Mammalian Biology 90 (2018) 30–37

Contents lists available at ScienceDirect

Mammalian Biology

journal homepage: www.elsevier.com/locate/mambio

Original investigation

Assessing the effects of helicopter disturbance in a mountain ungulate on different time scales

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ARTICLE INFO

Article history:
Received 9 August 2017
Accepted 2 February 2018
Handled by Mauro Lucherini
Available online 6 February 2018

Keywords:
Activity
Alpine ibex
Conservation
Helicopter
Human-induced disturbance

ABSTRACT

Noisy human activities such as helicopter traffic may affect physiology and behaviour of wild animals. Since chronic behavioural modifications can ultimately alter reproductive success and population dynamics, studying the response of different taxa and species to human-induced disturbance in different habitats is paramount. The present study analysed data collected from 10 male Alpine ibex (*Capra ibex*) monitored with GPS collars to assess their response to disturbance caused by helicopter overflights. We compared ibex activity levels in the hours before and after 34 helicopter overflights during the summer of 2013 in Gran Paradiso National Park (Italy), a protected area that is essential for the conservation of Alpine ibex. The behaviour of Alpine ibex was affected both during and after helicopter overflights: compared to the average activity levels in the hours before the disturbance event, activity increased during the disturbance and decreased during the hour following the overflights. The reduction in activity persisted over the whole day of the helicopter disturbance and finally went back to normal levels during the following day. There was no evidence of habituation to the disturbance throughout the study period. The prolonged behavioural response to the disturbance suggests that frequent helicopter overflights may ultimately affect the ibex's body conditions, as well as the life-history traits of a population. These findings highlight the importance of considering medium and long-term behavioural responses in assessing disturbance-related effects on wildlife populations.
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Introduction

Helicopters are becoming widespread means of transportation in the Alps and in other mountainous areas as they combine swiftness, safety, comfort and versatility, especially on rugged terrains. Their use, however, entails obvious drawbacks for wildlife, such as the disturbance caused by the sudden loud noise. The potential effects of noisy human activities on wildlife are of increasing interest to researchers and wildlife conservationists (Lima and Dill, 1990): the disturbance caused by such noisy activities as helicopter traffic was described in different taxa (Barber et al., 2010; Chan and Blumstein, 2012) ranging from birds (Harris, 2005; Hughes et al., 2008) to mammals (Bleich et al., 1990; Miller and Gunn, 1979; Southwell, 2005; Stankowich, 2008; White and Gregovich, 2017). In fact, wild animals have evolved behavioural responses to specific predator-like stimuli such as noisy and fast objects (Dill, 1974), paraglide and other outdoor activities (Gander and Ingold, 1997; Schnidrig-Petri and Ingold, 2001), which are perceived as threats (Knight and Cole, 1991). The effects of human-caused disturbance on animal behaviour can be similar to the effects of predation risks and environmental threats (Frid and Dill, 2002), or even more marked (Ciuti et al., 2012). Indeed, helicopter disturbance may have short-term behavioural effects such as reduction in foraging activity (Tracey and Fleming, 2007), increase in vigilance behaviour (Giese and Riddle, 1999) and change in time budgets, as well as long-term effects, such as habitat shift (Cadsand, 2012) and increase in home range size (Andersen et al., 1990). The behavioural response to helicopter disturbance may also include increased metabolic rate (experiments conducted with unmanned aerial vehicles – UAV: Ditmer et al., 2015) and decreased forage intake (Stockwell et al., 1991). Human activities, therefore, may affect several life history traits such as individual reproductive success and population dynamics.

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https://doi.org/10.1016/j.mambio.2018.02.001
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Table 1
List of the helicopters that were used during summer 2013 over Gran Paradiso National Park. Emitted noise is measured following the Standards of ICAO during overflight at 150 m of altitude and is expressed with different measurement units with respect to each helicopter's size. For helicopters whose weight exceeds3175 kg, the noise emitted is expressed in EPNdB (Effective Perceived Noise in decibels as specified in chapter 8 of the ICAO Standards Annex 16, Volume I, Chapter 8). For helicopters whose weight does not exceed 3175 kg mass, noise is expressed in dBA SEL (DeciBel at a Single Event Level measured at 150 m of altitude). Helicopter SA315 B (Lama) complies with the provisions of Article 6.1 of Regulation 216/2008 and does not need to comply with the Standards of ICAO Annex 16, Volume I, by virtue of the date of type certification.

