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Aggressive behaviour of greater mouse-eared bat (*Myotis myotis*) towards lesser horseshoe bats (*Rhinolophus hipposideros*) in a hibernaculum

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Introduction

Aggression occurs in many forms and can be an important adaptive behaviour (Rarmirez, 1998). Also among bats, aggressive behaviour is observed in different situations, and can take on different forms, as occurs in other mammals. Aggression in bats has been observed during feeding. This behaviour is expressed through chasing and pursuing fight patterns as well as through scaring away a newcomer of the same or different species from the feeding area (Ransome, 1990). Many times this type of behaviour is accompanied by agonistic and aggressive calls generated and emitted by the aggressive bat (Racey and Swift, 1985; Ransome, 1990; Barlow and Jones, 1997).

Aggressive behaviour is also often observed during the mating season (McCracken and Wilkinson, 2000). In this case, it concerns the males, which defend their roost sites (Davidson and Wilkinson, 2004) or female groups (McCracken and Bradbury, 1981; Gerell-Lundberg and Gerell, 1994). Such behaviour is also observed in mating colonies and consists of utilizing and defending the traditional roosting and foraging sites by females (McCracken and Bradbury, 1981; Rydell 1989; Kerth *et al.*, 2002). In most cases, the aggression is usually reduced to agonistic behaviour, that is, to confrontational behaviour without fighting. However, there are rare incidents of direct fights (physical contact) between bats (Rydell, 1986), which very rarely lead to the

wounding or death of a bat (Bell, 1980). The aggressive behaviour of bats, which results in the wounding or a killing of a bat, is, of course, connected to the carnivorous nature of some species (Fischer *et al.*, 1997), cannibalism, or infanticide (Kunz and Ebensperger, 1999; Hinkel and Weidner, 2005), as well as to rabies (Bell, 1980; Caire, 1998). Often, aggressive behaviour among bats is observed during transport and/or in captivity (Wimsatt, 1959; Hinkel and Weidner, 2005). However, during hibernation aggressive behaviour among bats, which leads to the wounding or even death of another individual, is extremely rare (Jurczyszyn, 1995; Hinkel and Weidner, 2005).

Materials and Methods

The behavioural observations of *Myotis myotis* were carried out in the Zbójecka in Łopień Cave (20°17'E and 49°42'N). The cave is situated in southern Poland, in the Beskid Wyspowy Mountain Range of the Flysch Carpathians, on the northern slope of Mt. Łopień. Three entrances are situated at the height of about 880 m a.s.l. The passage involved is about 433 m long and 19 m of denivelation. It is the largest hibernaculum of *Rhinolophus hipposideros* in Poland. A winter colony of this species numbers from about 160 to 500 individuals (the count numbers were obtained between 1997–2005, in the middle of the winter season, i.e. in February). Furthermore, members of other eight species have been observed hibernating in the cave. However, their number has never exceeded 10 individuals (author's unpubl. data). Almost all of the bats remained in the largest hall (10 m high, 4 m long, and 3 m wide) or in its nearest vicinity.

Results

During one of the routine observations, on March 20th, 2003, a case of fatal aggression by *M. myotis* was observed. It involved an action of continuous wing beating and biting of one *R. hipposideros* lying on the floor of the cave. The very moment of knocking down or capturing the victim was unfortunately not observed. Most of the beating and biting actions were concentrated on the victim's head and neck. The fallen bat tried to defend itself by biting and emitting audible distress sounds. Its movements, however, were slow (either as a consequence of being only partially aroused from torpor, or being weakened by the inflicted wounds). The greater mouse-eared bat did not react to the light or even to the very close human presence. It was not until an attempt to photograph the bat from the nearest possible distance was made that the greater mouse-eared bat took fright and flew away. The events described took place in the span of a few minutes. The outcome of this behaviour was the death of the female *R. hipposideros*. An examination of the dead bat's body showed there were no external injuries except for intensive bleeding from its ears and eyes (Fig. 1). At a distance of a few metres from this place, another dead individual *R. hipposideros* was found. Its death probably occurred several, or several dozen, minutes earlier because its wounds were still fresh and unclotted blood spots were visible (Fig. 1). The injuries of this individual were much more serious. The bat's right forearm was broken in two places, and intensive bleeding from the ears and eyes had occurred. Although the death of this bat was not observed directly, the events and the characteristics of the inflicted wounds strongly suggest that this individual was also killed by *M. myotis*.

