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Alopecia in Rickett's Big-Footed Bat *Myotis ricketti* (Chiroptera: Vespertilionidae) in Relation to Age and Sex

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Zhan-Hui Tang, Guang-Liang Zhang, Lian-Xi Sheng, Ti-Yu Hong, Guang-Jian Zhu, Jian Yang, Yan-Yan Gong, Yu Zeng, Hui-Jian Hu, and Li-Biao Zhang (2012) Alopecia in Rickett's big-footed bat *Myotis ricketti* (Chiroptera: Vespertilionidae) in relation to age and sex. *Zoological Studies* **51**(4): 494-499. We report alopecic syndrome (hair loss) in Rickett's big-footed bat *Myotis ricketti* (Chiroptera: Vespertilionidae), in Guilin, China, from June 2009 to Sept. 2010. The coat condition of bats was scored on a 3-point scale: AS0 (normal), AS5 (sparse hair), and AS10 (alopecia). Abnormal hair patterns were observed between early June and late Sept. when fresh hair again covered the abnormal region. The prevalence of alopecic syndrome varied in relation to age and sex, and reached a peak in late June. Adult females showed significantly higher incidences of prevalence of alopecic syndrome (90.9%) than adult males (55.3%) (χ^2 = 23.0, *d.f.* = 1, $p < 0.01$) from June to Aug. However, in immature bats, alopecia patterns were not observed in either sex, and only a sparse (AS5) hair condition occurred. No difference in the incidence of the condition was noted between males (51.5%) and females (60.0%) (χ^2 = 0.8, *d.f.* = 1, $p > 0.01$) from July to Aug. There was a significant difference between adults and juveniles (age) in the scale of occurrence of alopecia, and also its prevalence (χ^2 = 11.4, *d.f.* = 1, $p < 0.01$). We propose that parasitism, androgens, anthropogenic activities, or a combination of these factors might account for age and sexual differences in alopecia. http://zoolstud.sinica.edu.tw/Journals/51.4/494.pdf

Key words: *Myotis ricketti*, Alopecia, Age difference, Sexual difference.

Alopecic syndrome (hair loss over areas of the body, including the head, chest, abdomen, neck, and back) rarely occurs in non-human mammals, although a few studies reported recurrent flank alopecia in dogs (Scott et al. 2001, Bassett et al. 2005, Gomes et al. 2008), alopecia areata in cows (Paradis et al. 1988), and also alopecia in bats (Pedersen et al. 2003 2009, Bello-Gutiérrez et al. 2010). Generally, hair loss in mammals can occur because of a range of factors, including mineral disorders and deficiencies, plant toxins, ectoparasites, lactation, infectious diseases, a vitamin imbalance, loss of genetic diversity, mutations or immunologic disorders, and general stress working alone or in concert as likely causal agents (Noxon 1995, Novak and Meyer 2009). Pedersen et al. (2009) presumed that alopecia in bats on Montserrat was due to a zinc deficiency and/or ingestion of plant toxins. Tiunov and Makarikova (2007) demonstrated seasonal molting in female *Myotis petax* when examining patterns of pigmentation on the underside of the skin using a dissecting microscope. Cryan et al. (2004) also demonstrated seasonal molting in hoary bats

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Lasiurus cinereus using a stable hydrogen isotope analysis of hair. Bats typically molt into a new pelage once per year (Quay 1970), but in this study, we found that hair loss in Rickett's big-footed bat *Myotis ricketti* (Chiroptera: Vespertilionidae) was not associated with normal molting. Alopecic syndrome in *M. ricketti* was regularly observed during our field study on the reproduction biology of this species over several years (Wang et al. 2008), but no systematic data were initially collected until 2009 and 2010. The aim of the present study was to present systematic information on age- and sex-biased patterns of alopecic syndrome in *M. ricketti* studied in Guilin, southern China.

