



Review

A review of urban wildlife management from the animal personality perspective: The case of urban deer

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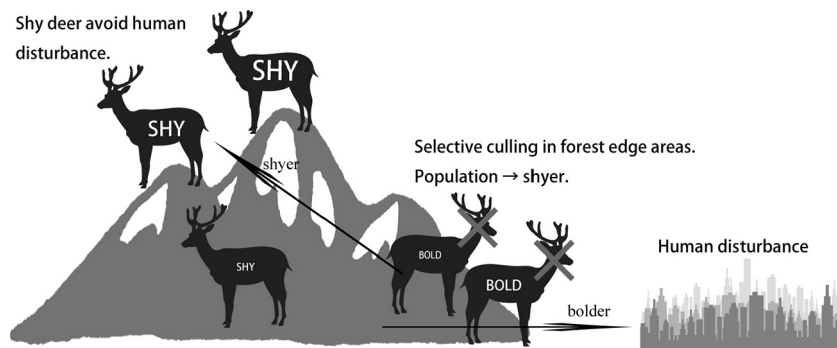
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HIGHLIGHTS

- Urban deer increase the risk of zoonosis and wildlife–vehicle collisions.
- No effective measures against the urban deer problem have been implemented to date.
- Bolder deer prefer forest edge and tend to be urban deer.
- Culling in forest edge area reduces boldness of the population.
- Managing the boldness of deer populations could effectively resolve the problem.

GRAPHICAL ABSTRACT



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ABSTRACT

Wildlife living around urbanized areas is often a cause of crucial issues such as zoonosis and wildlife-vehicle collisions. Despite this, residents hold positive views on the presence of urban wildlife primarily due to aesthetic reasons. This accepting attitude towards our coexistence with urban wildlife has made it difficult for wildlife managers to come to a consensus concerning the importance of human-urban wildlife conflicts. Although countermeasures such as lethal force and/or fencing are commonly used to control human-wildlife conflicts, these approaches are rarely applied in the case of urban wildlife. It is essential to recognize the gap between the current state of urban wildlife management and advanced scientific knowledge of urban wildlife behavior in order to mitigate urban deer conflicts. Fortunately, behavioral ecologists have been attempting to apply the perspective of individual differences, such as animal personality, to wildlife management. Studies have shown how the personalities of wildlife contribute to their adaptation to urban habitats. In order to prevent human-urban wildlife conflicts, recognizing the personalities of wildlife and selective culling of bold individuals should be conducted for deliberate selection for shyness when developing wildlife management plans. Making wildlife shy away from humans is essential to urban wildlife management. The aim of this study is to review observed measures against human-urban wildlife conflicts in Japan and to propose a new direction for innovative and effective approaches that takes animals personality into account to mitigate urban-wildlife conflicts. For this review we will target deer as a model species because deer are among the most serious of problem-causing urban wildlife.

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Contents

1. Introduction	577
2. Considering animal behavior for wildlife management	577
2.1. Spotlight on animal personality	578
2.2. Personality of DCIs	578
2.3. Microevolutionary measures against the urban wildlife problem	579
3. The example of urban deer management plans in Japan	579
3.1. Data collection	579
3.2. Recognition of the existence of urban deer	579
3.3. Urban deer management as described in wildlife management plans	579
3.4. Behavioral perspective	580
4. What is an innovative and effective measure?	580
Acknowledgement	580
References	580

1. Introduction

Wildlife damage is a worldwide concern (Wilson, 2004; Milner et al., 2014) and the definition of wildlife damage management covers a very large field. Any harm wildlife may cause, including human injuries or disease infection, loss of economic productivity, or a reduction in a person's quality of life or well-being could be considered wildlife damage (Conover, 2001). According to Reidinger Jr and Miller (2013), the goal of wildlife management is to control animal movement and reduce population size in order to avoid the human-wildlife conflict. In addition, changing the recognition and attitude of public towards wildlife is also one of the goals of wildlife management (Reidinger Jr and Miller, 2013). The measures taken by wildlife managers towards wildlife do not always coincide with public attitudes, and a consensus is needed for effective wildlife management. One difficult case is that of urban deer (e.g., white-tailed deer *Odocoileus virginianus*, sika deer *Cervus nippon*), as wildlife managers aim to mitigate urban deer problems using lethal methods and urban residents often do not agree with culling deer for aesthetic reasons (Coffey and Johnston, 1997; Porter et al., 2004).