Furthermore, close to the second victim, at a distance of about 1 m, another two dead *R. hipposideros* were lying next to each other in a state of decay. It is hard to precisely determine the time of their death. However, it probably took place no earlier than March 4th (the day of the previous survey visit). These two bats had skeletal injuries in the form of a broken forearm and finger bones as well as a lack of one-third of the parts of the wing membranes which contain the finger bones. Furthermore, a torn abdominal integument was observed on one of the

FIG. 1. Lesser horseshoe bats *R. hipposideros* killed by greater mouse-eared bat *M. myotis* (the arrows point out the places of breakage)

victims (however, no damage to the soft tissues was noticed).

Whilst making these observations the behaviour of the greater mouse-eared bat that had killed the other bats was also observed. The observation itself was not hard to make because the bat remained within the same hall all the time. Throughout this whole time period, the bat flew from place to place. The flights were interrupted by short resting periods. These observations covered about 1.5 h, during which time no more aggressive behaviour was observed. When the bat was captured, it turned out to be a female. Its body mass was 28.5 g and its forearm length was 63.7 mm. The behaviour of the captured bat was normal; the bat intensively defended itself and bit. No signs that it had been fighting were noticed. The captured bat was passed on to the Veterinary Inspectorate where it underwent tests for the presence of the rabies virus. The tests did not confirm its presence.

DISCUSSION

To our knowledge this is one of the very few observations of fatal aggression by *M. myotis* against a different hibernating bat species in the wild. Previously aggressive behaviour of *M. myotis*, resulting in the death and/or devouring of another bat was observed only in captivity (Kolenati, 1856; Brehm, 1864; Landois, 1883; Hinkel and Weidner, 2005). This behaviour is extremely rare during the hibernation period. One such direct observation took place in Poznań's forts (Jurczyszyn, 1995). The author observed active *M. myotis* bats not only poking hibernating individuals, but also often biting these other bats and even knocking them off their perches. One of the displaced males, which had been bitten around the genital area, died soon after the fall.

In this report, the aggressive behaviour of *M. myotis* towards *R. hipposideros* bats described, may be ascribed to the nature of its carnivorous aggression. It seems that the most probable cause of this behaviour was the intention to kill the bat and, furthermore, to devour it in order to quench hunger and replenish the its diminished energy supplies during this period.

The loss of wing fragments of one of the victims seems to confirm this and may also confirm the attempt of eating the victim. The diet studies of this species so far have not confirmed the presence of any vertebral

remains (Bauerová, 1978; Audet, 1990; Graf *et al.*, 1992; Arlettaz, 1995). The propensity for eating other bats by *M. myotis* is also confirmed by the observations in captivity or/in transport where the greater mouse-eared bats ate other bats entirely (Kolenati, 1856; Brehm, 1864; Hinkel and Weidner, 2005) or killed other bats and ate only wing fragments, much as what probably took place here in one specimen (Landois, 1883; Hinkel and Weidner, 2005).

The present case supports the hypothesis that this carnivorous behaviour was the result of the time of year when it occurred. At the end of the hibernation period, the bat's fat supplies accumulated during the summer and autumn seasons are being depleted (Ransome, 1968, 1990). Even during the hibernation period, when the circumstances are right, the bats, can leave the hibernaculum in order to feed themselves (Whitaker and Rissler, 1993). Due to the fact that the atmospheric conditions in the Beskid mountains during this period did not allow feeding beyond the hibernaculum (the average night temperature during this period was oscillating around zero), the bats might have tried to replenish their fat supplies by killing and eating other bats.

Myotis myotis, in continental Europe, feeds on, above all, the flightless ground-dwelling arthropods, particularly species from Carabidae (Bauerová, 1978; Audet, 1990; Graf *et al.*, 1992; Arlettaz, 1995). Thus, this species is equipped with strong teeth that are well adapted for killing victims with a hard crust.

