Received: 20 September 2022 | Revised: 30 September 2023 | Accepted: 11 October 2023

DOI: 10.1111/csp2.13045

CONTRIBUTED PAPER

Conservation Science and Practice
A journal of the Society for Conservation Biology
Open Access

WILEY

Research activity induces change in nest position but does not affect nest success in a vulnerable babbler

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Funding information
National Natural Science Foundation of China, Grant/Award Numbers: 31872961, 31272330; National Forestry and Grassland Administration of China; Sichuan Normal University, Grant/Award Numbers: XJ20200176, ZX20210336

Abstract

Studies show that birds cognize human disturbance as a potential predation risk. However, the responses of breeding birds to long-term continuous disturbance by research activities and whether researcher disturbance affects the fitness of target species remain poorly understood. In this study, we used field observation data collected over 6 years to assess the potential impacts of research activities on nest-site selection and nest success of the Emei Shan Liocichla (*Liocichla omeiensis*), a vulnerable babbler species endemic to Southwest China. Our results showed that Emei Shan Liocichlas tended to nest in taller nesting plants or the higher parts of nesting plants to increase nest-site height following researcher disturbance. The average height of Emei Shan Liocichla nests increased by 52.2% over the 6-year study period, from 129.8 ± 9.2 cm in 2009 ($n = 11$) to 197.5 ± 12.1 cm in 2015 ($n = 18$). While some pairs adopted a different strategy, placing their nests in Rosaceae plants with thorns instead of the bamboo *Chimonobambusa szechuanensis* (the favored nesting plant of the Emei Shan Liocichla) under high interference pressure, which made it more difficult for researchers to approach their nests. There were no significant differences both in clutch size and nest success between the low- and high-disturbance groups. The study revealed the behavioral response pattern of breeding Emei Shan Liocichlas to researcher disturbance, which will contribute to conservation of this threatened songbird and the knowledge of reproductive strategies of birds. Developing specific guidelines for fieldwork and strengthening visitor management within its core habitat of Emei Shan Liocichla during breeding period should be considered.

KEYWORDS

behavioral plasticity, *Liocichla omeiensis*, nest success, nest-site selection, researcher disturbance

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1 | INTRODUCTION

Nest-site selection is an important component of avian habitat selection, which has an important effect on the reproductive performance of birds (Ma et al., 2021; MacDonald et al., 2016; Tryjanowski et al., 2000). Nest predation is regarded as the main cause of nest failure in most bird species (Ibáñez-Álamo et al., 2015; Martin & Roper, 1988; Nilsson, 1984; Samsonov et al., 2022), and nest position plays a determining role in reducing nest predation (Badyaev, 1995; Dwight et al., 2020; Kolbe & Janzen, 2002). Birds often choose safer nest sites to increase nest success (Antczak et al., 2005; Bachir et al., 2008; Negro & Hiraldo, 1993).

Studies show that birds cognize human disturbance as a potential predation risk (Antczak et al., 2005; Chen et al., 2011; Frid & Dill, 2002). Thus, the influence of research activities on avian reproduction (especially that of rare and endangered species) has long attracted the attention of ornithologists (Hu et al., 2020; Rodway et al., 1996). Research activities may disturb avian breeding behavior and consequently affect their reproductive parameters (Götmark, 1992). Studies of various bird species reveal that research activities can have a positive effect (Ibáñez-Álamo & Soler, 2010; Richardson et al., 2009), negative (Sandvik & Barrett, 2001; Tremblay & Ellison, 1979), or neutral effect (Hu et al., 2020; Ibez-Lamo et al., 2011; Lloyd et al., 2000; Ortega et al., 1997) on nest success, suggesting that specific analyses are required for different species.

For many animals, a change in behavior is very often the first response to human-altered conditions (Wong & Candolin, 2015). Some birds exhibit adaptive behavioral plasticity in nest-site selection in response to human-induced disturbance. For example, Black Redstarts (*Phoenicurus ochruros*) were found to shift their nests to deeper locations in cavities in the subsequent breeding season after researcher disturbance (Chen et al., 2011). Most similar studies assess short-term effects of researcher disturbance (Antczak et al., 2005; Dreibelbis et al., 2011). However, breeding bird responses to long-term continuous disturbance caused by research activities remains poorly understood. Besides, previous studies mainly focus on the direct interference of nest check, while the indirect interference caused by nest searching is often ignored.

