Mammalian Biology xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Mammalian Biology

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

Original investigation

Decreasing reservoir water levels improve habitat quality for Asian elephants

Ashoka D.G. Ranjeewa[a], Jennifer Pastorini[b,c,*], Karin Isler[c], Devaka K. Weerakoon[a], Helani D. Kottage[d], Prithiviraj Fernando[b]

[a] Department of Zoology, University of Colombo, P.O. Box 1490, Colombo 3, Sri Lanka
[b] Centre for Conservation and Research, 26/7 C2 Road, Kodigahawewa, Julpallama, Tissamaharama, Sri Lanka
[c] Anthropologisches Institut, Universität Zürich, Winterthurerstrasse 190, 8057, Zürich, Switzerland
[d] School of Mathematics and Applied Statistics, Faculty of Engineering and Information Sciences, University of Wollongong, Northfields Ave., Wollongong, NSW, 2522, Australia

ARTICLE INFO

Article history:
Received 15 June 2017
Accepted 9 October 2017
Handled by Emmanuel Serrano
Available online xxx

Keywords:
Asian elephant
Body condition
Water management
Irrigation
Wildlife management

ABSTRACT

Population health and habitat quality are intimately related and seasonal changes in habitat quality are likely to be reflected in the body condition of animals. We studied seasonal variation of body condition in free ranging Asian elephants (*Elephas maximus*) in Udawalawe National Park, Sri Lanka based on visual scoring of individually identified elephants. We assessed the body condition of 218 adult females and 329 adult males from January 2008 to November 2012 and examined its relation to monthly rainfall and water level of the Udawalawe reservoir. Contrary to expectations, body condition of elephants was higher in the dry season, when primary productivity decreases due to lack of rainfall. However, the body condition showed both a seasonal and inter-annual negative co-relation with reservoir water level. A possible explanation for improved body condition in the dry season is the greater availability of fresh grass due to the emergence of reservoir bed grasslands with the drawdown of water. Our results underscore the importance of water management of large irrigation reservoirs in elephant conservation in Sri Lanka.

Introduction

The main regulator of large herbivore occurrence and densities arguably is fodder availability hence primary productivity (Mduma et al., 1999). Key factors affecting primary production are photoperiod, temperature, soil nutrients (McNaughton et al., 1988; Burke et al., 1990), rainfall (Deshmukh, 1984) and soil moisture (Nippert et al., 2006). In a given area in the tropics, seasonal and inter-annual variation in photoperiod, temperature and soil nutrients is minimal. However, changes in rainfall, hence soil moisture and its temporal variability significantly affect productivity even in the tropics (McNaughton, 1985; Weltzin et al., 2003). In seasonal habitats, primary production decreases drastically and high quality forage biomass accumulated during the wet season rapidly converts to low quality in the dry season (Sinclair, 1975; McNaughton, 1985). Therefore a positive relationship exists between large herbivore biomass and rainfall in seasonal habitats (Coe et al., 1976; Mduma et al., 1999).

Body condition is an indicator of an animal's health and fitness (Gerhart et al., 1996). Body condition of free ranging Asian elephants (*Elephas maximus*) may be influenced by a variety of factors. Differences in resource availability among localities may cause variance in body condition among populations. Climatic variations have a direct bearing on food availability and quality, hence are reflected in seasonal and long-term body condition changes of a given population (Sukumar, 1989; Desai, 1991). Elephants are hindgut fermenters with rapid food passage times, low digestibility and energy intake, and are inefficient in dealing with plant toxins (Clauss et al., 2003; Dumonceaux, 2006). They require about 150–300 kg of fodder daily to sustain themselves (Vancuylenberg, 1977) and have evolved to be generalized herbivores consuming over a hundred plant species in any given location (McKay, 1973; Sukumar, 1990; Samansiri and Weerakoon, 2007; Campos-Arceiz and Blake, 2011).

Ungulates require an average of 4–5% of crude protein to maintain their body weight (Sinclair, 1975). Grass is preferred by many mammalian herbivores, as it is easy to gather and process and has few secondary compounds. With the onset of dry season,

* Corresponding author at: Centre for Conservation and Research, 26/7 C2 Road, Kodigahawewa, Julpallama, Tissamaharama, Sri Lanka.
E-mail address: jenny@aim.uzh.ch (J. Pastorini).