An example which indicates the strength of the bats' teeth is the fact that the forearm bones in one of the bats were broken in two places. The strength of the jaws and the teeth allows the bat to kill other bats. One cannot exclude the possibility that in extreme situations, during the hibernation period, when the fat supplies are very low, this species can kill other bats and devour them in order to survive the hibernation period.

Cases of carnivorous behaviour by bats during hibernation are extremely rare. Regular surveys in a *Nyctalus noctula* hibernaculum allowed the observation of a case of one individual of this species being eaten by two others. However, it was impossible to definitely tell if it was killed by the two bats earlier or if it died of natural causes and became their food later (Hinkel and Weidner, 2005).

However, against the hypothesis of the aggression being the result of starvation are the relatively favourable body reserve state of *M. myotis* and the lack of damage to most of the soft tissues of the dead bats. The body mass of *M. myotis*, which acted in an aggressive manner, is similar to the mass of other *M. myotis* females hibernating in Poland at this time of the year. The average body mass of the females, examined in the middle of March 2006 in Międzyrzecz Underground Fortifications, was 27.7 g (n = 10), in some cases even 32 g (K. Rogowska and T. Kokurewicz, personal comm.). In eastern Poland (Krzanowski, 1961), similarly, the female's average body mass exceeded 31 g in February, whereas in April it constituted less than 28 g, in some cases exceeding 31 g (for that reason the mass had to be higher in March). Therefore, it seems that the energetic potential of the *M. myotis* female did not exclude the starvation-based aggression. The lack of losses in the victims' soft parts does not explicitly exclude this hypothesis. In some cases an aggressively behaving *M. myotis* would consume a flying membrane of a bat — without affecting the victim's soft tissues (Landois, 1883; Hinkel and Weidner, 2005). It is difficult unambiguously to determine what was the reason for the animal's aggressive behavior. The gathered evidence indicates that the above situation could be the consequence of the carnivorous

aggression, though it is impossible to reject other little known causes of described behaviour.

It is worth noticing that hibernation is the only period when this type of attack by *M. myotis* towards *R. hipposideros* can be successful. A torpid bat is unable to defend itself successfully or to escape from a predator for a significant time period. The time taken for a torpid lesser horseshoe bat to become fully awake in these thermal conditions (the recorded temperature in the place where the bats were being observed was 7°C) is more than 30 min (Harmata, 2000). It seems that it is sufficient time for *M. myotis* to be able to kill or wound badly *R. hipposideros* and thus prevent it from escaping or significantly restricting its defensive abilities without exposing itself to wounding. During the period of normal activity the body parameters of *M. myotis*, that is size, wing morphology, and aerodynamics, would not allow this carnivorous behaviour (Norberg and Fenton, 1988). In addition, the bats from the rhinolophid family are characterized by a manoeuverable flight pattern (Neuweiler, 1989) and, probably, an attacked, active, and flight-capable horseshoe bat would easily escape. Thus, during this period such an attack would most likely have been unsuccessful. In this case, an attack coming from land predators and birds should be ruled out. For the most part they eat their victims entirely, and we know that the bats are part of their diet from analyses of their fecal or owl pellets, where the undigested vertebral remains are seen to be crushed and broken, and soft tissues digested. Here, the bodies of the two bats were found to be well-preserved and lying right next to each other. Secondly, the accessibility to the cave's roof above the place where the bats were found is most likely limited for land predators, and the areas where they were found are too difficult of access and too distant from the entrance, and thus are inaccessible to birds. The body damage characteristics also strongly indicate that they were the victims of another bat's attack. Death by natural causes should also be ruled out. It is most unlikely that this type of death could have happened to these two bats which were hibernating right next to each other. Dead *R. hipposideros* are rarely observed in the Zbójecka in Łopień Cave.

The data presented suggests that some insect-eating bat species may quench their hunger by killing other bats and eating parts of them in the late hibernation period. The lack of data regarding this type of behaviour during this period may result from the fact that making this type of observation requires constant monitoring. In the winter season within hibernacula, this is a difficult thing to do.

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