

## Vigilance Synchrony in Overwintering Black-necked Crane Family Groups in Lhasa, Tibet: Postprint

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### Abstract

Previous studies on animal vigilance behavior have predominantly been based on the classical random independent model; however, recent theoretical and empirical research has challenged this model. Depending on the degree of synchrony in vigilance behavior, collective vigilance may manifest in two patterns: mimicry-based synchronous vigilance and coordination-based vigilance to avoid redundancy. This study examined the vigilance behavior of wintering black-necked crane family groups in the Yarlung Tsangpo Nature Reserve, China. Independent samples t-tests were employed to verify differences in individual vigilance levels attributable to age and the presence of offspring, one-way ANOVA was used to compare collective vigilance levels across different types of family groups, and paired t-tests were utilized to compare observed collective vigilance values with expected values under the independence assumption, thereby determining the vigilance synchrony of wintering black-necked crane family groups. The results demonstrated that juvenile black-necked cranes in family groups exhibited significantly lower vigilance time than adult black-necked cranes, but the presence of young did not significantly influence the vigilance level of adults. No differences were found in collective vigilance levels among different types of black-necked crane family groups, yet they did not display synchronous vigilance as anticipated. Vigilance behavior patterns represent adaptive expressions of animals in specific environments. The habitat of wintering black-necked cranes lacks predators employing a lagged-target strategy and high-intensity predation risk, which may be insufficient to elicit high-intensity vigilance synchrony whose primary function is predation risk reduction. Concurrently, the priority of food acquisition during the resource-scarce winter may also diminish the need for synchronous vigilance.

## Full Text

# Vigilance Synchronization of Wintering Black-Necked Crane Families in Tibet

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## Abstract

Most previous studies of animal vigilance behavior have been based on Pulliam's classical random independent model, which posits that individuals scan their environment independently and that one individual's vigilance state does not influence others in the group. However, recent theoretical and empirical research has challenged this model, demonstrating that collective vigilance can manifest as either imitation-based synchronized vigilance or overlapping-avoidance coordinated vigilance, depending on the degree of synchronization among group members.

In this study, we investigated the vigilance behavior of wintering black-necked crane (*Grus nigricollis*) families in the Yarlung Zangbo River National Nature Reserve in Tibet. The black-necked crane is a globally endangered species endemic to the Tibetan Plateau. We recorded video footage in the field and scanned 30-second intervals to document individual and collective vigilance behavior. Using independent samples t-tests, we examined how age and parental status affected individual vigilance levels. One-way ANOVA was used to compare collective vigilance levels across different family types, while paired t-tests compared observed collective vigilance values with those predicted under the assumption of independence to determine the degree of vigilance synchronization in wintering crane families.

The results showed that juvenile black-necked cranes spent significantly less time in vigilance than adults, primarily due to their lack of vigilance and foraging experience, which necessitates greater feeding time to meet energetic and developmental requirements. However, the presence of juveniles in family groups had no significant effect on adult vigilance levels. Furthermore, while there were no differences in collective vigilance levels among different types of crane families, the observed values did not indicate synchronized vigilance as predicted. Vigilance patterns represent adaptive behaviors in specific environments. In the wintering habitat of black-necked cranes, there are no lagging-target predators, and predation risk is insufficient to induce high-intensity vigilance synchronization primarily functioning to reduce predation risk. Additionally, during

resource-scarce winters, the priority of food acquisition may weaken the need for synchronized vigilance.

**Keywords:** black-necked cranes; collective vigilance; vigilance synchronization; synchronized vigilance; coordinated vigilance

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## 1. Study Site

The study was conducted in the Yarlung Zangbo River Middle Reaches Black-Necked Crane National Nature Reserve in Linzhou County, Lhasa, Tibet Autonomous Region, China (28°40′–30°17′ N, 87°34′–91°54′ E). The area features a plateau temperate semi-arid monsoon climate at an elevation of 3500–4500 m, characterized by cool summers, no high temperatures, distinct wet and dry seasons, and occasional winter snowfall. The natural vegetation consists primarily of alpine meadows dominated by *Aristida trisetata*, *Orinus thoroldii*, *Sophora moorcroftiana*, *Pennisetum centrasiaticum*, and *Stipa purpurea*, accompanied by *Ceratostigma minus*. In addition to natural vegetation, the region includes farmland where highland barley and wheat are cultivated. Agricultural fields serve as the primary area for observing wintering black-necked crane behavior, with leftover grains from harvests constituting their main food source.

