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RESEARCH PAPER

Issues in bat (Chiroptera) treatment and rehabilitation: the scale of the problem, reasons and effects of interventions

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Abstract. Bats are the second most numerous group of mammals in the world, after rodents. About 1,400 species have been described, of which 27 occur in Poland. All bats found in Poland are subject to strict species protection. Therefore, activities related to detention, including the treatment of injured, ill, or malnourished individuals, require appropriate permits. Caring for these mammals also requires knowledge of the biology and ecology of native species. Surveys were conducted in Polish wildlife rehabilitation centres, as well as among bat workers. The described interventions took place from September 2015 to September 2017. During this period, a total of 962 bats were taken under care. Most of the specimens required feeding and/or watering (645 specimens), 137 specimens suffered from injuries and/or diseases, 97 specimens were given emergency care, 77 specimens were taken from the environment without justified cause, and six specimens were born in captivity. Most of the interventions (760 individuals) resulted in the bats being released, 84 individuals remained under treatment or rehabilitation, 69 died, and a further 49 were euthanized. Statistical analysis showed a difference in the reasons for intervention and the intervention outcome between the care provided by rehabilitation centres and bat workers.

Key words: bat workers, injuries, disease, threats, care, protection

Introduction

Bats are the second most numerous group of mammals in the world, after rodents. So far, about 1,400 bat species have been described worldwide (Simmons 2019), belonging to two suborders; Yinpterochiroptera and Yangochiroptera (Teeling et al. 2005). There are 27 species in Poland from the suborder Yangochiroptera. All bat species across the whole of the European Union are under legal protection. The protection of bats is also regulated by the Bonn Convention, the Bern Convention, the Agreement for the Protection of Bats in Europe – EUROBATS, and the Habitats Directive of the European Union. Seven species were included in the Polish Red Data Book of Animals (Głowaciński 2002a) as endangered or near-threatened species, and eight species were included in the red list of endangered and endangered animals (Głowaciński 2002b). Despite many studies

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conducted on bat faunas, it is still a poorly known group of animals. Likewise, the causes of their mortality are poorly understood. It is known that human activity and negative changes to the natural environment caused by urbanization, agricultural intensification, and industrialization have resulted in a decrease in habitat and feeding grounds (Piskorski 2015). In the 20th century, there was a decline in bat populations caused by the use of DDT-based wood preservatives and toxic pesticides, mainly insecticides (Geluso et al. 1976, Clark 1981, Thies & McBee 1994, Urbańczyk 2000, Bennett & Thies 2007, Dietz et al. 2009). Due to their small body size, the remains of dead individuals are rarely found, making it extremely difficult not only to determine the scale of mortality but also to know the causes of death, which in turn makes it difficult to plan effective protective measures. Contemporary threats to the bat population are mentioned in more detail by Frick et al. (2019), who highlight urbanization. Bat intrusions into apartments and offices were observed in large cities (Dietz et al. 2009, Klimaszewski & Popczyk 2014). Deprived of the possibility of escape, and without access to water and food, they cannot enter torpor or hibernate due to elevated temperatures, leading to weakness or death by starvation. There is also a risk of injuries directly caused by people who, out of fear, attack bats flying around their houses. Stebbings (1988), documented "the many purposeful killing of bats in Europe". This behaviour is largely due to lack of knowledge about bats. Another serious problem is domestic cats that hunt bats causing serious injuries (Ancillotto et al. 2013). According to Lesiński (2000), in the Kampinos Forest (a big forest complex in Central Poland), one cat hunted ten bats in a week, and in the period from 2002 to 2008, 17 cat attacks on bats of five species were described (Lesiński et al. 2008). Other animals hunting bats in Poland are birds of prey, including owls (tawny owl *Strix aluco*, barn owl *Tyto alba*, long-eared owl *Asio otus*, little owl *Athene noctua*, short-eared owl *Asio flammeus*, eagle owl *Bubo bubo*; Kowalski & Lesiński 2002) and martens *Martes* spp. Hibernating bats may periodically be the main component of the diet of the beech marten *Martes foina* (Tryjanowski 1997), and raccoon *Procyon lotor* (Cichocki et al. 2020). Bird predation on bats can be significant. In the UK, it is estimated that birds of prey kill 200,000 bats annually (Speakman 1991). Bats, like other animals, also suffer from traffic accidents. Road infrastructure has a significant impact on bat mortality (Lesiński 2011, Gołębniak 2012). The situation is similar in the case of wind farms. According to O'Shea et al. (2016), wind farms account for the highest number of bat deaths.

