 ± 12.1, *F* = 0.221, P = 0.004) but not group scan frequency ((Mean ± SD = 44.4±9.8, *F* = 6.471, P = 0.803) (Table I). And groups near the highway (<100 m) had significant higher group scan level than those far away (Table I). These results reflected the human disturbance effects on the Demoiselle crane's vigilance.

The results of ANCOVA showed that both the group size and distance to the highway significantly affected the vigilance level (Table II). As the group size increased, group scan frequency increased significantly and the group scan level decreased. These results provided supports for the group size effects for Demoiselle crane (Table II).

Discussion

Our results found that group size had a significant effect on vigilance of Demoiselle crane at both the group scan level and group scan frequency. Both the predation pressure and resources competition can shape the group size effect on vigilance, and in this study the group size effect might be explained by resource competition. The study area is a suitable site for migratory water birds, and every autumn thousands of Demoiselle crane stay here for more than 7 days (Ma, 2011). With the high density of cranes in limit range, the pressure of food resources competition is high for Demoiselle crane. Besides that, the predation pressure of the Demoiselle crane in the study area is relatively low. Since the Balikun Lake is close to the county and the highway, the predators of Demoiselle crane are very seldom seen in this area. So the group size effect on vigilance behavior in this study might be the food resources competition.

We also found that when the Demoiselle crane were near the highway, their vigilance levels are significant higher than those far away from the highway. This result showed the human disturbance effects on vigilance behavior and it consist with some previous studies such as in red-crowned cranes *Grus japonesis* (Wang *et al*., 2011) and great bustard *Otis tarda* (Wang *et al*., 2015). In recent years human disturbance effect on wildlife behavior attracted more and more concerns. The human disturbances can have a significant effect on vigilance behavior (Wang *et al*., 2011, 2015), foraging efficiency (Burger and Gochfeld, 1991), and breeding success (Parsons and Burger, 1982). Therefore, the human disturbance effects should be considered for vigilance behavior research in the future.

Groups with juveniles are usually considered as more vulnerable. Some studies found for these vulnerable groups' vigilance level was relatively higher (Li *et al*., 2009; Xu *et al*., 2013). And in this study we found similar results: adults Demoiselle crane with young were more vigilant than adults without juveniles. Although the predator pressure were relatively low in the study area, the human disturbance had significant effect on crane's vigilance. Under this situation the adult Demoiselle crane with young needed to pay more attention on their juvenile's

safety than other adults without juveniles.

Conclusion

In conclusion, group size effect was supported by our data. Group size had a positive relationship with group scan frequency and negative relationship with group scan level. Human disturbance and predation vulnerability also had significant impact on the Demoiselle crane's vigilance behavior. In high disturbance area the cranes were vigilant more than those in low disturbance area. Therefore, group size effect and human disturbance are important factors for vigilance behavior of Demoiselle crane, and these two factors should be considered in future vigilance behaviors study.

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Statement of conflict of interests

The authors declare that there is no conflict of interests regarding the publication of this article.

References

Beauchamp, G. and Ruxton, G.D., 2003. *Am. Natural.,* **161**: 672-675. https://doi.org/10.1086/368225

Berger, J. and Cunningham, C., 1988. *Ecology,* **69**: 177-183. https://doi.org/10.2307/1943172

BirdLife, 2016. *Species factsheet:* Anthropoides virgo. BirdLife International. Downloaded from http://www.birdlife.org (07/03/2016).