Model	Length (m)	Empty weight (kg)	Standard Noise	Margin	Noise Measurement Unit
AB139	16.7	3622	90.7	6.6	EPNdB
AB412	17.1	3200	93.4	2.8	EPNdB
A119	13.0	1430	86.5	0.9	dBA SEL
SA315B	10.24	2300	–	–	–

Responses to helicopter disturbance, however, are species-dependent and caution should be used when extrapolating responses to disturbance from one species to another. For instance, Stoen et al. (2010) demonstrated that bears responded less actively than moose to approaching helicopters. This might be due to inherent differences in the behavioural patterns of species on different trophic levels (prey vs. predators). Different responses to human-caused disturbance, however, may also occur in closely related species (Frid and Dill, 2002), possibly on account of their different anti-predator strategies and of the different environments where they evolved. In spite of context-specific differences, though, a consistent behavioural pattern was detected in mountain ungulates: the intensity of responses was found to be inversely related to the helicopters' distance (Coté, 1996; Coté et al., 2013; Frid, 2003; Stockwell et al., 1991). The strongest behavioural responses were recorded when helicopters flew within 500 m above the ground (or less: Coté, 1996; Frid, 2003), but effects were also recorded with helicopters flying at a longer distance (up to 2000 m) and even when they were not visible to the animals (Cadsand, 2012). It is worth noting that many of the recent studies on the effect of helicopter disturbance on ungulates were conducted in North-America (Cadsand, 2012; Coté et al., 2013) and northern Europe (Stoen et al., 2010), where environmental characteristics and habitat extension are considerably different from those of Alpine areas (e.g. morphology and size of the valleys). Consequently, context-specific studies should be carried out to prevent dangerous disturbance-related effects on Alpine populations.

Special concerns arise when a species proves unable to habituate to helicopter disturbance (e.g., mountain goats, *Oreamnos americanus,* Coté et al., 2013), because this may lead to acute or chronic behavioural modifications, such as changes in habitat selection (Cadsand, 2012). These modifications should be of primary concern to researchers and managers, because they may ultimately affect population parameters. Notwithstanding, evidence of long-term behavioural or physiological modifications is not common in literature, probably because of the greater difficulty in measuring and ascribing such modifications to specific disturbance events. So far, studies have focused on the direct observation of animals' reactions during and immediately after helicopter overflights (Coté et al., 2013; Frid, 2003). The effects of disturbance during the hours and on the days after helicopter overflights, instead, are less investigated (Cadsand, 2012; Stoen et al., 2010). In order to gain a better understanding of the overall effect of overflights on wildlife, though, accurate behavioural measurements should be made during the hours/days before as well as after the overflights. In this respect, the development of such tools as GPS collars equipped with activity sensors allows for the continuous measurement of the activity levels of individuals, thus covering unpredictable disturbance events and providing a more reliable assessment of their long-term consequences.

In this study, we investigated the effects of helicopter overflights on the activity levels of Alpine ibex (*Capra ibex*) in Gran Paradiso National Park (GPNP), a protected area located in the Italian Alps that is essential for ibex conservation. We analysed the activity levels of 10 males fitted with collars that provided activity data relative to the hours and days before, during and after helicopter disturbance. The aim of the study was to assess whether helicopter overflights affected the Alpine ibex activity rhythms. In the case that the helicopter affected the activity of an individual ibex, we expected a modification (increase or decrease) of activity levels after the disturbance event with respect to the hours and the day before it. Moreover, as previous research showed that animals could show a decreasing stress response to repeated disturbance (e.g., Goldstein et al., 2005), we also considered the hypothesis that ibex could habituate to the helicopter disturbance.

Material and methods

Study area and population

The study was conducted from May to September 2013 in the Levionaz basin, in the Gran Paradiso National Park (GPNP; Northwestern Italian Alps; 45° 25′ N, 07° 34′ W). The study area is located in the middle of the National Park, above the tree line, between 2300 and 3500 m a.s.l. and it covers approximately 80 ha. The area is characterised by high-altitude alpine meadows (mainly *Festuca varia*), moraines, rock cliffs and glaciers. For more details on the study area see Grignolio et al. (2007). In our study site, male ibex typically live at different altitudes depending on the period of the year: during daylight hours in May, males generally inhabit areas between 1500 and 2000 m a.s.l.; in June, they move up to 2000–2500 m a.s.l., while in July, August and early September, they generally live between 2700 and 3200 m a.s.l. (Aublet et al., 2009; Grignolio et al., 2004). During the annual autumn census of 2013, 67 male ibex were recorded in Levionaz by the National Park rangers.

In the Levionaz basin, ibex were captured and individually marked with coloured plastic ear tags (Allflex®: Allflex Europe (UK), 77 Greenchurch Street, London) or GPS collars (Vectronic Aerospace GmbH) within the framework of a long-term study on the life history of the species. The capture and marking protocols implemented in this study were authorised by the Italian Ministry of Environment (authorisation nr. 25114, dated 21/09/2004) following the positive review by the Italian National Institute for Environmental Protection and Research (ISPRA). Capture and marking were then carried out while trying to minimize the effects on the animals (Brambilla et al., 2013; Brivio et al., 2015).

Above the National Park overflights are forbidden, except for mountain rescue purposes. However, the National Park authority can authorise flights on request, provided that these meet specific conditions regarding period, route, and lowest altitude (no less than 500 m above ground level). During summer 2013, several rescue flights were carried out over the study area and overflights were also periodically authorised for the transportation of materials to mountain huts, trail maintenance and territory monitoring. A list of the helicopters in use in the study area along with their technical specifications and the decibels emitted (measured following the Standards of ICAO Annex 16, Volume I) is reported in Table 1.

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