

LETTER TO THE EDITOR

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An unusual homing behavior found in the Sichuan Partridge during the early brooding period

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Abstract

In this study, we report an unusual homing behavior of the Sichuan Partridge (*Arborophila rufipectus*) at the Laojunshan National Nature Reserve, Sichuan Province, China. Hen Sichuan Partridges led the chicks back to the nests where they hatched in the evening and roosted there over night. This behavior lasted 6.7 ± 4.3 nights (range = 1–15; $n = 13$) after the chicks hatched. At this stage, the hens became very vigilant to predators and human disturbance. If disturbed, they often abandoned the nests immediately and no longer returned thereafter. The ambient temperature at night during the early brooding period of Sichuan Partridge at our study site was ~ 12.4 °C. Our findings suggest that hen Sichuan Partridges may make trade-offs between nest predation risks versus the thermoregulatory needs of their young.

Keywords: *Arborophila rufipectus*, Early brooding period, Homing behavior, Predation risk, Thermoregulation

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In the breeding season, birds build nests to protect their eggs and young from predators and adverse weather conditions (Zheng 2012; Deeming and Reynolds 2015). However, most birds rarely return to their nests after fledging as this could make them more vulnerable to predators and increase exposure to nest ectoparasites (Scholer 2015). There are only a few reports of reuse of old nests by recently fledged young, such as the Ferruginous Hawk (*Buteo regalis*) in South Dakota, in which the young returned to the nests to obtain food from the adults and to roost for another 2 weeks after fledging (Blair and Schitoskey 1982). Galliformes are a group of precocial species that chicks leave the nest soon after hatching and move around for foraging following the hen (Zheng

2015). There are not any reports in wild Galliformes that the chicks return to their nests during the brooding period (McGowan 1994).

The Sichuan Partridge (*Arborophila rufipectus*) is a globally endangered Galliforme species native to the mountains of southwest China. It builds a domed, and partially enclosed nest with a 6–8 cm × 8–10 cm entrance (Fu et al. 2017). During the breeding season of 2011, we first noted that hen Sichuan Partridges led their newly hatched chicks back to the nests where they were born, and then roosted in the nests all together over night. We continued to observe this behavior in the field from 2011 to 2019. The aims of this study were to describe this unusual homing behavior and preliminarily analyze its ecological significance.

The study was carried out at the Laojunshan National Nature Reserve (28°39'36"–28°43'38"N, 103°57'36"–104°04'12"E; altitude 900–2009 m) in southwest China. The climate is temperate with high precipitation (> 1500 mm per year) and relative humidity (> 85%). The average annual temperature is about 12.0–14.7 °C. The vegetation is characterized by evergreen broadleaf forest,

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mainly including *Castanopsis* spp., *Schima* spp., *Camellia* spp., *Eurya* spp., and *Rhododendron* spp. The reserve has the world's largest wild population of the Sichuan Partridge, about 300–400 individuals (Fu and Chen 2017).

The nests were located through systematic searches during the breeding season. We monitored breeding behavior of the partridge using Tinytag Plus 2 temperature data loggers (TDL) (TGP-4520, Gemini Data Loggers, UK) and infrared cameras (IC) (Ltl 6210, Acorn, CN). The data logger had two external probes, which allowed us to record both internal nest and corresponding ambient temperatures (Fu et al. 2012). The temperature difference was taken as an indicator of adult presence and absence from the nest (Manlove and Hepp 2000; Greeney 2009). The infrared cameras placed at or around the nests were used to monitor activities of

Sichuan Partridges and their potential predators. Data are presented as mean \pm SD.

In total, 148 Sichuan Partridge nests (including 24 old nests built in the last breeding season) were found from 2011 to 2019. We monitored 60 of them with IC and (or) TDL. A total of 15 successfully hatched Sichuan Partridge nests were monitored during the nine breeding seasons.