The Emei Shan Liocichla (*Liocichla omeiensis*) is a rare babbler species endemic to the mountains of Southwest China (Lei & Lu, 2006). It is classified as "Vulnerable" on the IUCN Red List (https://www.iucnredlist.org/) because of its small, declining population and fragmented range (BirdLife International, 2022). It is also listed as a nationally protected animal in China (National Forestry and Grass Administration and Ministry of Agriculture and Rural Affairs, 2021). This species usually uses the edges of or gaps within natural broadleaf forest between elevations of 1450 and 2150 m for nesting, where vegetation around nests is mainly the bamboo *Chimonobambusa szechuanensis*, small shrubs, and lianes with few large trees (Fu et al., 2011). The Liocichla prefers nesting in the bamboo as its thick leaves provide concealment, reducing the risk of nest predation (Fu et al., 2011, 2016). The existing information on its ecology of Emei Shan Liocichla is quite inadequate, which restricts effective conservation and management of this species (Fu et al., 2013).

This work is part of a broad ecological study of Emei Shan Liocichla. In this study, we assessed the potential impacts of research activities on the nest-site selection and nest success of the Emei Shan Liocichla based on 6 years of field data. Our main aims were to understand the behavioral responses of the bird to the long-term continuous disturbance caused by researchers during breeding period, and to assess whether researcher disturbance affects the fitness of Emei Shan Liocichla, which may contribute to conservation of this threatened songbird and the knowledge of reproductive strategies of birds.

2 | METHODS

2.1 | Study site

The study was conducted at the Laojunshan National Nature Reserve (28°39′36″–28°43′38″ N, 103°57′36″–104°04′12″ E; Figure 1) in Southwest China during the 2009–2011 and 2013–2015 breeding seasons (from April to August). The reserve is one of the most important distribution sites of the Emei Shan Liocichla. The climate is temperate with high precipitation (>1500 mm per year) and relative humidity (>85%). The dominant vegetation type is evergreen broadleaf forest. There is abundant bamboo (mainly *C. szechuanensis*) at altitudes from 1200 m to 2000 m. The Red-billed Leiothrix (*Leiothrix lutea*) (dominant species) and Red-winged Laughingthrush (*Trochalopteron formosum*) (common species) are two main ecologically similar species with Emei Shan Liocichla (rare species) in sympatry within the reserve (Fu, 2010).

2.2 | Field survey

During the breeding seasons, we investigated the breeding biology of Emei Shan Liocichlas at the Laojunshan National Nature Reserve. There inhabits a small population of about 100 Emei Shan Liocichlas at our study site (Fu, 2010). The areas of the reserve and nest searching

