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Short Communication

Tick Parasitism in Several Japanese Tits in the Zuojia Nature Reserve, Jilin Province, China

Mingju E[1,3], Kaiyan Li[2], Fangbing Liu[1,3], Lumeng Xu[1] and Duo Liu[1,3]*

[1]*School of Life Sciences, Changchun Normal University, 677 Changjibei Road, Changchun 130032, China*
[2]*Jilin Engineering Laboratory for Avian Ecology and Conservation Genetics, School of Life Sciences, Northeast Normal University, 5268 Renmin Street, Changchun 130024, China*
[3]*Jilin Functional Biomolecule Engineering Research Center, Changchun Normal University, 677 Changjibei Road, Changchun 130032, China*

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ABSTRACT

Ticks as highly specialized blood-sucking arthropods have been reported to parasitize birds. However, in Paridae, there are only reported tick parasitism cases in a few species. In May-July 2023, four adult Japanese tits (*Parus minor*) were found to be parasitized by ticks for the first time in Northeast China. One of the adult hosts was found dead during the incubating period in the nest, and three of the parasitized adult hosts were found while ringing adult birds. All four adult Japanese tits were parasitized by only a single tick each, and the attachment site was under the neck. In addition, the body length and body weight of these four parasitized individuals were higher than the average of those unparasitized individuals. Here, we suggested that one of the original tick species in our study area expanded its host range to include the tits, and the hosts with larger body size are more likely to be parasitized by ticks.

Ectoparasites are common in birds. For parasites, they might preferentially feed on hosts in good nutritional condition (Keymer et al.,1983; Tschirren *et al*., 2007), from which they derive resources for their own growth, survival and reproduction (Durette, 2000). While, the behavioral trait could influence the transmission efficiency. For instance, the swifts *Apus apus* spend most of their time in flight, which may restrict the transmission pathways of ectoparasites that rely on ground or vegetation contact for infection (Lee and Clayton, 1995). In addition, the environmental conditions where hosts of ectoparasites live may also relate to the occurrence pattern of ectoparasites. For example, high relative humidity allows some ectoparasites to search for hosts for a longer period, as high humidity can reduce the likelihood of dehydration for these ectoparasites, thereby increasing their chance of finding and infesting the host (Perret *et al*., 2004). Thus, the interaction between the host's own condition and the parasite's adaptive behaviour may influence host choice (Tschirren *et al*., 2007).

Ticks (Ixodida, Ixodoidea) are highly specialized blood-sucking arthropods (ectoparasites) with three life stages (larva, nymph, adult), and are widely distributed from tropical to subarctic regions (Dehhaghi *et al*., 2019; Wang *et al*., 2023). Ticks can parasitize hosts belonging to a wide range of animal groups, including terrestrial mammals, birds, reptiles, and even humans. Notably, ticks are capable of transmitting many human and animal pathogens. As one of the main hosts of ticks, birds transmit viruses that ticks carry (Buczek *et al*., 2020; Norte *et al*., 2020; Rollins *et al*., 2021).

Ticks have been reported to parasitize birds, such as Trochilidae, Columbidae, Dendrocolaptidae, and Fringillidae (Ogrzewalska *et al*., 2011). Tick attachment sites on birds are generally in thin-skinned locations, such as on the face, ear, eyelid, or crown (Fracasso *et al*., 2019; Ogrzewalska and Pinter, 2016). The great tit *(Parus major)*, which is distributed in the northwestern part of Europe, is mainly parasitized by two types of ticks: Treehole tick *Ixodes arboricola*, which parasitizes birds during breeding and roosting, mainly by parasitizing them in nests (Van *et al*., 2014), and castor bean tick *Lxodes ricinus*, whose larvae

* Corresponding author: liuduoccsfu@163.com
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and nymph primary hosts are ground-feeding birds (Heylen and Matthysen, 2011; Taragel'ová *et al*., 2005), whereas adult ticks preferentially parasitize large vertebrates (Talleklint and Jaenson, 1993). In addition, great tits often suffer mixed parasitism by treehole tick and castor bean tick (Heylen *et al*., 2014; Kocianova *et al*., 2017). However, there are fewer reported cases of tick parasitism in other geographically distributed birds in Paridae.