## 2. Study Species

The black-necked crane is a nationally protected first-class species and a globally endangered bird, unique in that both its breeding and wintering periods are spent on the plateau. Its main breeding grounds include the Qinghai-Tibet Plateau and adjacent regions, while wintering areas are distributed primarily across southern Tibet, India, and Bhutan. In the Yarlung Zangbo River National Nature Reserve, black-necked cranes arrive from breeding grounds in early November and depart in early April. Wintering habitat vegetation types include valley shrublands and farmland. Common flocking patterns include conspecific flocks and mixed-species flocks. Family groups consist of two adult cranes and one or two juveniles. Conspecific flocks comprise non-breeding individuals or several families, while mixed-species flocks involve black-necked cranes grouping with grey cranes, common cranes, or ruddy shelducks. Juvenile cranes are similar in size to adults but show distinct plumage differences, making them easily distinguishable.

## 3. Data Collection

We located black-necked crane families by walking or driving along different routes, typically maintaining a distance of 200–400 m from flocks to minimize disturbance while ensuring video clarity. Upon locating target families, we used a Sony CX270 video camera to record behavior from 8:00 to 19:00. We documented sampling time, flock size, family composition type, and any obvious disturbances such as livestock startling the cranes or noisy tractors passing by.

Recording was terminated early if flock composition changed, if cranes took flight, or if severe weather (snow, etc.) occurred. To avoid pseudoreplication, we did not resample the same family on the same day.

#### 4. Data Analysis

We analyzed video samples exceeding 20 minutes in duration, replaying footage and using focal animal and scan sampling methods to quantify individual and collective vigilance levels. We scanned at 30-second intervals, recording for each individual  $k$  the proportion of scans in which the focal animal was vigilant, denoted as  $p$ . Vigilance was defined as when a crane stopped foraging, extended its neck upward, and looked around the environment. For each family, observed collective vigilance level was calculated as the proportion of scans in which at least one individual was vigilant. To ensure data normality, we applied a square-root transformation.

We used independent samples t-tests to compare vigilance levels between adults and juveniles, and between adults with and without offspring. To test whether individual vigilance was influenced by other family members and whether wintering crane families employed synchronized or coordinated vigilance, we compared observed collective vigilance values with expected values calculated under the assumption of independence. The expected value formula was:

$$V_{\text{exp}} = 1 - \prod(1 - p_k)$$

where  $p$  represents the vigilance time proportion of individual  $k$ , and  $n$  represents group size. We calculated  $n$  in two ways: (1) considering only adult cranes in the family, and (2) considering all individuals in the family. When calculating observed values, we similarly used two criteria: at least one adult vigilant, or at least one individual vigilant. This ensured consistency between observed and expected values. We used paired t-tests to compare  $V_{\text{obs}}$  and  $V_{\text{exp}}$ . If observed values were significantly greater than expected, it would indicate individuals tended to avoid overlapping vigilance bouts (coordinated vigilance). If observed values were significantly less than expected, it would indicate individuals tended to mimic companions' vigilance (synchronized vigilance). No significant difference would suggest independent scanning. We also randomly selected one adult and one juvenile per family to compare synchronization between them. All analyses were conducted using SPSS 18.0, with significance set at  $P = 0.05$ . Data are presented as mean  $\pm$  SE from untransformed values.

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#### 5. Results

**5.1 Sampling Summary** We filmed 42 wintering black-necked crane families with a total recording time of 1604.83 minutes (range: 4.4-35.3 minutes per family). Videos with continuous, unobstructed footage exceeding 20 minutes

(mean:  $25.9 \pm 1.1$  minutes) were used for scanning. The sample included two-adult families (61.9%), two-adult-one-juvenile families (33%), and two-adult-two-juvenile families (4.9%). Individual scanning totaled 3121.5 minutes ( $28.2 \pm 0.5$  minutes per crane).

**5.2 Individual Vigilance** Independent samples t-tests revealed that adult black-necked cranes spent significantly more time in vigilance ( $0.199 \pm 0.014$ ) than juveniles ( $0.074 \pm 0.011$ ;  $t = 6.495$ ,  $P < 0.001$ ). In families with juveniles, adults spent  $0.210 \pm 0.017$  of their time vigilant, slightly higher than adults without juveniles ( $0.178 \pm 0.024$ ), but this difference was not significant ( $t = 1.093$ ,  $P = 0.278$ ).

**5.3 Collective Vigilance Synchronization** One-way ANOVA showed no significant differences in collective vigilance levels among the three family types, whether considering only adults ( $F = 1.712$ ,  $P = 0.195$ ) or all individuals including juveniles ( $F = 2.876$ ,  $P = 0.069$ ) [Figure 1: see original paper].