MATERIALS AND METHODS

Study site

The study was conducted at Seven Star Cave, in urban Guilin City, Guangxi Province, South China. The colony of *Myotis ricketti* studied resides in a limestone cave, situated within a typical karst landscape. This region has a subtropical climate with an annual mean temperature of 19.3°C, and an annual precipitation averaging 1900 mm with seasonal variation. The cave is 1100 m long, 50 m at its widest point, and 20 m at its highest point. It has 2 entrances, with one (about 15 m above the ground) used as a tourist corridor and by most bats that roost in the cave. The other entrance is at the foot of the opposite side of the hill and is locked by an iron-grid gate. The cave was also occupied by *M. siligorensis*, *Nyctalus plancyi*, *Pipistrellus pipistrellus*, *Hipposideros armiger*, *H. larvatus*, *H. pratti*, *Rhinolophus rex*, *Miniopterus fuliginosus*, and *Ia io* during the study period.

Bat captures and pelage observations

Visits were undertaken toward the end of each month between June and Sept. in 2009 and 2010. Bats were captured with mist nests when they emerged before and returned to the cave after nightly foraging. Each *M. ricketti* captured was held in a cotton cloth bag before it was transported to a laboratory at the College of Life Science, Guangxi Normal Univ., situated 4 km away from the capture site. All other bat species captured were immediately released. *Myotis ricketti* individuals were sexed and aged, and the reproductive condition of females and coat condition were noted. Juvenile bats were defined on the basis of epiphyseal gaps, being differentiated from adults by the degree of fusion of the epiphyses at the metacarpal-phalangeal joints (Kunz and Anthony 1982, Kunz and Robson 1995), and also based on fur color as adults have reddish-brown dorsal fur compared to the steel-grey hair of juveniles. Alopecic syndrome was scored on a scale of AS0, AS5, and AS10 (Table 1) (Olsen et al. 2004, Honess et al. 2005, Berg et al. 2009). To ensure consistency, the same person carried out all observations. Bats were released at the site of capture after the coat condition was examined.

Statistical analysis

The accuracy of the statistical analysis was limited by the difficulty in obtaining enough wild-caught individuals. We could not obtain enough specimens except in July (168 individuals), as ambient temperature continually decreased during autumn, and respective sample sizes for the investigations in June, Aug., and Sept. were 25, 60, and 26 bats. All samples included adults and juveniles except in June, which included only adults (juveniles were not yet volant, so were not trapped in the nets).

We tested for differences in prevalence related to the sex of adults and juveniles using a χ^2 test for independence. All statistical analyses were performed with SPSS 17.0 (SPSS, Chicago, IL, USA). In Sept., almost no individuals showed signs of alopecic syndrome (with a prevalence of 3.8%; 1/26 bats), so data from this month were not applied in the tests. Chi-square tests were

Table 1. Coat-condition grade indices in *M. ricketti* used to quantify alopecic syndrome

Score		Criterion
AS0	Good	No signs of hair loss; normal, full hair cover
AS5	Sparse	Some areas showing signs of hair loss only, but not totally bare; some sparse hair growth visible
AS10	Alopecia	At least 1 area with absolute or total hair loss; bare skin visible

used to test for differences in the prevalence of alopecic syndrome between adult male and female individuals from June to Aug. combined. Because most juveniles were not capable of flight in June, we tested for differences in the prevalence of alopecic syndrome between sexes of juveniles, and for a difference in the prevalence of alopecia between adults and juveniles from July to Aug. only.

RESULTS

Alopecic syndrome patterns

During fieldwork, we diagnosed alopecic syndrome in *Myotis ricketti*. The syndrome was characterized by hair loss, mostly on the scalp (head), and on the abdomen in some cases. A few individuals demonstrated hair loss on the back and neck (Fig. 1). Alopecia was found in males and females and ranged from slight (AS5) to severe (AS10). Alopecic syndrome patterns (AS5 and AS10) were observed in *M. ricketti* from June to Aug., while AS10 was observed only in adults, in which AS10 was a significant phenotype (Fig. 1A-C).