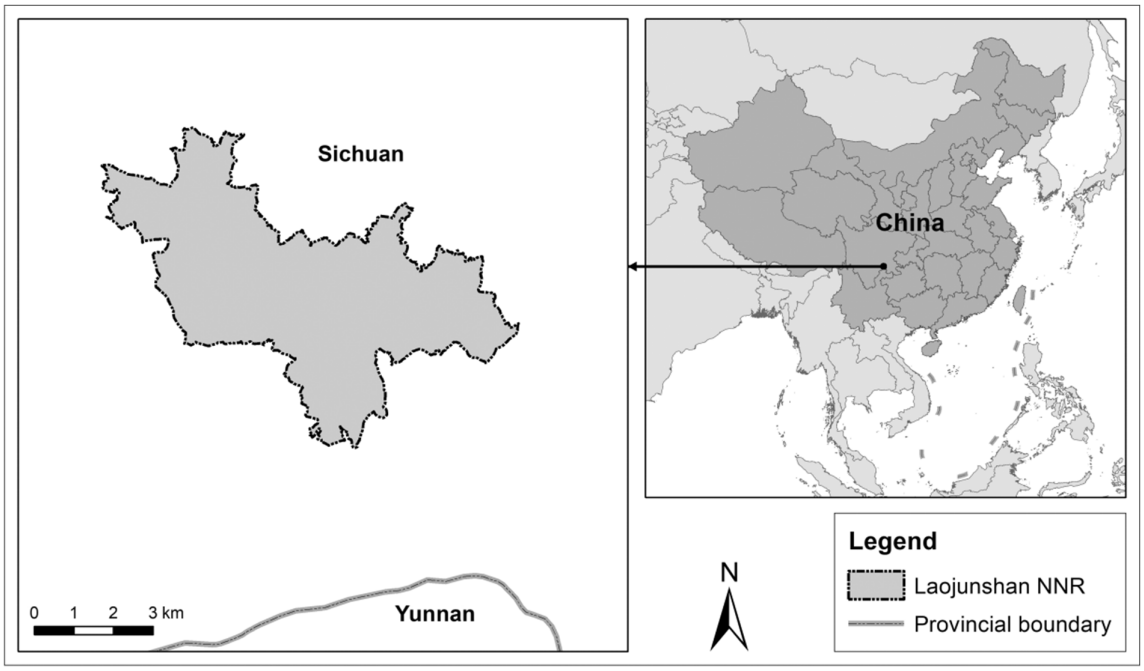


FIGURE 1 Laojunshan National Nature Reserve, Sichuan, China.

are ~35 km^2 and ~6 km^2, respectively. We tried to wear leg rings with the bird to better study its breeding behavior, but it was difficult to see the Liocichla in the field due to its secretive nature and the dense vegetation (Fu et al., 2011), so we terminated the leg-ring marking plan finally.

Nest searching is the biggest challenge during fieldwork as the liocichla's nests are very hidden (Fu et al., 2011). While the bird exhibits strong territoriality throughout the breeding season, and announces its territoriality through characteristic songs (a loud and complex whistle) uttered by males (Fu et al., 2011). We used this biological characteristic to locate approximate range of its nest through observing parental behavior and tracking breeding pairs, and then found the nest by systematic searching (Fu et al., 2016). The bird does not breed synchronously, and if the first brood breeds unsuccessfully, it will try to breed a second (Fu, 2010). Therefore, nest searching covered its whole breeding period of the bird.

To determine nest predators, during the breeding seasons of 2013–2015, infrared cameras (Ltl 6210, Acorn) were placed ~1 m from 17 nests (i.e., 3 for 2013, 9 for 2014, and 5 for 2015) at the nestling stage or late incubation period when the adults would not abandon their nests easily (Fu et al., 2016). We visited nests regularly (every 1–7 days) to record basic nesting parameters such as clutch size, hatching success, and fledging success. Usually, we visited nests every 3–4 days. In order to determine certain key time points (e.g., hatching time and fledging time), it was necessary to continuously check the nest. To reduce interference, we only measured some eggs early in this study (2009 and 2010), without measuring nestlings. In addition, due to abnormal weather (e.g., rainstorms), the interval between nest checks may be extended.

After breeding activity at a nest had ceased, the following variables were measured: nesting-plant species and height, nest-site height, nest concealment, and other 13 nest-site habitat variables including altitude, slope aspect, tree cover, shrub cover, bamboo cover, herb cover, and distance to the nearest forest edge (see Fu et al., 2016 for details about all the habitat variables and their measures). Following Hoover and Brittingham (1998), a modification of white cover board was used to estimate nest concealment above and around nests from 2009 to 2011 (data for other years was incomplete). Nest check and variable measurement for all nests were subject to the same standard. All the researchers were strictly trained (including the techniques of nest searching and data collection) to minimize interference with avian breeding activities. Generally, only one researcher (occasionally two) visited the nests, but everyone participated in nest searching weekly.

Nests were considered successful if at least one nestling fledged. This study follows the guidelines and has been approved (No. 2022LS036) by the Animal Ethics Committee of Sichuan Normal University.

2.3 | Data analysis

In order to explore the impact of nest searching, we divided six breeding seasons into low-disturbance groups including the years of 2009, 2011, and 2013 (1–2 researchers), and

high-disturbance groups including the years of 2010, 2014, and 2015 (3–4 researchers) according to the number of researchers involved in field investigation of nest searching, of which the breeding season of 2009 was regarded as the year with the least disturbance caused by research activities as it was the first year for this study and was not disturbed before, while the breeding season of 2015 as the year with the most cumulative interference.

Effects of research activities (low-disturbance vs. high-disturbance) on nest-site height, nesting-plant height, the ratios of nest-site height to nesting-plant-height, and nest concealment were tested using general linear mixed models (GLMM). To further test whether the whole characteristics of nest-site habitat changed, we compared the differences of 13 nest-site habitat variables between years (2009 vs. 2015) and groups (low-disturbance vs. high-disturbance). We also compared the clutch size and nest success of Emei Shan Liocichlas between the low- and high-disturbance groups to test whether nest searching changed their fitness. We calculated nest success using the Mayfield method (Johnson, 1979; Mayfield, 1975). The relevant equation is nest success = DSR^n, where n = the total duration in days of egg-laying, incubation, and nestling periods (Fu et al., 2011), and DSR is the daily nest survival rate. We analyzed the DSR in Program MARK (Dinsmore et al., 2002). Chi-square Test was used to analyze the difference in nest success across the six breeding seasons. The independent samples T-test and the Wilcoxon rank sum test were used to evaluate the differences between normally distributed variables and abnormally distributed variables between groups, respectively.

