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Modeling of population growth for the European bison *Bison bonasus*

Nathia Hass Brandtberg

Section for Ecology and Evolution, Copenhagen University, Denmark

Abstract: The paper presents first attempt of modeling the population of European bison kept at Island of Bornholm. The tool FITOM v.1 was created and compared with results of one commonly used programs RAMAS. It was found that results obtained in this way were underestimated. Following this early pilot study the program will be developed.

Keywords: modeling, Island of Bornholm, Almindingen, European bison, introduction

Introduction

Many species on a global scale have become extinct due to an increasing human population. Since the 1970s the number of endangered species has increased rapidly (Butchart *et al.* 2010). The European bison became extinct in the wild in 1919, but was successfully reintroduced in 1952. In the last 60 years its population has grown to more than 3500 individuals, distributed in over 36 countries (Kuemmerle *et al.* 2011, Tokarska *et al.* 2011, Daleszczyk & Bunevich 2009).

In May 2012, seven individuals of the subspecies *B. b. bonasus* were introduced to a fenced area in Almindingen at the Danish island Bornholm. The population consists of six cows born from 2006 to 2010, and one bull from 2008. The Danish Nature Agency Bornholm is in charge of this introduction project, and recommends a target population for Almindingen no larger than 25 individuals. Therefore the Professor Gösta Nachman from the Section for Ecology and Evolution at Copenhagen University in Denmark developed a programme that predicts population growth and survival for the European bison.

The programme *FITOM Bison* consists of a modified Leslie matrix, which is often used in population programmes, but in this programme the Leslie matrix takes into account sex related differencessee figure 1.

On the Figure 1 presents the modified Leslie matrix. The green box shows the birth rate and describes the annual number of sexually mature females capable for calving. Both: females coloured red and males coloured blue are divided in three age categories (*calves*, *juveniles* and *adults*). Sex ratio and mortality rate were also changeable in the non-coloured boxes.

Method and Analysis

The usability of the programme *FITOM Bison* version 1 as a tool for predicting population growth was tested against the programme *RAMAS*

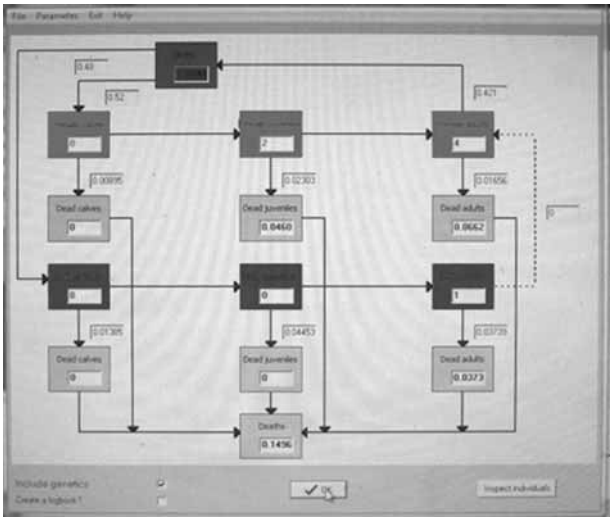

Figure 1. Modified Leslie matrix

Metapop population growth for single population models. The reliability of the programme *FITOM Bison* was tested against the known growth rate for the Białowieża population. All simulations for the two programmes were carried out for a period of 10 years and replicated 100 times.

The biological information used in the programmes was obtained from earlier studies by Tokarska *et al*., (2011) Daleszczyk & Bunevich (2009) and Hartl & Pucek (1992). The studies showed that the subspecies *B. b. bonasus* had an average annual survival rate at 98 percent, cows could live up to 18–20 years and bulls up to 12 years. Both cows and bulls get sexually mature around 3–4 years, but bulls do not participate in the mating until they turn 6 years. Sexually mature cows calve every second year and the sex ratio among calves is 48:52 with a domination of females.

Results

According to the programme *RAMAS Metapop population growth* for single population models, the Danish population consisting of seven individuals will exponentially grow to the level of 65 individuals after 10 years (fig. 2A). Contradicting the programme *FITOM Bison* predicts a median population at 10 individuals, but as seen in figure 2B the confidence levels are from the extinction to 28 individuals.

The reliability test showed that the programme *FITOM Bison* underestimated the population growth for the Bialowieża population. In 1960 the Białowieża population consisted of about 40 individuals, and 5 and 10 years later – respectively 100 and 200 individuals (Mysterud *et al.* 2007). The programme *FITOM Bison* predicted the Białowieża population to reach respectively 61 and 67 individuals after 5 and 10 years, see figure 3.