Female Sichuan Partridges incubated alone. The incubation period was about 29 days. The chicks left nests for the first time usually in the morning or at noon 1 day after hatching. When the time arrived, the cock came to the nest and served as a guard. The hen walked out of the nest first, and then the chicks followed one by one. In the evening, the hen led the chicks back to the nest, roosting communally over night (Fig. 1), while the cock roosted alone on the tree near the nest (usually < 100 m). Such homing behavior back to the nest was often repeated for multiple nights (Fig. 2). The corresponding ambient temperature at night during the early brooding period of Sichuan Partridge was 12.4 ± 1.7 °C ($n = 7$ nests). The patterns of incubation-hatch-homing by the Sichuan Partridge are shown in Fig. 2.

Of 15 successful nests that were monitored, the homing behavior has been observed in 13 nests (Table 1). For all the 13 nests combined, the hens and their chicks returned to their nests at $18:49$ p.m. ± 40 min, and left at $07:00$ a.m. ± 36 min. The mean homing times after hatching were 6.7 ± 4.3 nights (range = 1–15; $n = 13$). At this stage, the hens became very sensitive to the security of nest sites. If disturbed, whether by predators or human beings, they often abandoned the nests immediately and no longer returned thereafter.



Fig. 1 The video screenshot showing that a hen Sichuan Partridge and its brood were roosting in their nest at night (data from Nest 201909)

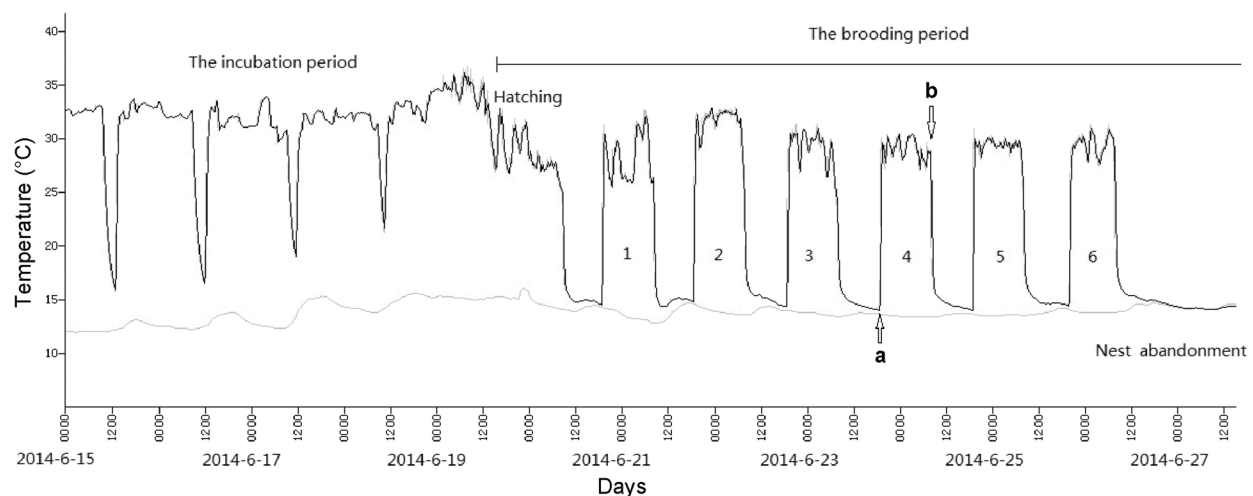


Fig. 2 The patterns of incubation-hatch-homing by a hen Sichuan Partridge at the Laojunshan Nature Reserve, Sichuan Province, China (data from Nest 201418). Black lines represent internal nest temperature, while gray lines represent corresponding ambient temperature. The numbers indicate that the hen Sichuan Partridge led the young back to the nest for six consecutive nights. The arrows indicate return (a) and departure (b) time

Table 1 Summary of homing behavior of the Sichuan Partridge during the early brooding period at the Laojunshan National Nature Reserve, Sichuan Province, China

Nest code	Monitoring method	No. of eggs hatched	Time for the 1st departure	No. of homing nights after hatching
201405	IC	6	0840	0
201408	IC + TDL	5	1010	0
201401	IC	2	1031	1
201607	IC	4	1005	1
201315	IC	4	0930	3
201417	IC + TDL	5	0855	3
201106	TDL	5	0640	5
201107	IC + TDL	3	1101	6
201418	TDL	5	0835	6
201515	IC + TDL	5	0800	7
201612	IC	3	0713	7
201409	IC + TDL	6	0820	10
201904	IC	5	1118	11
201905	IC	6	1425	12
201909	IC	5	Unknown	15