All analyses were carried out using SPSS 20.0. Significance levels for all analyses were set at $p < .05$. Data are presented as mean ± SE.

3 | RESULTS

A total of 75 Emei Shan Liocichla nests were found during six breeding seasons (2009: $n = 11$; 2010: $n = 15$; 2011: $n = 7$; 2013: $n = 9$; 2014: $n = 15$; 2015: $n = 18$). Nest success was 29.8% (2009), 24.5% (2010), 30.6% (2011), 14.7% (2013), 35.5% (2014) and 21.9% (2015), respectively. Average nest success was 26.2 ± 7.4% ($n = 6$ years). There was no significant difference in nest success across years ($\chi^2 = 10.472$, $p = .063$). The comparisons of clutch size and nest success between the low- and high-disturbance groups also show no significant difference (Table 1).

Nest-site height, nesting-plant height, and the ratios of nest-site height to nesting-plant height all exhibited obvious upward trends (Figure 2). That is, Emei Shan Liocichlas tended to nest in taller plants (predominantly the bamboo *C. szechuanensis*; Figure 2B) or the higher parts of nesting plants (Figure 2C). As a result, the average height of Emei Shan Liocichla nests increased 52.2% over the 6-year study period, from 129.8 ± 9.2 cm in 2009 ($n = 11$) to 197.5 ± 12.1 cm in 2015 ($n = 18$; Figure 2A). The means of the three nest-site variables mentioned above in the high-disturbance group were significantly higher than those in the low-disturbance group (Table 2). Here, it is worth noting that nest-site height showed greater variance in 2014 and 2015 (high disturbance years) compared to earlier years.

The concealments above nests (2009: 90.0 ± 2.7%; 2010: 95.3 ± 1.3%; 2011: 93.1 ± 1.8%) and around nests (2009: 89.5 ± 2.6%; 2010: 92.9 ± 1.3%; 2011: 94.6 ± 1.4%) also showed an increasing trend, but there were no significant differences between groups (low-disturbance vs. high-disturbance; Table 3).

GLMM analyses showed that research activities (low-disturbance vs. high-disturbance) might have significant effects on nest-site height ($F = 9.400$, $df = 1$ and 73, $p = .003$) and the ratios of nest-site height to nesting-plant height ($F = 6.577$, $df = 1$ and 73, $p = .012$), but slight effects on nesting-plant height ($F = 3.446$, $df = 1$ and 73, $p = .067$) and nest concealment (the one above nests: $F = 3.189$, $df = 1$ and 31, $p = .084$; the one around nests: $F = 0.397$, $df = 1$ and 31, $p = .533$).

The comparisons of all 13 nest-site habitat variables between years (2009 vs. 2015) (Table 4) and groups (low-disturbance vs. high-disturbance) (Table 5) showed no significant differences, although some of habitat variables (e.g., tree cover) varied obviously (Table 4).

In addition, interestingly, the proportion nesting in bamboo decreased substantially from 88.5% in the

TABLE 1 Comparisons (mean ± SE) of clutch size and nest success of Emei Shan Liocichla (*Liocichla omeiensis*) between the low- (2009, 2011, and 2013) and high-disturbance (2010, 2014, and 2015) groups at the Laojunshan National Nature Reserve, China.

Reproductive parameters	Low-disturbance group	High-disturbance group	*t*-value and significance	*Z*-value and significance
Clutch size	2.7 ± 0.2 ($n = 15$ nests)	2.6 ± 0.1 ($n = 32$ nests)		−0.107 ($p = .915$)
Nest success (%)	25.0 ± 5.2 ($n = 3$ years)	27.3 ± 4.2 ($n = 3$ years)	−0.341 ($p = .750$)	