In our study area, the Japanese tit *Parus minor* is the most abundant bird species. The breeding season of Japanese tits is from April to July. The number of eggs in a clutch is 6-14. The duration of incubation is approximately 13-14 days, and the nestling period is approximately 16-20 days (unpublished data). Some Japanese tits in the population underwent secondary breeding, which began in late May or early June. Since 2012, we have performed macroscopic examinations of adult and nestling Japanese tits. Only in 2023, we found four Japanese tits parasitized by ticks; this was the first time that Japanese tits were found to be parasitized by ticks in our study area. The purpose of this experiment is to explore the tick parasitism in Japanese tits, compare parasitized and unparasitized Japanese tits with each other, and speculate on the possible factors influencing tick parasitism.

Materials and methods

The study site is located in the Zuojia Nature Reserve (44°1′-44°6′N, 126°-126°1′E), Jilin Province, Northeast China. We installed approximately 450 nest boxes on trees 3-4 meters in height. Prior to the breeding season, we annually cleaned the residual nest material in the nest boxes and replaced some of the old, broken nest boxes (Yin *et al*., 2023). We monitored the breeding of secondary cavity-nesting birds, such as Japanese tits (average of 60-100 pairs per year), yellow-rumped flycatcher *Ficedula zanthopygia* (average of 30-40 pairs per year), Eurasian Nuthatch *Sitta europaea* (average of 10-20 pairs per year), and Daurian redstart *Phoenicurus auroreus* (average of 10-20 pairs per year) in the study area. From April to July, we regularly (at least once a week) checked the occupancy of the nest boxes and recorded the breeding status of the birds. From 2012 to 2024, we have performed macroscopic examinations of adult and nestling Japanese tits when nestlings 5-10 days old for ticks. Meanwhile, we ringed and measured their physical parameters, including body weight, length, wing length, tarsus length, tail length, and so on (Li *et al*., 2022). Since we only found four Japanese tits parasitized by ticks in 2023, we conducted a preliminary analysis of the physical indicators of these parasitized individuals and those of unparasitized individuals in the same year. Here, we randomly chose 40 unparasitized Japanese tits (20 females and 20 males in 2023) to show the normal range of measurements for this species. Then, we compared the indicators of these four parasitized individuals with the average indicators of the population.

Results and discussion

From 2012 to 2024, we checked a total of 1239 adults and 6610 fledglings (Table I). Except 2023, we did not find any cases of ticks parasitizing the tits. In 2023, we found that Japanese tits were parasitized by ticks for the first time, with a total of 4 parasitized tits. On May 10, 2023, when we ringed an adult tit in nest box 20-F6, the male was found to be parasitized by one tick at the neck. On May 13, 2023, we found one female tit dead in the nest box 20-B22 in a crouched incubation position; the carcases was still warm when we removed it, and she was parasitized by one tick on her neck. On June 21, 2023, when we ringed the adult tit in nest box 21-F2, the male was also found to be parasitized by a tick on his neck. On June 30, 2023, when we ringed in nest box 20-F1, the female was found to be parasitized by a tick on her neck. For all of the parasitized Japanese tits, we measured physical condition of them (Table II). We found that the body length and body weight of these four parasitized individuals were higher than the average of those unparasitized individuals, while no obvious patterns were found in other physical indicators.

Except for the dead individual, we removed the parasitized ticks from the body surface to protect the birds. No secondary patriotization or death was observed during subsequent observation or monitoring. Since the four tick specimens had not been carefully preserved and the number of samples was insufficient, we could not accurately identify the species.

Table I. Number of ringed adults and fledglings of Japanese tits in the Zuojia Nature Reserve, Jilin, 2012-2023.

Year	Number of ringed adults	Number of ringed fledglings	Number of birds parasitized by ticks
2012	90	412	0
2013	46	228	0
2014	34	513	0
2015	45	373	0
2016	42	342	0
2017	52	472	0
2018	122	545	0
2019	176	658	0
2020	161	690	0
2021	142	512	0
2022	64	370	0
2023	142	724	4 (adults)
2024	123	771	0
Total	1239	6610	4

Table II. Comparison of physiological parameters between unparasitized and parasitized Japanese tits in 2023.