In North America there are a lot of problematic situations with urban deer. The main problems caused by urban deer are zoonosis transmission and deer-vehicle collisions (Conover, 2001; Heltai, 2013). Deer are an important reservoir host of tick-borne diseases (Inokuma et al., 2008). In the state of Connecticut, human infection rates of tick-borne diseases (e.g., Lyme disease) in suburban and urban areas were 42% and 15% respectively in 2002 (Kilpatrick et al., 2007). Lyme disease is a multi-organ animal-borne disease, caused by spirochetes of *Borrelia burgdorferi*, and typically affects the skin, nervous system, musculoskeletal system, and heart. This disease is found throughout North America, Europe (e.g., Germany, Austria, Slovenia, and Sweden), and Asia (Steere et al., 2004). The number of cases of Lyme disease reported in the United States has increased from 491 in 1982 to 17,029 in 2001, despite federal, state, and local efforts to prevent the disease (Hayes and Piesman, 2003). About 60,000 cases are reported each year in Europe (Hayes and Piesman, 2003).

In addition, deer-vehicle collisions can cause serious economic and bodily harm to the public (Stout et al., 1993). In the United States, the victim percentages of deer-vehicle collision in suburban and urban residents were 19% and 13%, respectively (Kilpatrick et al., 2007; Stout et al., 1993;). In the case of New York state, about half (49%) of the residents had nearly hit a deer with their vehicles and 28% had been involved in deer-vehicle collisions in their past (Stout et al., 1993). In addition, the economic loss caused by deer-vehicle collision should not be overlooked; e.g., these collisions account for 4% of all crashes reported in the United States (Bissonette et al., 2008), and up to 13% reported in the state of Iowa (Gkritza et al., 2014). In the United States, 100–200 persons/year were killed by deer-vehicle collisions (Rondeau and Conrad, 2003).

Once deer have adapted to urban habitats, conventional control methods are no longer easy to perform. Lethal methods, for example, are hard to practice because it would be unacceptable for public in urban areas, and excluding deer with fencing is unrealistic in urban areas (Heltai, 2013). As a result, wildlife researchers have paid little attention to urban wildlife management so far (Podgórski et al., 2013). Only 1.2 and 2.6% of the content in the well-respected American journals “The Journal of Wildlife Management” and “Wildlife Society Bulletin” were directly related to urban wildlife (Magle et al., 2012). In addition, urban residents tend to have a positive attitude towards the presence of urban deer, while in rural areas, deer are considered a nuisance because of the crop damage they cause. The acceptance of coexistence with urban deer makes it difficult to build a consensus concerning lethal methods against them (Coffey and Johnston, 1997; Porter et al., 2004).

Recent behavioral studies have illustrated a new perspective for wildlife management. The ability of an animal to adjust to novel challenges (e.g., human-subsidized resources and anthropogenic disturbance) is likely to be important to its success in urban environments and this ability is tied to behavioral traits (Lowry et al., 2013). Behavioral research has begun to recognize that vertebrates show individual differences in behavior (Hendry et al., 2011; Réale et al., 2007). Thus, some animals might inherently be better suited to urban environments because the animals have a bold personality (Lowry et al., 2013).

In this review, first, we describe the importance of considering animal behaviors for wildlife management activities. Second, we attempt to explain behavioral differences between urban and forest deer based on the concept of animal personality. Next, we illustrate the gap between actual deer management and scientific knowledge of behavioral ecology. Finally, the efficiency of manipulating personality through selective harvesting of a target population is suggested.

2. Considering animal behavior for wildlife management

Although the increase in wildlife populations has been considered a main cause of increased conflicts (Conover, 2001), other factors may also be involved (for example, bear: Mizukami et al., 2005; Sato et al., 2004; deer: Hewison et al., 2001; Honda et al., 2014; Kilpatrick et al., 2007; macaque: Izumiyama et al., 2003; wild boar: Honda et al., 2008). For example, some management issues are related to animal behavior (Goldstein et al., 2006; Honda et al., 2014). This phenomenon is derived from so-called ‘problem animals’, referred to in behavioral ecology as ‘damage-causing individuals (DCIs)’ (Honda and Iijima, 2016). The term ‘problem animal’ is commonly used in wildlife management; however, research on problem animals is not enough (Goldstein et al., 2006). For example, problem animals in urban areas would have a small flight initiation distance (i.e. the distance at which animals flee from approaching humans, hereafter FID), because urban wildlife has adapted to highly disturbed areas (Stillfried et al., 2017b). However,

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