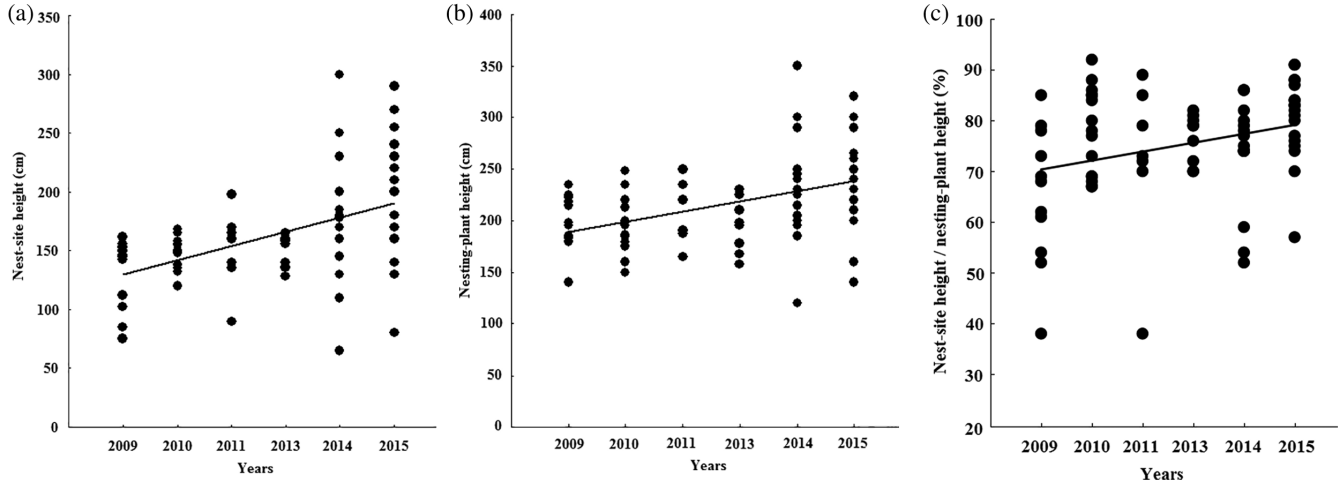


FIGURE 2 Changes in Emei Shan Liocichla (*Liocichla omeiensis*) nest-site height (a), nesting-plant height (b), and nest-site height to nesting-plant height ratio (c) across years at the Laojunshan National Nature Reserve, China.

TABLE 2 Comparisons (mean ± SE) of nest-site height, nesting-plant height, and the ratios of nest-site height to nesting-plant height of Emei Shan Liocichla between the low- (2009, 2011, and 2013) and high-disturbance (2010, 2014, and 2015) groups at the Laojunshan National Nature Reserve, China.

Nest-site variables	Low-disturbance group ($n = 27$)	High-disturbance group ($n = 48$)	*t*-value and significance
NSH (cm)	141.6 ± 5.4	175.3 ± 7.0	−3.794 ($p < .001$)
NPH (cm)	201.4 ± 5.2	224.1 ± 7.0	−2.598 ($p = .011$)
NSH/NPH (%)	70.9 ± 2.5	77.6 ± 1.4	−2.564 ($p = .012$)

Abbreviations: NPH, nesting-plant height; NSH, nest-site height; NSH/NPH, the ratios of nest-site height to nesting-plant height.

TABLE 3 Comparisons (mean ± SE) of nest concealment of Emei Shan Liocichla (*Liocichla omeiensis*) between the low- (2009, 2011) and high-disturbance (2010) groups at the Laojunshan National Nature Reserve, China.

Nest concealment	Low-disturbance group ($n = 18$)	High-disturbance group ($n = 15$)	*t*-value and significance
The one above nests	91.2 ± 1.8%	95.3 ± 1.3%	−1.848 ($p = .075$)
The one around nests	91.5 ± 1.8%	92.9 ± 1.3%	−0.630 ($p = .533$)

low-disturbance group to 55.9% in the high-disturbance group, whereas the proportion nesting in Rosaceae plants with thorns increased considerably from 7.4% in the low-disturbance group to 25% in the high-disturbance group.

