Säugetierkundliche Informationen, Jena 8 (2011) 63 - 68 30.01.2011

Analysis of population modeling results of the Common hamster (*Cricetus cricetus*)

Analyse von Populations-Modellierungsergebnissen des Feldhamsters (*Cricetus cricetus*)

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Zusammenfassung: Der Feldhamster war einmal ein Schädling aber ist heutzutage eine bedrohte Tierart. Eine Möglichkeit, die wichtigen Vorgänge in einer Hamster-Population besser zu verstehen, ist sie in einem Modell zu simulieren. Wir konstruierten ein tagesbasierendes Modell um zu beurteilen, welche die wichtigsten Prozesse für die Erhaltung einer Population sind. Hamster-Populationen wachsen unter grundliegenden Bedingungen (der Literatur entnommen), aber es ist nicht viel Spielraum für eine Variation jedes Parameters, ohne einen Rückgang in der Population (maximal 10%) zu verursachen. The wichtigsten Parameter sind das Überleben im Winter, von Mai bis Juni und von August bis September.

Schlagworte: Feldhamster, *Cricetus cricetus*, Populations-Modellierung

Abstract: The Common hamster was a pest species once in the Low Countries but is nowadays an endangered species. One way to get a better understanding of the important processes in hamster populations is to simulate them by means of a model. We constructed a daily based model to evaluate which processes are the most important for population sustainability. Hamster populations grow under basic scenario settings (derived from literature) but there is not much room for variation within each of the parameters without causing a decline in the population (maximum 10%). The most important parameters are the winter survival, the May-June and the August-September survival.

Key words: Common hamster, *Cricetus cricetus*, population modeling

Introduction

The Common hamster (*Cricetus cricetus*) is a middle sized rodent that lives in agricultural areas in Europe and Asia. Although it was once considered a pest in the whole of the distribution area, it is now critically endangered in the most of western Europe (Belgium, The Netherlands, France and western parts of Germany) and some eastern European countries report a strong decline (NECHAY 2000, BIHARI 2008).

The Common hamster is a protected species in many countries, but an effective conservation strategy has to start with a good knowledge of the population ecology of a species. By means of a model, it is possible to examine which factors are the most important for the persistence of a population. A few models were already developed in the past. LEIRS (2003) constructed a dynamic population model and suggested that populations in Western Europe went extinct within 100 years because of the short breeding season. ULBRICH & KAYSER (2004) made an

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individual-based model and found that adult and subadult females are the most sensitive component of the hamster population, connectivity between habitats is very important and late timing of the harvest can help in creating a persistent population.

Our goal was to construct a refined population model and include the many parameter values that have been measured in recent studies. In this way, we want to see how populations evolve, which parameters are the most important and to find out if an adjusted management can help to improve the sustainability of a population.

Material and methods

A conceptual population model was constructed in STELLA (STELLA 9.0.1.V) with the factors that are thought to influence the population. Hamsters were divided in 3 functional groups according to age: juveniles (0-60 days), adults before first winter (until 31st December of the year of birth) and adults (starting from the 1st of January, in their second year of life). We based the parameterization on literature data, personal communication and reasonable guesses. Most of the parameter values are based on research results from the Netherlands (KUITERS et al. 2010), but data from other countries were also used.

Juveniles in the model had a chance of 25% to survive the first two months of their life. Hence only few data exist on the survival of juveniles (KUPFERNAGEL 2007), but some studies have presented recapture rates of juveniles (GORECKI 1977, KAYSER & STUBBE 2003). In our model we used a juvenile survival of 0.25 for the first 60 days, which is comparable with the calculated survival and within the range of KUPFERNAGEL (2007) who measured survival rates for juveniles of 20-50% after one month.

Animals who survive their first 60 days had thereafter an adult daily mortality rate, depending on the month (Table 1). This adult daily mortality rate is identical for adults before first winter and adults and was calculated based on KUITERS et al. (2010).