Seasonal changes in hair patterns

We captured 279 individuals of *M. ricketti* in the 2 summers. Alopecic syndrome phenotypes were observed during all visits. In late Sept., almost all individuals with alopecic syndrome had new hair in the alopecic region (Fig. 1D), but 1 individual (3.8%; 1/26 bats) with alopecic syndrome (AS5) was observed. The overall prevalence of alopecic syndrome in the samples continually decreased from 88.0% in June to 3.8% in Sept., while the prevalence of AS10 continually decreased from 52.0% to 0%; however, the highest prevalence of AS5 occurred in Aug. (Table 2). During the period of the highest prevalence of alopecic syndrome (June to Aug.), 78.5% (106/135 bats) of individuals experienced hair loss in adults, of which 67.9% (72/106 bats) of specimens were

Fig. 1. Images of alopecic bats of *Myotis ricketti* captured in Seven Star Cave, Guilin City, Guangxi Province, South China, from June 2009 to Aug. 2010. Alopecia normally appeared on (A) the head and neck, (B) chest and abdomen, and (C) head. In late Sept., fresh hair covered the previously affected abnormal region (D). (A) AS5, (B) and (C) AS10, (D) AS0, as defined in table 1.

severely hairless (AS10) in the syndrome region, and 32.1% (34/106 bats) were categorized as AS5. The overall prevalence of alopecic syndrome was 55.1% (65/118 bats) in juveniles in July and Aug. combined.

Sex and age differences

During the 2 summers of investigations, the alopecic phenotype (AS10) and the sparse phenotype (AS5) were observed in adults, but only AS5 was observed in juveniles. Alopecic syndrome was mostly observed from June to Aug., so sex differences related to the prevalence of alopecic syndrome were analyzed based on the data collected during this period. Individuals with alopecic syndrome comprised the majority of adults (78.5%; 106/135 bats), and 55.1% (65/118) showed signs of alopecic syndrome in juveniles. The prevalence of alopecic syndrome was higher in adults than juveniles ($\chi^2 = 11.4$, $d.f. = 1$, $p < 0.01$).

In adult females, 90.9% (80/88 bats) of individuals showed signs of alopecic syndrome, and in adult males, 55.3% of bats showed signs of alopecic syndrome (26/47 bats). In juveniles, 60.0% (30/50 bats) of individuals were scored as AS5 in females, and 51.5% (35/68 bats) in males. We found that the prevalence of alopecic syndrome in adults differed between the sexes ($\chi^2 = 23.0$, $d.f. = 1$, $p < 0.01$), with the prevalence of alopecic syndrome higher in adult females than males. There was no difference in the prevalence between female and male juveniles during the study period ($\chi^2 = 0.8$, $d.f. = 1$, $p = 0.45$).

DISCUSSION

Rickett's big-footed bat *Myotis ricketti* showed varied patterns of hair-coat condition throughout the course of the 2 summers. The proportion of individuals exhibiting alopecic syndrome decreased from June to Sept. Compared to adults, juveniles only showed a low incidence of alopecic syndrome for a relatively short time period. In *M. ricketti*, remarkable sex differences in the prevalence of alopecic syndrome occurred in adults from June to Aug., but there was no significant sex-related difference among juveniles. Perhaps juveniles experience similar levels of parasite exposure and hormone profiles during the early stages of life (Lučan 2006, Christe et al. 2007, Zhang et al. 2010). We have no data of the situation in other months of the study years due to the absence of *M. ricketti* from the study area, so the time of emergence of alopecic syndrome could possibly be earlier than June. But late Sept. was clearly when alopecic syndrome ended, because individuals that had experienced alopecic syndrome again exhibited normal hair length in the affected regions, although these new hairs were fresh and lighter in color compared to the darker, older hair.

Fur loss in wild bats is rarely observed, but when noted, it was frequently related to ectoparasite infestations or normal physiological conditions, such as reproductive behavior or molting (Bello-Gutiérrez et al. 2010). In captivity, alopecia in bats was attributed to endocrine disorders or poor nutrition (Bello-Gutiérrez et al. 2010) and can respond to increases in dietary micronutrients (Heard 1999).

