Reproduction of the female Common hamster (*Cricetus cricetus*) in Limburg, the Netherlands

Reproduktion weiblicher Feldhamster (*Cricetus cricetus*) in Limburg, Niederlande

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Zusammenfassung: Der Status des (Feld)Hamsters hat sich im letzten Jahrhundert geändert von einer agrarischen Pest-Art hin zu einer stark gefährdeten Tierart. Um dem Aussterben zuvorzukommen, wurde im Jahr 1999 in den Niederlanden ein Zuchtprogramm gestartet. Damit ist es möglich geworden, Hamster in speziellen Hamsterreservaten wieder einzubürgern. Kenntnis über die Fortpflanzungsökologie ist unentbehrlich, um das Vorangehen zu bestimmen. Diese Arbeit hat sich deshalb auf die Frage konzentriert, wie viel Würfe jährlich im Feld produziert werden: von Hamstern direkt aus dem Zuchtprogramm, durch wilde Tiere (Nachwuchs von ausgesetzten) und umgestellten wilden Tieren. Vorausgesetzt das Hamster während der ganzen Reproduktionszeit (Mai – September) überleben, wurde festgestellt, dass auf Grund von Umzug von einem zum anderen Bau, wilde Hamster 1,9 Wurf hochzogen. Für eine ansteigende Population sollte dass reichen. Umgestellte wilde Hamster hatten 1,4 Würfe und ausgesetzte Tiere nur 0,9 Würfe. Diese Situation besteht in den Reservaten, wo kaum geerntet wird. Außerhalb der Reservate können die Hamster höchstens einen Wurf hoch ziehen. Damit können auf konventionell bewirtschaftetem Ackerland die hohen Verlusten nicht kompensiert und keine stabile Population erhalten werden.

Schlagworte: Feldhamster, Fortpflanzungsökologie, jährliche Anzahl an Würfen, Wiederansiedlung, Reservat

Abstract: The status of the Common hamster in Europe has changed during the past century from an agricultural pest to an endangered species. To prevent extinction in the Netherlands, a breeding program was set up, from which hamsters were released in the wild in several hamster reserves in the province of Limburg. Knowledge on the reproductive ecology of the Common hamster is essential to determine the progress of the reintroduced populations in Limburg. Therefore, this study concentrated on the question how many litters were produced annually by captive-bred, wild (offspring of captive-bred) and wild-moved (wild hamsters moved by humans from one reserve to another) hamsters in the Netherlands. Based on the total time the hamsters were alive during the reproductive season (May-September), it was determined that wild hamsters could have 2.5 litters on average, wild-moved 1.8 and captive-bred 1.6. When the movements of hamsters during the breeding season, were also taken into account, wild hamsters were able to raise 1.9 litters, which should be enough to get a growing population. Wild-moved hamsters could have 1.4 litters and captive-bred only 0.9. However, since juveniles born from captive-bred hamsters are considered wild, a population of captive-bred individuals will decline at first, but will start growing after 1-2 year. When hamsters are living outside hamster reserves, they are only capable of raising 1 litter, because the crops are harvested around July. One litter a year is not enough to compensate for the high mortality that hamsters experience on conventional managed fields and it is thus not possible to maintain a stable population solely on conventional managed fields.

Key words: Common hamster, reproductive ecology, annual number of litters, reintroduced population, reserve

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Introduction

Common Hamsters preferable live in dense cereal and Lucerne (*Medicago sativa)* fields, which makes it very difficult to measure their reproductive output. In most studies capture-recapture methods are used to determine the number of juveniles and to monitor reproduction (KAYSER 2003). However, this method has been found to have a disturbing effect on female hamsters during the reproductive season in a study in Belgium (VERBIST 2008). An alternative, non invasive, method to estimate the reproductive output, is using the data on radio-tracked hamsters as available in the Netherlands.

In this study, based on hamsters with a radio-transmitter, we determined the number of litters that a female hamster could have had during the reproductive season in the Dutch province of Limburg. The number of litters was first calculated on the total survival-time of the hamsters and secondly also on the burrow residence time: the time a hamster had spent at one burrow. This was done for three 'groups' of hamsters, namely hamsters that were born in the wild, captive-bred hamsters that were released into the wild and wild hamsters that were moved by humans from one area to another.