4 | DISCUSSION

This study revealed the plasticity of nest-site selection in the Emei Shan Liocichla. Nest location is considered as an adaptive response to predation pressure (Barrientos et al., 2009), interspecific competition (Wiebe, 2016), vegetation structure and climate change (Auer & Martin, 2013; Fu et al., 2022), and human disturbance (Hanane, 2014). Our results showed that there was no significant difference in nest success of Emei Shan Liocichlas across years, which partially indicates that predation pressure might have little effect on nest-position change of the Liocichla. At our study site, the Red-billed Leiothrix and Red-winged Laughingthrush, two main ecologically similar species to Emei Shan Liocichla, did not exhibit significant fluctuations in their population numbers (unpublished data from Yiqiang Fu, the corresponding author of this study), and we did not find any obvious abnormal changes in vegetation and climate (personal observations by Yiqiang Fu) either across the 6 years. Studies show that birds that are less tolerant to human disturbance tend to nest elsewhere after a breeding season where they experience disturbance (Götmark, 1992). Although Emei Shan Liocichla is a babbler that is sensitive to human interference (Fu et al., 2011); however, the interference of human activities in the reserve is relatively slight, which has been continuously reduced due to strengthened management in recent years (Fu et al., 2011). Thus, the researcher-induced disturbance is likely to be the main factor influencing nest-site selection by the Emei Shan Liocichla.

Breeding birds are highly capable of assessing and responding to changes in predation risk to themselves and nestlings (Fontaine & Martin, 2006; Lima, 2009). For many animals, human-caused disturbance is similar to

TABLE 4 Comparisons of nest-site habitat variables of the Emei Shan Liocichla (*Liocichla omeiensis*) between the years of 2009 and 2015 at the Laojunshan National Nature Reserve, Sichuan, China.

Habitat variables	The year of 2009 ($n = 11$)	The year of 2015 ($n = 18$)	*t*-value and significance	*Z*-value and significance
AL (m)	1719.4 ± 49.0	1697.9 ± 41.0	0.331 ($p = .743$)	
SA	1.9 ± 0.3	2.1 ± 0.2	−0.425 ($p = .674$)	
TH (m)	3.5 ± 1.5	2.7 ± 1.2		−0.542 ($p = .674$)
TC (%)	11.3 ± 6.2	2.4 ± 1.4		−1.028 ($p = .438$)
SH (m)	3.1 ± 0.3	3.3 ± 0.3	−0.556 ($p = .583$)	
SC (%)	35.0 ± 8.1	35.9 ± 8.2	−0.072 ($p = .943$)	
BH (cm)	209.2 ± 5.4	224.4 ± 20.0	−0.737 ($p = .470$)	
BC (%)	58.2 ± 9.4	60.2 ± 9.0	−0.150 ($p = .882$)	
HH (cm)	37.4 ± 12.6	20.6 ± 2.5		−0.203 ($p = .842$)
HC (%)	17.2 ± 6.3	10.4 ± 2.8	0.988 ($p = .340$)	
LA	2.5 ± 0.2	2.8 ± 0.1		−1.143 ($p = .412$)
DF (m)	18.5 ± 2.1	15.0 ± 1.7	1.288 ($p = .209$)	
DW (m)	33.5 ± 6.8	22.6 ± 5.8	1.198 ($p = .241$)	

Abbreviations: AL, altitude; BC, bamboo cover; BH, mean height of bamboo; DF, mean distance to the nearest forest edge; DW, distance to water; HC, herb cover; HH, mean height of herb; LA, liana abundance; SA, slope aspect; SC, shrub cover; SH, mean height of shrubs; TC, tree cover; TH, mean height of trees.

TABLE 5 Comparisons of nest-site habitat variables of the Emei Shan Liocichla (*Liocichla omeiensis*) between the low- (2009, 2011, and 2013) and high-disturbance (2010, 2014, and 2015) groups at the Laojunshan National Nature Reserve, Sichuan, China.

Habitat variables	Low-disturbance group ($n = 27$)	High-disturbance group ($n = 48$)	*t*-value and significance	*Z*-value and significance
AL (m)	1712.0 ± 33.4	1680.2 ± 23.7		−1.032 ($p = .302$)
SA	2.0 ± 0.2	1.9 ± 0.1		−0.539 ($p = .590$)
TH (m)	4.4 ± 1.0	2.8 ± 0.6		−1.316 ($p = .188$)
TC (%)	10.3 ± 3.1	6.1 ± 1.7		−1087 ($p = .277$)
SH (m)	3.3 ± 0.2	3.0 ± 0.1	1.314 ($p = .193$)	
SC (%)	32.0 ± 4.4	43.4 ± 4.6		−1.292 ($p = .196$)
BH (cm)	209.7 ± 3.5	203.0 ± 10.9		−1.453 ($p = .146$)
BC (%)	67.6 ± 5.3	54.3 ± 5.5		−0.989 ($p = .323$)
HH (cm)	28.5 ± 5.7	24.6 ± 2.2		−0.873 ($p = .383$)
HC (%)	17.5 ± 3.5	13.3 ± 1.9		−0.851 ($p = .395$)
LA	2.7 ± 0.1	2.8 ± 0.1		−0.961 ($p = .337$)
DF (m)	15.4 ± 1.4	14.8 ± 1.2		−0.576 ($p = .564$)
DW (m)	26.6 ± 3.8	25.9 ± 3.0	0.144 ($p = .886$)	