Physiological parameters	Mean (Min~max) of unparasitized tits		Parasitized Japanese tits			
	Female (n=20)	Male (n=20)	Female ID		Male ID	
			20-B22	20-F1	21-F2	20-F6
Bill length (mm)	10.16 (9.24~11.07)	9.91 (9.00~11.20)	9.33	10.94	11.35	9.67
Skull width (mm)	17.06 (14.40~20.00)	17.73 (14.74~20.71)	16.21	17.63	16.76	16.28
Head length (mm)	27.86 (24.05~29.77)	28.00 (24.51~30.86)	28.31	28.93	29.99	28.42
Head height (mm)	10.79 (8.81~14.30)	12.13 (9.13~14.20)	9.87	9.31	9.82	11.56
Tarsus length (mm)	21.76 (19.40~23.86)	22.01 (18.40~24.25)	19.29	20.77	22.79	23.31
Wing length (mm)	66.14 (59.60~70.89)	70.34 (64.41~76.96)	70.56	69.21	67.25	64.61
Tail length (mm)	59.80 (52.30~68.25)	63.72 (57.00~74.22)	60.78	61.73	66.14	59.56
Body length (mm)	125.30 (117.95~130.14)	131.32 (120.00~139.42)	129.34	130.61	134.32	136.92
Body weight (g)	13.55 (5.18~14.86)	14.71 (13.42~15.46)	15.20	14.59	16.25	15.31

In 2023, the four adult Japanese tits that were parasitized by ticks bred in new nest boxes. These boxes were specifically introduced to replace any old or broken ones that were previously in use. According to a previous study, ticks prefer to parasitize nestlings if both adults and nestlings can be parasitized (Heylen *et al*., 2014). However, we did not find Japanese tit nestlings parasitized by ticks during our nest box inspections. Therefore, it is highly unlikely that ticks will hide within the nesting material inside the nest boxes. We presumed that four adult tits were possibly parasitized by ticks, most likely when they were roosting or feeding outside the nest.

All four tits were parasitized by only one tick individual. Ticks are heterogeneously distributed among host individuals, then some individuals are susceptible to being parasitized by multiple ticks at the same time (Shaw and Dobson, 1995; Woolhouse *et al*., 1997). Hundreds of Japanese tit adults and fledglings have been ringed and checked every year. However, we never found any cases of them being parasitized by ticks except 2023. According to our observation, the number of rodents in the study area is decreasing annually. When the number of hosts for ticks becomes too small, it is necessary to expand the range of hosts. Therefore, the possible reason why Japanese tits were suddenly infected with ticks may be that the survival conditions for ticks have seriously deteriorated in this special year.

The attachment site of all four Japanese tits was the neck. Ticks generally choose to feed on thin skin locations, and the thin skin under the neck of birds is suitable for attachment (Barré *et al*., 1991). However, other common attachment sites in birds, such as the face, ear, eyelid, and crown, have not been found to be parasitized. Although the samples of the ticks were not adequate, we could identify them as the same genus by field observation. Therefore, we suggest that this species is rarely parasitize the Japanese tits at our study site and that it is the easiest site to attach. However, as the sample size increases, there is also the possibility of discovering instances where ticks reside in tits other body sites.

The four parasitized Japanese tits had higher body length and body weight than unparasitized individuals. One possible explanation is that individuals with larger body size are more likely to be parasitized by ticks. A larger host body size would lead to a greater surface area and perhaps a more complex surface architecture within which to escape host-grooming activities (Rózsa, 1997). In addition, Ticks as blood-sucking parasites may trigger certain responses in the host's body. For example, the host may attempt to increase its food intake to maintain or restore its blood volume and overall energy balance, leading to weight gain potentially (Tschirren *et al*., 2007).

Additionally, we found an incubating female Japanese tit dead in her nest. Ticks can harbor a variety of viruses, such as Bourbon virus (Shah *et al*., 2023) (BRBV), Dhori virus (DHOV), and Powassan virus (POWV), which can affect their hosts through parasitic relationships (Yu *et al*., 2021). Therefore, we suggest that the host was parasitized by a tick harboring a particular virus and that the host may have died as a result of the infection.

Conclusions

This study enriches the recorded species of tick hosts, even the Japanese tits were the rare hosts. In this study, all four parasitized individuals were adult birds, with ticks attached at the base of the neck. Each parasitized individual was parasitized by only one tick. In addition, the body length and body weight were higher in parasitized individuals. We propose that a larger sample size of parasitized and unparasitized Japanese tits could help better understand the relationship between hosts and ticks, providing valuable insights into the ecology and evolution of tick-host interactions.

DECLARATIONS

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Statement of conflict of interest

The authors have declared no conflict of interest.

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