http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

OPEN ACCESS Pakistan Journal of Biological Sciences

ISSN 1028-8880
DOI: 10.3923/pjbs.2020.1227.1230

Short Communication
Determining Optimal Stock Density of Punjab Urial (*Ovis vignei punjabiensis*) in Captivity for Breeding, Population Growth and Reintroduction Potential

Romaan Hayat Khattak, Zhensheng Liu, Liwei Teng and Nathan James Roberts

College of Wildlife and Protected Area, Northeast Forestry University, Harbin, 150040, People's Republic of China

Abstract

Background and Objective: The Punjab urial (*Ovis vignei punjabiensis*) is an endangered wild sheep of Pakistan, raised in captivity with the aim of re-introduction. To date, no information is available about population trends of this species in captivity. The current study was conducted with the aim to evaluate the population trend to better guide captive breeding for improved productivity and conservation value. **Materials and Methods:** Annual population data recorded and maintained by the Wildlife Department Khyber Pakhtunkhwa, Pakistan, were used. The data were compiled and analyzed in Microsoft Excel 2010 for determining growth rates and package Growthcurver in R-version 3.5.1 was used to produce a graphical representation of the population trend. **Results:** The overall average annual population growth rate was rN = 0.22. Results revealed a fast initial growth rate with an average value of rN = 0.4 per year. Birth rates of bN = 0.45 for the first nine years were considerably higher than the death rates dN = 0.22 and the population increased with exponential growth. In the subsequent year, very high mortalities rates (dN = 1.2), likely attributed to the clumping of the population, resulted in the collapse of the population, leaving it in a state of unstable equilibrium. **Conclusion:** Results support the evaluation of management data to reveal carrying capacity in captive populations, to guide and inform appropriate release of surplus animals into natural habitats.

Key words: Growth rates, captive populations, Pakistan, Punjab urial, carrying capacity

Citation: Romaan Hayat Khattak, Zhensheng Liu, Liwei Teng and Nathan James Roberts, 2020. Determining optimal stock density of Punjab urial (*Ovis vignei punjabiensis*) in captivity for breeding, population growth and reintroduction potential. Pak. J. Biol. Sci., 23: 1227-1230.

Corresponding Author: Zhensheng Liu, College of Wildlife and Protected Area, Northeast Forestry University, Harbin, 150040, People's Republic of China

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Studying long term population trends plays a major role in species conservation by assessing the species risks and designing promising conservation and management strategies[1,2]. Identifying populations which are at risk of crumbling or likely to be extirpated in near future is a central problem in conservation biology. No matter how large a population may be, it is difficult to declare its sustainability without having knowledge of population temporal trends. The rate of a species population increase or decline depicts a very clear idea about its future, whether it will thrive or will collapse at once[3].

Fast growing human populations are lethally-directly and indirectly-affecting wildlife by disintegrating and shrinking their natural habitats through developmental processes[4]. Thus, keeping and raising threatened species in captivity is increasing as a means to produce viable and healthy populations with the aim of reintroduction[5,6]. In the meantime, captive populations face a number of pressures in artificial confined environments, which can possibly affect the biology of species[7]. Thus, it becomes a serious concern to study the population trends of threatened species in captivity, in order to establish truly sustainable populations as entire species[8].

The Punjab urial (*Ovis vignei punjabiensis*) is a wild sheep declared as globally vulnerable by International Union for Conservation of Nature (IUCN) with declining population trends and endangered in Pakistan[9]. Punjab urial are gregarious ungulates and herds usually consist of females, lambs and immature males[10]. Usually this ungulate species gives birth to 1-2 lambs with an estimated average of 1.18 young per female per gestation[11]. The species is presently under captive breeding management in Khyber Pakhtunkhwa (KPK) Province of Pakistan with the aim of reintroduction[12], under the auspices of Wildlife Department KPK. To date, no assessment has been made to investigate the population trends of Punjab urial in captivity, here or elsewhere. Therefore, the current study was a first leading step to assess the population trend and growth rates of Punjab urial in captivity and to suggest recommendations for improved population management.

MATERIALS AND METHODS

Study area: The current study was conducted in January, 2020 at Cherat Wildlife Park (CWP) located in Nowshera district of Khyber Pakhtunkhwa province, Pakistan. The study area is a sub-tropical scrub forest. The annual average minimum temperature in winter is 10.1°C, while in summer the average maximum temperature reaches up to 38.6°C. Mean annual temperature is 22.4°C, with average annual rainfall up to 532 mm. An enclosure having an area of 14,300 m^2 was built and the captive breeding project was launched in 2008 at CWP with a single breeding pair of founder animals.

Data collection: The first ever long-term captive breeding population data of Punjab urial was used in this study, a consecutive twelve-year period from 2008-2019. Time series population data were compiled from the records maintained by the Wildlife Department and Park authorities. Microsoft Excel 2010 was used to arrange the data.