Abbreviations: AL, altitude; BC, bamboo cover; BH, mean height of bamboo; DF, mean distance to the nearest forest edge; DW, distance to water; HC, herb cover; HH, mean height of herb; LA, liana abundance; SA, slope aspect; SC, shrub cover; SH, mean height of shrubs; TC, tree cover; TH, mean height of trees.

predation risk (Frid & Dill, 2002). Natural selection should favor flexibility in nest-site selection behavior when environmental variability influences individual fitness (Chen et al., 2011). A number of studies show that birds can alter nest positions to adapt to environmental changes (Forstmeier & Weiss, 2004; Kearns & Rodewald, 2013; Wang et al., 2008). Our findings indicated that Emei Shan Liocichlas tended to build their nests in taller nesting plants or the higher parts of nesting plants following researcher disturbance. This suggests that Emei Shan Liocichla pairs prevented researchers from approaching their nests mainly by increasing the height of nest sites in response to researcher disturbance. In addition, some pairs placed their nests in Rosaceae plants with thorns,

which made it more difficult for researchers to access their nests and consequently appears to be a behavioral strategy, although it is an alternative plausible explanation on this behavior that more concealed nests in thorny bushes were found in subsequent years as researchers were getting better at finding nests. The above behavioral responses suggested that long-term continuous interference caused by research activities might strengthen the bird's anti-predatory strategy. We hardly carried out fieldwork at the study site in 2012, while the average nest-site height of the Emei Shan Liocichlas in 2013 (148.7 ± 4.6 cm, $n = 7$) differed little from that in 2011 (151.1 ± 12.9 cm, $n = 7$), and even fell slightly, which further confirmed the impacts of research activities.

There were no significant differences in all nest-site habitat variables between the years of 2009 and 2015 (Table 4) and the low- and high-disturbance groups (Table 5), indicating that although the nest position and even nesting plant changed, it did not alter the general characteristics of Emei Shan Liocichla nesting habitat. Studies show that tree cover, bamboo cover, liana abundance, and distance to forest edge were the most important variables influencing nest-site selection in this species (Fu et al., 2016). Our results showed that tree cover declined from 11.3% in 2009 to 2.4% in 2015 (Table 4). Lower tree cover is conducive to the growth of undergrowth vegetation (e.g. bamboo and liana, see Table 4), consequently improving nest concealment of Emei Shan Liocichla and the concealment of its activities. Although bamboo cover decreased in Table 5, shrub cover increased, and their ecological effects (enhancing concealment) are similar. The inconsistent results between Table 4 and Table 5 perhaps indicate that under the dual effects of high predatory pressure (nest predation is the primary reason for nest failure of the Emei Shan Liocichla, see Fu et al., 2016) and researcher disturbance, its nest site selection may not necessarily be optimal. In addition, we cannot deny the possibility that the small sample sizes in this study may lead to somewhat biased results.

Nest fate and nest success are related to nest-site height and nest concealment (Best & Stauffer, 1980; Colombelli-Négrel & Kleindorfer, 2009; Guan et al., 2018). Birds can reduce nest predation by nesting in sites that are difficult for predators to access or locate (Cresswell, 1997; Latif et al., 2012). The main predators of Emei Shan Liocichlas are squirrels, snakes, raptors, and jays, and the babbler usually hides its nest in dense bamboo forests to mitigate high predation risk (Fu et al., 2013, 2016). Good concealment of nests can reduce the possibility of being detected and approached by predators or humans. In this study, it seemed that researcher disturbance did not affect the nest success of the Emei Shan Liocichla. Compared with the low-disturbance group, the nest concealment of the high-disturbance group did not decrease, and even increased slightly (Table 3), which might be one possible reason why there was no significant difference in nest success across years. Nest-site height may be evolutionarily conservative in many bird species (Martin, 1988). However, the average height of Emei Shan Liocichla nests exhibited a substantial increase of 52.2% over the 6-year study period, which seems to have a cumulative effect. We speculate that the bird's experience of being disturbed during the breeding process in the previous year may affect its decision on nest-site selection in the following year. Zhang et al. (2017) reported a similar behavioral response to photographer disturbance in the Blue-crowned Laughingthrush (*Pterorhinus courtoisi*). While Great Gray Shrike (*Lanius excubitor*) pairs with disturbed nests in 1 year also significantly increased nest-site height in the following breeding season (Antczak et al., 2005). In addition, why did nest-site height show greater variance in 2014 and 2015 (high disturbance years) compared to earlier years (Figure 2A)? On the one hand, due to the increase in the number of researchers, with the expanded searching area, more nests were found, possibly including some previously undisturbed nests; on the other hand, it may be related to the difference in experience of finding nests among researchers as skilled ones caused less interference.