Adult females are pregnant during 18 days and produce 2 litters (but see WENCEL et al. 2001, HARPENSLAGER unpublished). The data of giving birth were fixed on the 25th of May and the 8th of July (MAURICE LA HAYE, pers. comm..). However, in reality litters can be born from the beginning of May till the end of August. The litter size was fixed on 7 (WENCEL et al. 2001, LA HAYE et al. unpublished poster), although lower average litter sizes of 3.3 were reported in Austria (FRANCESCHINI & MILLESI 2004) and 6 in a breeding program in Germany (HEIMANN & WEINHOLD 2008). In the basic model, animals were not capable of reproducing before they survived their first winter and had become second year adults. We modeled only the females because hamsters are polygamous, and the females represent the growth potential of the population. The model is daily based, and was run for 50 years (18250 days). We started with 50 females on the 1st of January of year 1.

After determination of all parameter values for the basic scenario, parameter values were one by one reduced until a stable population was reached. In this way we were able to determine the

Tab. 1 Monthly survival of female adults before first winter and female adults (according to KUITERS et al. 2010).

Basic Scenario	
Monthly survival Spring (May-June)	0.89
Monthly survival Mid-Summer (July)	0.84
Monthly survival Late-Summer (August-September)	0.90
Monthly survival Winter (October-April)	0.94

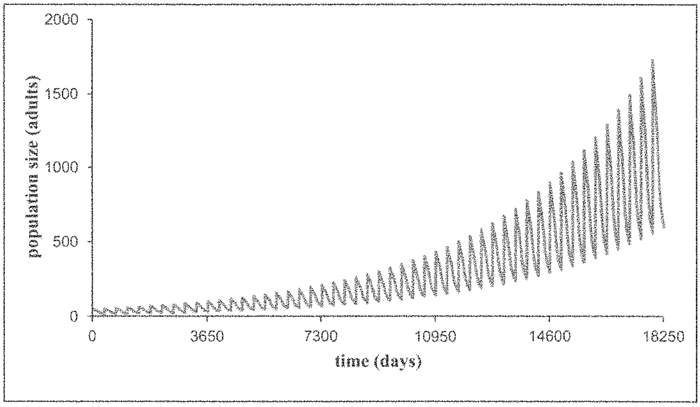

Fig. 1 Population evolution when the basic scenario parameters were used in the model.

minimum value of a parameter without causing a decline in the population (the other parameters were kept at their basic scenario value).

Finally, the elasticity of parameters was determined. The elasticity (e) is calculated by $(\Delta\lambda/\lambda)/(\Delta a/a)$. λ is the growth (or the decline) over 50 years of the population, a is the parameter. By changing the parameter, running the model, and comparing the growth of the scenario with the altered parameter with the growth in a basic scenario, the importance of the adjusted parameter can be determined. We also constructed some scenarios where young of the first litter were able to reproduce in the year of their birth, to examine the effect of 'juvenile' reproduction.

Results

Running the model with the basic scenario resulted in a steadily rising population with a maximum number of females of 1729 in year 50.

The reduction of the parameters led to a stable population (Table 2). The elasticity of the parameters was determined (Table 3). The population growth was also evaluated with and without reproduction of animals in their year of birth (Table 4).

Discussion

The chosen parameter values were of course very important for the outcome of the model. The determination of these values was done to the best of our knowledge and represents a situation

Tab. 2 Possible (maximum) reduction of the parameters without resulting in a declining population.

Parameter	Basic scenario value	Stable	%
Monthly survival Spring (May-June)	0.89	0.856	-4%
Monthly survival Mid-Summer (July)	0.84	0.757	-10%
Monthly survival Late-Summer (August-September)	0.90	0.860	-4.5%
Monthly survival Winter (October-April)	0.94	0.930	-1%
Litter size	7	6.27	-10%
Juvenile survival rate	0.27	0.224	-10%

Tab. 3 Elasticity of the parameters.