Statistical analysis: As the collected data were from a closed population where there was no emigration or immigration, natality and mortality rates were taken to calculate the average population growth rate. The data were analyzed in Microsoft Excel 2010 to estimate annual growth rates by using the following formula[13]:

$$\frac{\Delta N}{\Delta t} = bN - dN$$

$$\frac{\Delta N}{\Delta t} = rN$$

where, bN is the natural birth rate, dN is the natural death rate and rN is the natural growth rate in time t. In addition package Growthcurver in R version 3.5.1 was used for depicting the population trend.

RESULTS

A total of 12 years of data were analyzed and the average annual growth rate were calculated as rN = 0.22. Along the chronological time series, fast growth by the population was observed after launching the program followed by a subsequent overshoot and drastic collapse in the next short years (Fig. 1). In the first nine years, the average birth rate and death rate shown by the population was bN = 0.45 and dN = 0.21, respectively. In year 9, a birth rate of bN = 0.8 was observed and the population reached a total of N = 31 animals, but a very high death rate of dN = 1.2 immediately followed which caused a decline in the population from N = 31 to N = 19.

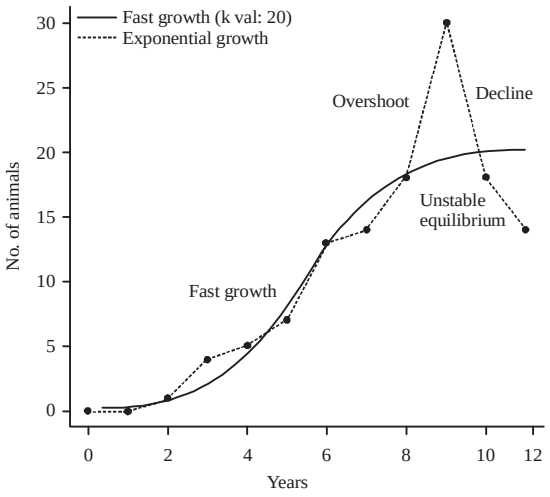

Fig. 1: Time series population trend and carrying capacity (k) of captive Punjab urial (*Ovis vignei punjabiensis*)

DISCUSSION

Investigating the variations in species population dynamics impart useful knowledge and provide empirical results for guiding and informing the planning of future conservation and management policies and practices. Ungulate population dynamics are shaped by the complex effects of many factors. In this paper, the population trend in time series format was explored, which clearly highlighted the fluctuation and capacity in the captive breeding population of Punjab urial.

Newly stocked wild sheep in a separate natural habitat are capable of rapid initial population growth up to rN = ≥1.2 per year[14]. The results for annual population growth rate presented here are rN = 0.22, which showed that the population has grown unacceptably slowly. The slow population growth of captive breeding animals cannot be similar to the one growing in the natural habitats because of several limitations in the controlled environment and also depending on the number of founder animals.

The population trend line (Fig. 1) showed a fast growth in the initial years. The recruitment rates were fairly higher than the mortalities and thus, showed the somewhat exponential growth. This same case of rapid initial exponential growth was reported in a population of big horn sheep *(Ovis canadensis)* after their stocking which reported by Singer *et al.*[14]. It is also reported that wild sheep are capable of initial rapid exponential growth after re-introduction if the environment is favorable[15]. It is assumed that the peak in the curve presented in this study showed a rapid increase in the population due to the increased number of breeding pairs. Genetic studies of the captive Punjab urial population would be required to investigate and mitigate potential inbreeding depressions.

These large mammals are included in the category of k-selected species and hence they can't afford the continuous exponential growth. Wild sheep can hardly maintain long term rapid growth as they are gregarious and become more susceptible to infections and diseases as the population grows[16]. In order to investigate the cause of the drastic decline in this population additional information from the records were evaluated, finding that significant mortality was caused due to sudden and prevalent parasitic infections. In this population, it is considered that the parasitic infections are likely the limiting factor responsible for the drastic decline which created a state of unstable equilibrium.

Here, the peak population number N = 31 was roughly used to determine the unit area offered per animal. Each animal was offered an area approximately 398 m^2, which fulfilled the standard criteria of basic animal welfare. While analyzing the data by using package Growthcurver, a carrying capacity K = 20 was estimated based on the annual population growth rates. It is noted that a population that overshoots the carrying capacity or is at carrying capacity is at the threshold of sudden drastic decline[17]. Results presented for the population trend here are in agreement with this statement[17].

Considered together, the results here have identified the effective carrying capacity for this single breeding facility, demonstrated the application of easily replicable analyses to readily available stock inventory data and revealed a likely cause of preventable population collapse. Additional breeding facilities may apply these same methods to achieve sustained population growth. To realize goals of conservation by re-introduction, surplus animals above respective carrying capacities can be considered for appropriate release with monitoring-either as individual facilities or coordinated collectively among facilities-ensuring that the total number of animals released together (among other factors) is sufficient to achieve required survivorship for meaningful re-introduction success and the sustained restoration of wild populations.