IC infrared camera, TDL temperature data logger

To our knowledge, this is the first report of homing behavior after hatching in any species of Galliformes in the wild. An explanation for the unusual homing behavior is compensating for the underdevelopment of thermoregulation in the chicks. In most species of Galliformes, the recently hatched chicks lack full thermoregulatory capacity (Zheng 2015). The chicks cannot maintain their own body temperature and are periodically brooded by the hen to prevent them becoming chilled. The Sichuan Partridge has an unusual incubation pattern with low nest attentiveness of ~81.2% over the incubation period, and long exposures of ~4.2 h below the physiological zero temperature of 26 °C for developing embryos for each daily recess (Fu et al. 2017). This may lead to worse development of thermoregulation in the early stage of their life of the Sichuan Partridge than other birds. The ambient temperature at night was low (~12.4 °C) during the early brooding period of the Sichuan Partridge at our study site. Therefore, hen partridges and their chicks may choose to roost communally in the domed nests with good insulation during the chilly nights, which can effectively reduce energy costs that may be critical for the development of thermoregulation in chicks.

Reducing predation risk of the broods is another explanation for the unusual homing behavior. Predation was the main cause of breeding failure of the Sichuan Partridge (Fu and Chen 2017). The partridge prefers to nest near to the trails that are frequently used by pedestrians (Fu et al. 2017). As predators may avoid areas where

human activity is high, leading to spatial refuges from predation (Muhly et al. 2011), it is possible that hen partridges lead the chicks back to their nests when they perceive the risk of nest predation to be low. Besides, the main predators of the partridge are some nocturnal mammals with sensitive senses of smell, such as *Prionodon pardicolor* and *Mustela sibirica* (Fu and Chen 2017). It is also possible that the domed-shape nests of the species actually shield the chicks and might reduce their scent releasing into the air around them, thus protecting them somewhat from predators.

The homing times of Sichuan Partridge varied greatly, and the longest homing record was 15 nights (i.e., Nest 201909) (Table 1). Five cases of nest abandonment in advance (compared with Nest 201909) were caused by predators (Nests 201515, 201607, and 201905) and human disturbance (Nests 201405 and 201408), respectively. In the remaining nine cases, the reasons why they abandoned their nests were not clear. Considering that the species faces great nest predation pressure during the breeding period (Fu and Chen 2017), and the recently hatched young moves mainly around the nests not far away, we speculate that the predation risk around the nests might affect “decision-making” (homing or abandonment) of the hen Sichuan Partridges.

Scholer (2015) reported a case of post-fledging use of an old nest by an adult House Wren (*Troglodytes aedon*) and its brood for two consecutive nights when the temperature dropped below freezing to − 2 and − 3 °C,

respectively. Preble (1961) also reported a similar incident of the Wren. As there are only two independent cases, it is difficult to assess whether this behavior is a stable survival strategy in the House Wren. However, most of the hen Sichuan Partridges in our study exhibited same homing behavior, which may represent an adaptive breeding strategy to cope with high predation pressure and low ambient temperature within their breeding habitats to increase the fitness of offspring.

In conclusion, our findings suggest that hen Sichuan Partridges may make trade-offs between the thermoregulatory needs of young versus the predation risks of the broods, which also provides evidence for flexibility in parental care behavior. Future research is needed to assess the impacts of nest ectoparasites on this unusual homing behavior. In this study, we did not track the chicks' fate due to the lack of effective individual identification and tracking technology. Further work is also needed to determine where the family groups roosted after they abandoned the nests, and what impact will these abandonments have on the survival of the young.

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Authors' contributions

YF and ZZ conceived the study; YF and BC collected the Data; SW and SD analyzed the data; all authors contributed to manuscript preparation. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used during the current study are available from the corresponding authors on reasonable request.

Ethics approval and consent to participate

Our study was carried out in agreement with the Law of the People's Republic of China on the Protection of Wildlife and was approved by the Laojunshan National Nature Reserve Administration.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no conflict of interests.

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