Parameter	Basic scenario value	New	e
Monthly survival Spring (May-June)	0.89	0.979	27.33
Monthly survival Mid-Summer (July)	0.84	0.924	10.00
Monthly survival Late-Summer (August-September)	0.90	0.99	24.00
Monthly survival Winter (October-April)	0.94	0.987	116.27
Litter size	7	7.7	9.73
Juvenile survival rate	0.27	0.275	9.73

Tab. 4 Population growth in different juvenile reproduction scenarios.

Percentage of animals born in the first litter, who reproduce in the year of their birth	Population growth
0% (basic scenario)	0.075
12.5%	0.121
25%	0.167
100%	0.444

in the western part of the distribution area (mortality rates derived from hamsters in hamster reserves in the Netherlands). All parameters were fixed on a certain value but in the real world, these parameters fluctuate within a certain range. It would have been better if we had incorporated this variation, but this was not possible because of the lack of empirical data. The parameter values do not necessarily represent the real situation in the complete distribution range of the Common hamster. Parameter values may increase or decline but, in the end, the combination of all of them determines the growth (or decline) of a population.

The evolution of the population (during 50 years) has some striking aspects. The first is that a population can grow without the help of litters produced by juveniles in the year of birth which was opposite to our expectations. Second, the number of adults increased exponentially. This is because there was no carrying capacity defined in the model. The model was designed to find out if populations were theoretically able to grow, based on known parameters. The fluctuations within the graph were also striking. This is an artifact of the way the model was designed. The graph shows only the adults. Animals in the model become adult on the 1st of January (this is the first day of the next year). This is why the number of adults increased every 1st of January and gradually declined until the next 1st of January.

As shown in Table 2, parameters can only be reduced in a small interval (maximum 10%) without causing a population decline. This small range implies that hamsters are sensitive to small changes in parameters, and that a small change can have large effects on the population growth.

The interpretation of the elasticity of the parameters has to be done with care. The winter survival has the highest value, and seems to be the most important factor. However this parameter comprises 7 months and a small change in survival has therefore a large effect. The most important months during the active life of the hamster (hibernation excluded, value per month) are May-June and August-September. May and June are very important because females have their first litter. A change in the adult female survival in spring has a direct effect on the number of first litters produced that season and therefore the total number of adult and juvenile hamsters alive at the end of the breeding season. A change in survival in August-September had a larger effect on the population growth than in July because the young of the first litter are old enough in August-September to be influenced by a change in this parameter. The July parameter has the weakest effect because a smaller number of females has a second litter (a part of the females already died). Survival is difficult to manipulate, but providing cover by an adjustment of the agricultural management has a direct positive effect on survival and population persistence. Finally, the reproduction of hamsters in the year of their birth, which is possible in scenarios with late or no harvest, creates a valuable surplus for the population.

The different results of this model, compared to LEIRS (2003), can be due to the use of different parameter values and/or a refined time scale (days instead of months). However, the parameter values used here are not systematically higher than the values used by LEIRS (2003). The approach of this model is different than the model of ULBRICH & KAYSER (2004). They used a model based on individual behavior traits. Most known data gives an indication about parameter values without examining the behavioral processes. We constructed the model ourselves which gives more freedom than the use of available software e.g. VORTEX (LACY 1993). The time scale used here (daily based) is the same as used by ULBRICH & KAYSER (2004) and has as advantage that available data is not simplified by converting to a coarser scale.

Unfortunately there are gaps in our knowledge on parameter values. Data about the juvenile survival (in the first 60 days) and the percentage of animals reproducing in their year of birth are scarce or even absent and further research is needed for a better understanding of the hamster populations. The model remains to be tested with other data to simulate other situations (like the Austrian hamsters who appear to have much smaller litters (FRANCESCHINI-ZINK & MILLESI 2008)) and to gain a better overall insight in the population dynamics of the hamster. This model is a start, and has to be refined. Long term studies are of great value to determine temporal variation, and simultaneous studies in different areas in Europe can give a valuable insight in spatial variation. The results of the simulations can be used to influence management and to determine which aspects of the population of the hamster deserve extra attention and research.

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