Comparisons between observed and expected collective vigilance values revealed no significant differences. Whether considering only adults within families ( $V = 0.357 \pm 0.030$ ,  $V = 0.349 \pm 0.028$ ;  $t = 0.770$ ,  $P = 0.446$ ), all individuals ( $V = 0.387 \pm 0.028$ ,  $V = 0.385 \pm 0.030$ ;  $t = -0.734$ ,  $P = 0.470$ ), or between adults and juveniles within families ( $V = 0.269 \pm 0.025$ ,  $V = 0.262 \pm 0.023$ ;  $t = -0.760$ ,  $P = 0.452$ ), paired t-tests showed no significant deviations from independence [Figure 2: see original paper].

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## 6. Discussion

**6.1 Individual Vigilance Levels** As expected, we found that juvenile black-necked cranes in family groups spent significantly less time in vigilance than adults, consistent with studies on wintering black-necked cranes in Yunnan and with research on red-crowned and hooded cranes. This pattern relates to juveniles' insufficient experience in vigilance and predator escape, lower foraging efficiency, and the need to spend more time feeding to meet growth requirements. Previous research has demonstrated that predation vulnerability affects vigilance intensity in black-necked cranes, with groups containing juveniles (high predation vulnerability) showing more vigilant adults than groups without juveniles (low predation vulnerability). However, our study found no effect of juvenile presence on adult vigilance levels within families. This discrepancy may be explained by differences in juvenile age and the primary source of vigilance motivation. The previous study was conducted in September during the breeding season when juveniles were approximately three months old and faced substantial predation risk, necessitating parental care. In contrast, our wintering-season juveniles were about eight months old, nearly adult-sized. Furthermore, the previous study area was a protected core zone with minimal human disturbance,

where predation risk was the primary vigilance driver, creating a predation vulnerability difference between adults with and without young. Our study area comprised agricultural land with human activity as the main disturbance source, affecting all family types similarly and universally, thus eliminating differences in adult vigilance based on juvenile presence.

**6.2 Collective Vigilance Synchronization** Numerous studies have shown that individual vigilance within groups is not independent but is adjusted through imitation or overlap avoidance, resulting in synchronized or coordinated collective vigilance patterns. Synchronized vigilance involves individuals mimicking neighbors' vigilance states, producing more periods when no group member is vigilant and resulting in collective vigilance levels lower than predicted under independence. This pattern, while not enhancing collective vigilance, reduces individual predation risk and facilitates shared risk assessment. Coordinated vigilance involves individuals avoiding overlapping vigilance bouts, yielding collective vigilance levels higher than expected and effectively reducing the proportion of vigilance gaps. Coordination is efficient but costly, as enhancing collective vigilance requires individuals to constantly monitor companions and adjust behavior accordingly.

Our study did not find the expected synchronization tendency in wintering black-necked crane families, likely for multiple reasons. When food availability becomes critical for survival, energy acquisition takes precedence over safety assurance, and the resulting competition or urgent foraging needs reduce vigilance levels, consequently diminishing vigilance synchronization. This occurs because synchronization depends on baseline vigilance levels; when individual vigilance is already reduced during food-scarce winters, synchronization decreases accordingly. The priority of food acquisition also weakens the predation-risk-reduction function of synchronized vigilance.

Post-harvest agricultural activities, cultivation, and livestock grazing limit the availability of leftover grains that black-necked cranes depend upon during winter. Consequently, food-scarce wintering families likely fail to exhibit synchronized vigilance due to both reduced baseline vigilance and the primacy of foraging demands.

Vigilance primarily functions to detect potential threats and avoid predation, while both synchronized and coordinated vigilance represent adaptive patterns associated with specific environments and predation risks. Individuals detecting predators earlier have higher escape probabilities and lower predation risk, whereas late detectors or slow responders are more vulnerable. Synchronization based on monitoring and imitation can prevent individuals from being the last to detect risk or respond to escape, particularly when predators target laggards. Under such "lagging-target" predator strategies, vigilance synchronization is expected to be strengthened. However, black-necked cranes are large birds whose wintering juveniles are nearly adult-sized, and their primary disturbance source is human activity in foraging areas rather than lagging-target predators, elimi-

nating selective pressure for synchronization.

Black-necked cranes breeding and wintering on the Tibetan Plateau have co-existed with local Tibetan communities for generations, becoming deeply integrated into regional culture, customs, and even religious beliefs. The species is widely regarded as an auspicious symbol and is protected as a sacred bird in Tibetan areas. Although cranes foraging in farmland inevitably experience human disturbance, this disturbance may be insufficient to induce high-intensity vigilance compared to hunting pressure experienced by other studied species. Thus, the local human disturbance level may not be adequate to trigger strong vigilance synchronization in this culturally protected species.

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