In some cases injured or debilitated bats are taken under human care. Most of these are transferred to wild animal rehabilitation centres, the rest are dealt with by bat workers. Surveys were conducted to determine the scale of the problem of bats requiring assistance in Poland, to determine the causes of their diseases and injuries, and to identify species that most often require assistance. The causes and effects of interventions by rehabilitation centres and direct bat workers were also compared.

Material and Methods

In 2016-2017, surveys were conducted in wild animal rehabilitation centres throughout Poland, as well as among Polish bat workers. Only centres that dealt with the rehabilitation of mammals were taken into account. Bat workers were asked to fill in a questionnaire during the XXV and XXVI Polish Bat Research Conferences, which took place in 2016-2017. Data on interventions from September 2015 to September 2017 were collected. In total, 962 individuals were included in the research. The questions concerned: 1) the number of rehabilitated individuals, 2) the reason for the intervention, 3) the manner, and 4) the effects of the provided assistance.

The collected information allowed us to determine the number of bats that were taken from their natural environment without a valid reason, only required moving to a different place, were healthy but required feeding and/or hydration, were sick or injured, and required treatment and/or rehabilitation. Bats born in captivity constituted a separate group.

Bats were scored according to species in cases when the people caring for them were able to identify them. Immediate aid concerned situations requiring the release of healthy bats from places where they had become trapped. The animals that needed feeding and/or hydration were healthy animals, with no visible injuries or diseases, and did not require treatment. Individuals requiring veterinary treatment were categorized as sick and injured individuals.

Statistical analysis was conducted using R (version 2.0-1, R Foundation for Statistics Computing).

Table 1. Reasons for intervention.

Reason for intervention	Rehabilitation centres	Bat workers	Total cases
Taken without justification	53	24	77
Immediate aid	41	56	97
Weakness/feeding	442	203	645
Injuries/disease	65	72	137
Born in captivity	0	6	6
Total	601	361	962

Table 2. Result of intervention.

Effects of the intervention	Rehabilitation centres	Bat workers	Total cases
Release	497	263	760
Ongoing treatment	39	45	84
Euthanasia	42	7	49
Death	23	46	69
Total	601	361	962

The association between variables was calculated with a Chi-squared test. The level of statistical significance was set at $P < 0.05$. The percentage of individual effects obtained during interventions conducted by rehabilitation centres and bat workers was also compared.

Results

962 individual bats were included in the study. Of these, 77 were taken unnecessarily from the wild, 97 were given immediate aid, 645 required only hydration and feeding, 137 had injuries and/or diseases, and six were born in captivity (Table 1). Most of the interventions (760 individuals) resulted in the bats being released, 84 were kept during treatment, 49 were euthanized, and 69 died during the intervention (Table 2). In rehabilitation centres, injuries and diseases were recorded in 137 individuals. Some individuals suffered more than one trauma. In Table 3, the individual injuries are listed (193). In rehabilitation centres 154 injuries were recorded, and under bat workers' care 39, a total of 193 injuries. The most common were long bone fractures (82 cases in total) and damage to the wing membranes (48 cases). Wounds on the trunk were recorded in 27 cases, in 23 phalangeal fractures, and in 20 inflammatory conditions. Fractures of the spine and jaw were found only twice in two bats.