Several studies showed that species (including mammals, birds, and frogs) inhabiting urban areas may exhibit differences in the prevalence of infectious diseases compared to those inhabiting more-natural suburban and rural areas. Also, urban wildlife is usually exposed to higher pollutant concentrations and other stresses (Bradley and Altzier 2007, Bello-Gutiérrez et al. 2010). The Seven Star Cave in which we observed the prevalence of alopecic syndrome in *M. ricketti* is a tourist attraction, and attracts many people in

Table 2. Season, age, and severity variations in the prevalence of alopecic syndrome in *M. ricketti* captured at Seven Star Cave, Guilin City, Guangxi Province, South China, from June 2009 to Sept. 2010

Month	Prevalence in adults		Prevalence in juveniles	Overall Prevalence	
	AS10	AS5	AS5	AS10	AS5
June	52.0%	36.0%	0%	52.0%	36.0%
July	57.3%	21.3%	51.9%	30.4%	35.7%
Aug.	38.1%	28.6%	61.5%	13.3%	50.0%
Sept.	0%	0%	3.8%	0%	3.8%

AS5 and AS10 are described in table 1.

summer, suggesting that anthropogenic activities may have influenced the coat condition, as tourism affects the pelage of ring-tailed lemurs *Lemur catta* (Jolly 2009) due to anthropogenic disturbance. This however is an unlikely hypothesis as the other bat species roosting in the cave do not suffer alopecic syndrome under similar levels of disturbance.

Reproduction and foraging behavior may affect alopecic cycles. *Myotis ricketti* lactates during late May, and juveniles are weaned in late June (L. Zhang, unpubl. data), which was also the period of highest prevalence for alopecic syndrome. The higher prevalence of alopecic syndrome in adult females suggests that increased reproductive efforts combined with anthropogenic activities could be producing nutritional or endocrine disorders leading to alopecic syndrome.

Hormonal effects may also account for alopecic syndrome in *M. ricketti*. Androgens have profound effects on scalp and body hair in humans; scalp hair grows in the absence of androgens, while body-hair growth is dependent on the action of androgens (Kaufman 2002). Also, negative associations between steroid hormones, particularly testosterone, and immune responses are thought to play a major role in sex-biases in infestation by parasites (Grossman 1985, Zuk 1990, Folstad and Karter 1992, Roberts et al. 2004), and elevated testosterone levels can increase exposure to and transmission of parasites (Grear et al. 2009). Because temperate-zone bats typically mate during autumn, testosterone reaches its highest levels between mid-summer and early autumn. One would therefore expect seasonal variations in hair-coat conditions and/or parasite preferences, because parasites could take advantage of the immunosuppressive effect of testosterone and infect males during mating when opportunities for parasite transmission between sexes are high (Christe et al. 2007). Some researchers demonstrated that parasitism is a key factor influencing fitness in most organisms (Clayton and Moore 1997, Fredensborg and Poulin 2006, Dingemanse et al. 2009, Ho et al. 2011). We found lots of mites on bats captured during the investigation period, which suggests that ectoparasites might be a primary cause of alopecic syndrome in *M. ricketti*, and these abnormal hair patterns may have evolved to reduce the prevalence and/or intensity of parasite infections (or be pathological byproducts of an infection).

The mechanism accounting for seasonal and sexual differences in alopecia in *M. ricketti* is not clear. We propose that parasitism, androgens, or the combined effect of both might be possible causes of alopecia in *M. ricketti*. However, we should not rule out other possible causes such as dietary factors. As a fish-eating bat (Ma et al. 2003), *M. ricketti* is vulnerable to contamination (via fish) from environmental pollution. *Myotis ricketti* may be more vulnerable to parasites compared to other species as a price of its dietary specialization. If parasitism has been important in the evolution or maintenance of morphological plasticity in a host population, we would predict that the scalp pelage morphology of bats from populations at a higher risk of parasitism (or a higher intensity of parasites) should be more plastic than that seen in bats from populations with a lower risk (or a lower intensity of parasites). This might explain why *M. ricketti* alone presented seasonal alopecia, whereas it was not observed in other species in the same cave.

Additionally, heat dissipation and negative influences in the abiotic environment may also contribute to seasonal alopecia in *M. ricketti*. So, future studies should focus on possible causes, perhaps using experimental manipulations of parasite loads, and comparisons with rural *M. ricketti* populations, so that sex-biases in the occurrence of alopecia can be elucidated.

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