Burger, J. and Gochfeld, M., 1991. *Condor,* **93**: 259-265. https://doi.org/10.2307/1368941

Cameron, E.Z. and du Toit, J.T., 2005. *Anim. Behav.,* **69**: 1337-1344. https://doi.org/10.1016/j.anbehav.2004.08.015

Clark, C.W. and Mangel, M., 1986. *Theoret. Popul. Biol.,* **30**: 45-75. https://doi.org/10.1016/0040-5809(86)90024-9

Elgar, M.A., 1989. *Biol. Rev. Cambridge Philos. Soc.,* **64**: 13-33. https://doi.org/10.1111/j.1469-185X.1989.tb00636.x

Fernandez, G.J., Capurro, A.F. and Reboreda, J.C., 2003. *Ethology,* **109**: 413-425. https://doi.org/10.1046/j.1439-0310.2003.00887.x

Foster, W.A. and Treherne, J.E., 1981. *Nature,* **293**: 466-467. https://doi.org/10.1038/293466a0

Goncharova, M.V., Klenova, A.V. and Bragina, E.V., 2015. *J. Ethol.,* **33**: 165-175. https://doi.org/10.1007/s10164-015-0428-6

Klenova, A.V., Goncharova, M.V., Bragina, E.V. and Kashentseva, T.A., 2014. *Bioacoustics- Int. J. Anim. Sound Record.,* **23**: 247-265. https://doi.org/10.1080/09524622.2014.900648

Krause, J. and Ruxton, G.D., 2002. *Living in groups*. Oxford University Press, New York.

Laundre, J.W., Hernandez, L. and Altendorf, K.B., 2001. *Canadian J. Zool.,* **79**: 1401-1409. https://doi.org/10.1139/z01-094

Li, C.L., Zhou, L.Z., Xu, L., Zhao, N.N. and Beauchamp, G., 2015. *PLoS One,* **10**: 0118928. https://doi.org/10.1371/journal.pone.0118928

Li, Z., Jiang, Z. and Beauchamp, G., 2009. *J. Zool.,* **277**: 302-308. https://doi.org/10.1111/j.1469-7998.2008.00541.x

Ma, M., 2011. *A checklist on the distribution of the birds in Xinjiang*. Science Press, Beijing.

Martin, P. and Bateson, P., 1993. *Measuring behavior: An introductory guide*. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9781139168342

Parsons, K.C. and Burger, J., 1982. *Condor,* **84**: 184-187. https://doi.org/10.2307/1367667

Pulliam, H.R., 1973. *J. Theoret. Biol.,* **38**: 419-422. https://doi.org/10.1016/0022-5193(73)90184-7

Roberts, G., 1996. *Anim. Behav.,* **51**: 1077-1086. https://doi.org/10.1006/anbe.1996.0109

Sarwar, M., Hussain, I., Khan, A. and Anwar, M., 2013. *Avian Biol. Res.,* **6**: 269-274. https://doi.org/10.3184/175815513X13802893287049

SPSS, 2010. *IBM SPSS statistics for windows,* Version 19.0. IBM Corp., Armonk, NY.

Wang, M.Y., Chen, Q., Kuerbanjiang, H., Xu, F., Blank, D. and Yang, W.K., 2015. *Bird Study,* **62**:438-442. https://doi.org/10.1080/00063657.2015.1047736

Wang, M.Y., Ruckstuhl, K.E., Xu, W.X., Blank, D. and Yang, W.K., 2016. *PLoS One,* **11**: 0146725. https://doi.org/10.1371/journal.pone.0146725

Wang, Z., Li, Z.Q., Beauchamp, G. and Jiang, Z.G., 2011. *Biol. Conserv.,* **144**: 101-105. https://doi.org/10.1016/j.biocon.2010.06.025

Xu, F., Ma, M. and Wu, Y.Q., 2010. *Folia Zool.,* **59**: 308-312. https://doi.org/10.25225/fozo.v59.i4.a6.2010

Xu, F., Ma, M., Yang, W.K., Blank, D., Ding, P. and Zhang, T., 2013. *Wilson J. Ornithol.,* **125**: 208-212. https://doi.org/10.1676/12-049.1

Yang, R., Wu, H.Q., Yang, X.J., Jiang, W.G., Zuo, L. and Xiang, Z.R., 2007. *Waterbirds,* **30**: 80-85. https://doi.org/10.1675/1524-4695(2007)030[0080:DTBOTB]2.0.CO;2