Surveys in Wild Animal Rehabilitation Centres

Out of 84 wild animal rehabilitation centres located in Poland, mammals were looked after by 54 centres, of which 24 centres cared for bats, 14 had no contact with bats, and 16 did not respond to our survey. In the period from September 2015 to September 2017, 601 individuals were sent to rehabilitation centres, of which 53 individuals were taken from the environment without just cause, 41 individuals were given aid ad hoc, 442 individuals required feeding and/or hydration, and 65 individuals had injuries or were sick (Table 1). In the centres where the surveys were conducted, there were no cases of pregnancy or the birth of young bats. Among the surveyed centres, only three were able to identify the species of bats they housed. These were the dominant species in the region and easy to identify: *Vespertilio murinus*, *Nyctalus noctula*, *Eptesicus serotinus* (Table 4). Intervention in wildlife rehabilitation centres most often resulted in the release of bats into the natural environment (497 specimens, Table 2). 39 individuals were released after treatment was completed. Among all surveyed centres, 14 admitted that there are no conditions for long-term retention of injured bats, so they were euthanized. These were 42 individuals with fractures of long bones and forelimbs. A further 23 individuals brought to the centres died. More detailed data on diseases and injuries of bats were provided for 137 individuals (Table 3).

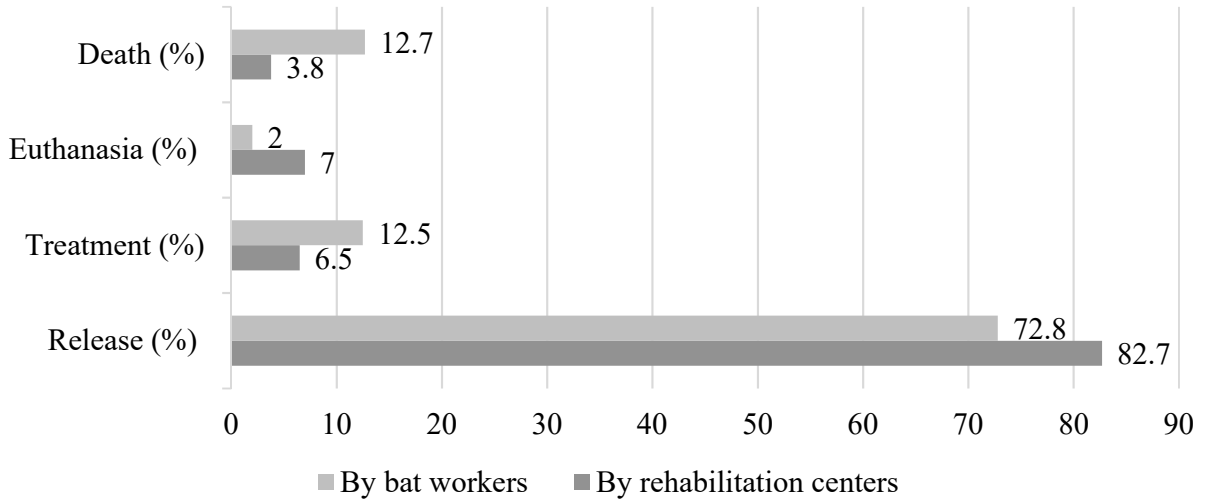

Fig. 1. Comparison of the percentage outcome of interventions carried out by rehabilitation centres and bat workers.

Table 3. List of bat diseases and injuries seen in rehabilitation centres and by bat workers (in some cases, one individual had several different injuries).

Injuries/diseases	Rehabilitation centres	Bat workers	Total injuries
Inflammation	12	8	20
Long bone fractures	62	11	82
Fractures of the phalanges	19	4	23
Fractures of the spine	-	1	1
Jaw fracture	-	1	1
Damage to the wing membranes	39	9	48
Wounds on the torso	22	5	27
Total	154	39	193

Table 4. Bat species received by rehabilitation centres and bat workers.