Life-history theory predicts clutch size reduction under high risk of nest predation, which has been hypothesized to be adaptive as it will improve parental survival prospects and future reproduction (Eggers et al., 2006; Roff, 1992). For instance, the Great tit (*Parus major*) can adjust clutch size in response to changes in the risk of nest predation (Julliard et al., 1997). The Siberian jay (*Perisoreus infaustus*) chose a nest site offering more protective covering and reduced clutch size when perceiving an increased risk of nest predation in the vicinity of nest sites (Eggers et al., 2006). We did not find that research activity affected clutch size variation in the Emei Shan Liocichla (Table 1). Consequently, we speculate that birds may make behavioral responses to external threats based on the level of risk: changing nest position and improving nest concealment are the most common behaviors, while clutch-size reduction means high risk of nest predation. Judging from its behavioral response mode, researcher disturbance may be a low risk for Emei Shan Liocichla.

In conclusion, our findings show that research activity affected nest-position and nesting-plant selection by the Emei Shan Liocichla, which provide evidence that birds may assess the risk of human disturbance and consequently adjust nesting strategies, suggesting the plasticity of avian breeding behavior. Future research needs to

test whether these changes affect interspecific relationships among sympatric bird species. It is undeniable that there are some defects in this study, such as lack of individual markers (unable to make precise comparative analyses) and the relatively small sample sizes. In addition, from the perspective of experimental design, if there is an undisturbed area as a control, it is more convincing. We speculate that the impacts of research activities on avian breeding behaviors are widespread across bird species (especially small-sized birds of the order Passeriformes), which needs to collect more reproductive ecology data of bird species to verify it in the future. We hope this study can draw the attention of ornithologists to the impact of long-term research activities on avian reproduction.

5 | CONSERVATION IMPLICATIONS

Nest predation and human disturbances (mainly caused by human visitors) have been suggested as two important factors affecting breeding success of Emei Shan Liocichlas (Fu et al., 2011). Research workers may influence a predator's ability to find nests in a number of different ways including leaving olfactory (e.g., scent) and visual cues (Lenington, 1979). Given the sensitivity of the species to human disturbance (Fu et al., 2011), we suggest developing specific guidelines for fieldwork, including nest searching and data collection. In general, for birds that are sensitive to human interference, we recommend that researchers minimize the frequency of visits to the nest and leave as soon as possible to avoid attracting predators. In addition, strengthened management of visitors within core habitat during breeding period should be considered.

AUTHOR CONTRIBUTIONS

Yiqiang Fu, Wenbo Liao, and Zhengwang Zhang conceived the study; Yiqiang Fu and Benping Chen collected the data; Lanlan Zhang and Yufeng Wang analyzed the data; Lanlan Zhang wrote the earlier manuscript; all authors read and approved the final manuscript.

ACKNOWLEDGMENTS

We thank the Laojunshan National Nature Reserve for allowing us to conduct this study. We thank Ming Xiang, Wencai Chen, Yongheng Wu, and Chiping Kong for their assistance with the fieldwork.

FUNDING INFORMATION

This work was supported by the National Natural Science Foundation of China (31872961 and 31272330), the special investigation project of key species of the National Forestry and Grassland Administration of China, and the scientific research projects of Sichuan Normal University (XJ20200176 and ZX20210336).

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflicts of interest.

DATA AVAILABILITY STATEMENT

All datasets used in this study are included in the main text.

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How to cite this article: Zhang, L., Wang, Y., Chen, B., Liao, W., Zhang, Z., & Fu, Y. (2023). Research activity induces change in nest position but does not affect nest success in a vulnerable babbler. *Conservation Science and Practice*, *5*(12), e13045. https://doi.org/10.1111/csp2.13045