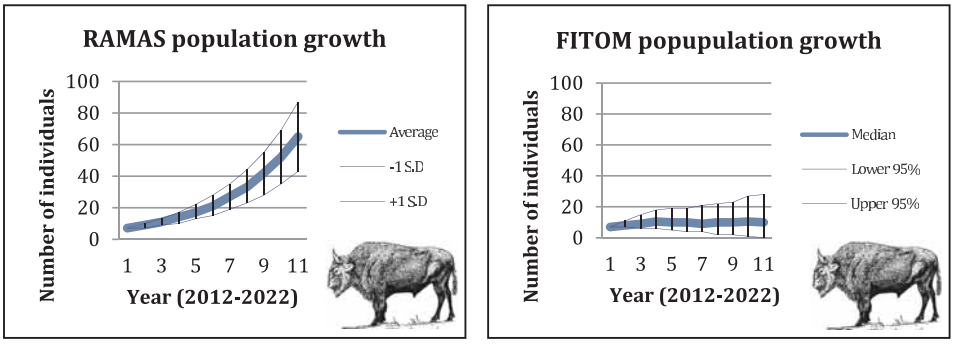

Figure 2A, 2B. The predicted number of individuals in the Danish population of European bison in 10 years after the introduction in 2012.

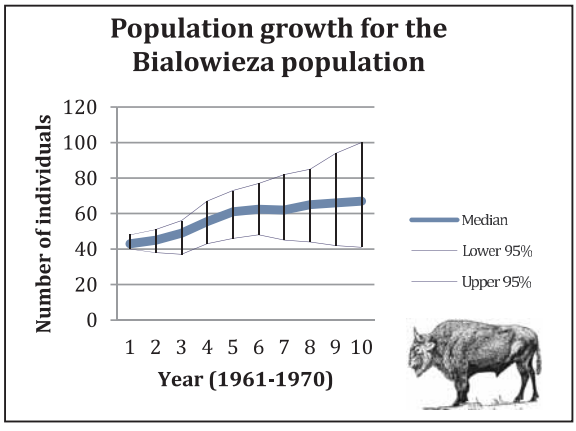

Figure 3. The predicted population growth for the Białowieża population calculated in the programme *FITOM Bison*.

Discussion

The programme *FITOM Bison* was developed to predict the population growth and survival rate of the European bison. Unfortunately, the results from this analysis indicated that the programme considerably underestimates the population growth. This raises a question: Can this new programme *FITOM Bison* be used as a tool for predicting population growth in the European bison? To answer this question more analyses need to be carried out for data on other populations than the one from Białowieża.

Partially, the underestimation of the growth rate in the model can be attributed to the way the model incorporates mortality rate and maximum age over time. In the model those two factors are designed as a linear decrease instead of a more complex pattern as e.g. polynomial and logarithmic. In the next version this approach will be revised as more data on those two factors will be obtained.

The programme *FITOM Bison* also includes results for a population's survival and genetic homogeneity, which were not discussed in this analysis.

Programmes calculating the population growth and survival rate are important in management projects such as the introduction of the European bison to Almindingen. In five years we will be able to see if the predicted growth of the Danish population by the programme *FITOM Bison* is more useful tool than simpler programmes as *RAMAS Metapop population growth* for single population models, despite that they do not account for sex related differences.

Acknowledgements

I am grateful to professor Gösta Nachman for taking the time to program this model for predicting population growth, survival and homogeneity for the European bison. I also thank Rudi El-fouly for inputs and the Danish Nature Agency Bornholm for making it possible to test the programme in the future.

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Modelowanie rozwoju populacji żubra *Bison bonasus*

Streszczenie: W pracy przedstawiono pierwsze próby zastosowania własnego narzędzia służącego modelowaniu wielkości populacji żubra dla stada w Almindingen na wyspie Bornholm. Narzędzie FITOM v.1. zostało opracowane w Kopenhaskim Uniwersytecie, a uzyskane przy jego pomocy wyniki porównano z wynikami ogólnie dostępnego programu służącego do przewidywania rozwoju populacji RAMAS. Stwierdzono, że wielkość populacji jest niedoszacowana przy użyciu programu FITOM. Wyniki są bardzo wstępne i program musi być udoskonalony.