Bat species	Rehabilitation centres	Bat workers	Total cases
Vespertilio murinus	5	36	41
Nyctalus noctula	30	213	243
Eptesicus serotinus	4	26	30
Pipistrellus spp.	13	53	66
Plecotus auritus	1	12	13
Others	3	21	24
Indefinite	545	0	545
Total	601	361	962

Surveys conducted among bat workers

18 bat workers completed the questionnaire. In total, they provided aid to 361 bats, of which 24 were taken from the natural environment without justification, 56 individuals were given immediate aid, and 203 required rehydration and feeding. Injuries or diseases were found in 72 individuals, and six females gave birth to offspring (Table 1). The interventions most often ended with the release of bats (263 individuals), and 45 remained under treatment. In the case of seven bats, euthanasia was performed, while 46 individuals died in care (Table

2). The surveyed bat workers identified all bats to species. *Nyctalus* spp. – 213, *Pipistrellus* spp. – 53, *V. murinus* – 36, *E. serotinus* – 26 and *Plecotus auritus* – 12, required help most often. The remaining 21 bats were represented by no more than four individuals belonging to the following species: *Myotis myotis*, *Myotis daubentonii*, *Myotis brandtii*, *Myotis nattereri*, *Barbastella barbastellus* (Table 4). The diseases and injuries were described in 39 bats (Table 3).

Statistical analyses were performed by comparing the differences between rehabilitation centres and bat workers. Statistical differences were found between the proportions of the causes of intervention (test χ^2:χ^2 = 51.5, $P < 0.001$; Table 1) and the result of the intervention (test χ^2:χ^2 = 48.3, $P < 0.001$; Table 2). In rehabilitation centres, proportionally more bats were released and euthanized, and in the care of bat workers, more bats died or were under treatment (Fig. 1).

Discussion

This study shows that the number of bats that received human help is considerable, and the assistance is often effective and results in the return of most of the individuals to their natural environment (Hájkova & Pikula 2007, Budinski et al. 2018, Vlaschenko & Prylutska 2018), which should be the main goal of rehabilitation (Miller 2016). The species distribution of bats receiving human assistance reflects the presence of synanthropic species found near human settlements. *Nyctalus noctula*, which is a long-distance migratory species (Hutterer et al. 2005), increasingly stays near summer retreats during winter (Dietz et al. 2009). In recent years, the presence of this species has been recorded more often in large cities during winter (Lesiński et al. 2001, Łochyński et al. 2014, Godlevska 2015), often in poorly isolated places (Lesiński & Janus 2019), where they frequently hibernate in the gaps between apartment blocks. These bats often require veterinary treatment and care (Routh 2003). In the studied group of 962 individuals, 137 individuals of this species received veterinary assistance. During the study, pain behaviour, breathing, and heart rate as well as the extent of the injuries were taken into account according to the recommendations of Bernard (2010), and in the case of extensive injuries, a decision was made to euthanize 49 subjects. Fractures often feature among injuries (Domańska et al. 2017), especially the bones of the forelimbs, as well as wounds (cavities) of the volatile membrane, infections and emaciation and dehydration (Hájkova & Pikula 2007), and as shown by the presented research, fracture of the phalanges and wounds on the torso.

As shown by our statistical analysis, both the causes and effects of interventions carried out by rehabilitation centres and bat workers are different. Wildlife rehabilitation centres receive a greater number of bats requiring help than do bat workers. More euthanasia is carried out in rehabilitation centres due to their inability to treat more demanding incidents, while a greater proportion of bats are treated by bat workers, who are more likely to attempt to save more severe cases. For the same reason, proportionally more bats were under treatment and rehabilitation with bat workers while proportionally more were released by rehabilitation centres. This difference may be reduced after the recovery and release of individuals under bat workers' care. It is also unknown how the released individuals fared in the wild.

Thanks to treatment and rehabilitation, it is possible to learn more about the behaviour of bats, how they enter hibernation, and care for their young (Poliakova et al. 2017). Cooperation with veterinarians who carry out examination of bats (visual inspection, imaging tests, laboratory tests, parasitological tests) also makes it possible to determine the causes of diseases and injuries of individual animals, responses to treatment and rehabilitation, and the development of young that are born in captivity.

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