https://doi.org/10.1016/j.mambio.2017.10.002
1616-5047/

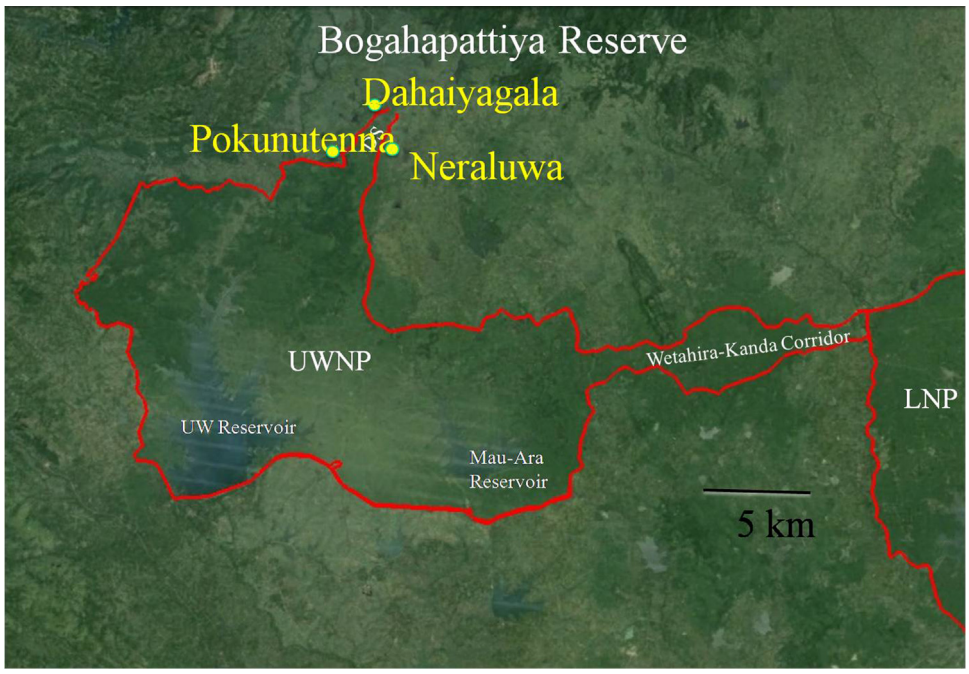

Fig. 1. Map of the Udawalawe National Park (UWNP), Dahaiyagala Sanctuary (DS) and parts of Lunugamwehera National Park (LNP). Electric fences at the park boundaries are marked with a red line. Image © 2011 Google Earth/Landsat/Copernicus. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

crude protein in grasses reduces from 8% to 1–3% and ungulates can obtain their required crude protein only through active selection of food material (Sinclair, 1975). Similarly, the preferred food of elephants is fresh grass, which is high in protein and low in silica and fibre (Sukumar, 1990). As grass matures, its protein content decreases and silica and fibre increase, and elephants shift to browse (Sukumar, 1990). Fresh grass is present only in the wet season and early dry season in the tropical habitats of Asian elephants (Fernando, 2015) hence its availability can be expected to have a major impact on elephant body condition. Sri Lankan elephants do not migrate and are non-territorial with comparatively small overlapping home ranges (Fernando et al., 2008b). Elephant density in Sri Lanka is about ten times that of any other range country (Fernando and Pastorini, 2011). Therefore in Sri Lanka, it can be expected that elephants will use their habitat intensively and habitat quality will have a major influence on their body condition.

Behavioural aspects such as sociality (Pinter-Wollman et al., 2009) and ranging patterns (Fernando et al., 2008b) may influence the body condition of groups and individuals differently. Female elephants live in social groups (e.g. Fernando and Lande, 2000) hence experience intra- and inter-group competition for resources (Janson, 1988). Males remain with their natal groups until puberty and become solitary thereafter (Lee, 1991). Therefore, adult males can be expected to experience less resource competition than adult females, hence have better body condition.

Unlike female elephants, which cease growth once reproductively active, males continue to grow well beyond puberty (McKay, 1973). Thus, adult males can be divided into three age-size classes; sub-adult, young-adult and mature-adult, which also correlate with behavioral aspects influencing body condition. 'Sub-adult' males leave their natal herds and go through a transition period of adaptation, which may result in decreased body condition. Once they adapt to a solitary lifestyle, as 'young-adult' males they are likely to have higher resource acquisition hence better body condition. 'Mature-adult' males experience an annual 'musth' period (Poole, 1987) with associated increase in ranging and loss of body condition as musth progresses (Poole, 1989; Fernando et al., 2008b).

Reproductive, physiological, health status and behavioural differences may cause individual variation in body condition. Reproductive females invest heavily in bearing and rearing of calves. Some males take risks in raiding crops (Chiyo et al., 2011; Ranjeewa et al., 2015) and may gain in body condition. However, stress and injuries sustained in raiding may impact body condition negatively. Additionally, management actions taken to mitigate the human-elephant conflict such as elephant drives, electric fencing and translocation may have severe repercussions on the wellbeing of elephants (Fernando et al., 2008a).

Thus, body condition assessment of free ranging elephants can help understand the impact of environmental, behavioural and management actions on elephant health, hence is of importance for elephant conservation.

The body condition index (BCI) of an animal is a numerical indicator of fat deposition in different regions of the body (Riney, 1960; Wemmer et al., 2006; Fernando et al., 2009). Body condition assessment is widely used in dairy herd management to monitor the nutritional status of cows by direct measurement of subcutaneous fat (Wildman et al., 1982; Otto et al., 1991) and ultra-sound scanning (Brethour, 1992). Body condition of wild animals cannot usually be assessed through direct measurement due to logistical, legal and ethical constraints, which preclude capture and slaying. An alternative is body condition scoring through visual assessment (Riney, 1960). Visual body condition scores and ultrasonic measurements of subcutaneous fat in dairy cows show a highly significant correlation, suggesting that visual body condition scores accurately reflect the amount of subcutaneous fat deposits (Edmonson et al., 1989; Zulu et al., 2001). Visual body condition scoring has been used in the study of mice (Ullman-Cullere and Foltz, 1999), pigs (Chikwanha et al., 2007), cows (Wildman et al., 1982), goats (Villaquiran et al., 2004) and reindeer (Gerhart et al., 1996). A few studies have also assessed the body condition of free ranging and captive elephants (Godagama et al., 1998; Wemmer et al., 2006; de Klerk, 2009; Pinter-Wollman et al., 2009; Ramesh et al., 2011). In this study we use an adaptation of the visual body condition scoring of Wemmer et al. (2006).

Please cite this article in press as: Ranjeewa, A.D.G., et al., Decreasing reservoir water levels improve habitat quality for Asian elephants. Mammal. Biol. (2017), https://doi.org/10.1016/j.mambio.2017.10.002