CONCLUSION

The results provide notable information about the population trends of Punjab urial in a single captive population by a freely-available and user-friendly method replicable in other facilities and institutions. The species seems capable of thriving in captivity, though clumping seems to be

the possible cause for population collapse. Identifying carrying capacity may identify opportunities for re-introduction and disease risk management.

SIGNIFICANCE STATEMENT

The current study is the first attempt to investigate the population trend of this threatened species in Pakistan. This study will help researchers and facilities managers to investigate deeply and uncover the other hidden and crucial population limiting factors, evaluating present management policies and practices and to design improved future conservation and management strategies, including captive management and reintroduction.

ACKNOWLEDGMENTS

We are thankful to Wildlife Department Khyber Pakhtunkhwa, Pakistan for allowing us to conduct this study and supporting us throughout the study. The study was financially supported by Nature National Science Foundation of China (31870512) and the Fundamental Research Funds for the Central Universities (2572014CA03), along with financial support from the Heilongjiang Touyan Innovation Team Program for Forest Ecology and Conservation Ningxia Helan Mountains National Nature Reserve.

REFERENCES

1. Zhang, M., X. Wang, Y. Ding, Z. Zhang and Z. Wang *et al*., 2012. Population dynamics of blue sheep *Pseudois nayaur* in Ningxia helan mountain National nature reserve, China. J. Vertebr. Biol., 61: 121-128.
2. DeCesare, N.J., M. Hebblewhite, M. Bradley, K.G. Smith, D. Hervieux and L. Neufeld, 2012. Estimating ungulate recruitment and growth rates using age ratios. J. Wildlife Manage., 76: 144-153.
3. Keith, D., H.R. Akçakaya, S.H.M. Butchart, B. Collen and N.K. Dulvy *et al*., 2015. Temporal correlations in population trends: Conservation implications from time-series analysis of diverse animal taxa. Biol. Conserv., 192: 247-257.
4. Brandon, K.E. and M. Wells, 1992. Planning for people and parks: Design dilemmas. World Dev., 20: 557-570.
5. Williams, S.E. and E.A. Hoffman, 2009. Minimizing genetic adaptation in captive breeding programs: A review. Biol. Conserv., 142: 2388-2400.
6. Witzenberger, K.A. and A. Hochkirch, 2011. *Ex situ* conservation genetics: A review of molecular studies on the genetic consequences of captive breeding programmes for endangered animal species. Biodivers. Conserv., 20: 1843-1861.
7. Gusset, M. and G. Dick, 2010. 'Building a future for wildlife'? Evaluating the contribution of the world zoo and aquarium community to *in situ* conservation. Int. Zoo Yearbook, 44: 183-191.
8. Schulte-Hostedde, A.I. and G.F. Mastromonaco, 2015. Integrating evolution in the management of captive zoo populations. Evol. Applic., 8: 413-422.
9. Sheikh, K. and S. Molur, 2005. Status and red list of Pakistan mammals, based on conservation assessment and management plan for mammals. IUCN., Pakistan, pp: 47.
10. Schaller, G.B. and Z.B. Mirza, 1974. On the behaviour of Punjab urial (*Ovis orientalis punjabiensis*). Proceedings of the International Symposium on the Behaviour of Ungulates and its Relation to Management Volume 1, November 2-5, 1971, University of Calgary, Alberta, Canada, 306-323.
11. Awan, G.A., M. Festa-Bianchet and T. Ahmad, 2006. Poaching, recruitment and conservation of Punjab urial *Ovis vignei punjabiensis*. Wildlife Biol., 12: 443-449.
12. Khattak, R.H., Z. Liu and L. Teng, 2019. Development and implementation of baseline welfare assessment protocol for captive breeding of wild ungulate-Punjab Urial (*Ovis vignei punjabiensis*, Lydekker 1913). Animals, Vol. 9, No. 12. 10.3390/ani9121102
13. Jones, J.H., 2008. Stanford summer short course: Leslie matrix I. Formal Demography Stanford Spring Workshop in Formal Demography May 2008. https://web.stanford.edu/~jhj1/teachingdocs/Jones-Leslie1-050208.pdf.
14. Singer, F.J., E. Williams, M.W. Miller and L.C. Zeigenfuss, 2000. Population growth, fecundity and survivorship in recovering populations of bighorn sheep. Restor. Ecol., 8: 75-84.
15. Rominger, E.M., H.A. Whitlaw, D.L. Weybright, W.C. Dunn and W.B. Ballard, 2004. The influence of mountain lion predation on bighorn sheep translocations. J. Wildlife Manage., 68: 993-999.
16. Jorgenson, J.T., M. Festa-Bianchet, J.M. Gaillard and W.D. Wishart, 1997. Effects of age, sex, disease and density on survival of bighorn sheep. Ecology, 78: 1019-1032.
17. Hilker, F.M., 2010. Population collapse to extinction: The catastrophic combination of parasitism and Allee effect. J. Biol. Dynam., 4: 86-101.