Materials and methods

Reproduction period and gestation/lactation times

The reproductive season was estimated to last from 1 May until 30 September (153 days), in accordance with observations made by FRANCESCHINI-ZINK & MILLESI (2008). The gestation time of a female Common Hamster is approximately 18-20 days (ULBRICH & KAYSER 2004, NECHAY 2000). Young hamsters emerge at the surface after 21 days, and will start looking for their own territory soon after (TAUSCHER et al. 2008, FRANCESCHINI-ZINK & MILLESI 2008). Thus approximately 40 days are assumed to be necessary for a female hamster to raise one *certain* litter, which is in accordance with observations made in Vienna, where the number of days between two litters was on average 42 days between the first and second, and 37 days between the second and third litter (MILLESI, pers. comm.). However, because it could also be possible that a litter is raised in less than 40 days, the terms *probable* and *possible* litter have been introduced. The number of days associated with a *certain*, *probable* or *possible* litter can be found in Table 1.

Tab. 1 Number of days associated with the number of *certain*, *probable* and *possible* litters.

Number of days	Certain no. of nests	Probable no. of nests	Possible no. of nests
120 or more	3	3	3
110-120	2	3	3
100-110	2	2	3
90-100	2	2	2
80-90	2	2	2
70-80	1	2	2
60-70	1	1	2
50-60	1	1	1
40-50	1	1	1
30-40	0	1	1
20-30	0	0	1
10-20	0	0	0
0-10	0	0	0

Determining the number of litters that a female common hamster had, was first done using only the total number of days each hamster survived during the reproductive season (May-September). The total survival of captive-bred and wild-moved hamsters is calculated as the number of days between the moment of release and the moment of death or the end of September. In wild hamsters it is the number of days since the 1st of May and the moment of death or the end of September. To prevent overestimation of survival, a hamster that was found dead was assumed to have died the day after the last alive sighting.

Secondly the number of *certain*, *probable* and *possible* litters was determined using the burrow residence time (BRT) which is defined as the number of days a hamster spent at one burrow, thereby taking movements into account. And assuming the 'failure' of a litter if movements were within 40 days. A hamster is assumed to have moved immediately after the last sighting at the old burrow. Locations within 10 meters of each other were assumed to belong to the same burrow due to the accuracy of the GPS device and were not counted as a movement. Also, to eliminate movements that resulted from the search for a new territory, a movement was only counted when the hamster stayed at the new burrow for at least 7 days. A similar method of calculating successful or unsuccessful litters was previously used by MÜSKENS et al. (2008), although they assumed that a period of 4 weeks (28 days) should have resulted in a certain litter.

Data

In this study, a data set was used that was collected between 2002 and 2008 by weekly tracking hamsters with implanted radio transmitters. In total it contained information on location, sex, age and status of 615 hamsters. In this study only the information on female common hamsters was used, divided into three categories: hamsters born in the wild (wild; n=49), hamsters born in the wild and then moved by humans to a new area (wild-moved; n=17) and hamsters born in captivity and released into the wild (captive-bred; n=104).

Missing hamsters

Although ideally all hamsters were followed from the moment of release with the transmitter until their death (or the end of September), some hamsters went missing during the breeding season because of failing transmitters. To calculate the number of litters these hamsters would have had, a correction had to be applied, because excluding them would result in a great loss of data. Two separate corrections are necessary, namely: one that corrects for the number of days that a missing hamster would have lived after disappearing, and one that corrects for the number of movements this hamster would have made and thus to determine the burrow residence time of these hamsters.

With the monthly survival rates, which were calculated from the hamsters that could be followed from release until death, it was calculated how long missing hamsters would have remained alive on average after disappearing. The survival rates differed between wild/wild-moved hamsters and captive-bred hamsters and are shown in table 2 (derived from KUITERS et al. 2007) and table 3 respectively. Because the monthly survival rates of the captive-bred ham-

Tab. 2 Monthly survival rate of wild and wild-moved hamsters.

Month	Survival rate
May	0.892
June	1.000
July	0.869
August	0.857
September	0.871

Tab. 3 Monthly survival rates for each month after release for the captive-bred hamsters.

Month (after release)	Survival rate
1st	0.63
2nd	0.73
3rd	0.89
4th	0.89
5th	0.89

Tab. 4 Conversion rate used to correct for the BRT in missing hamsters.

Group	Conversion rate
Wild	0.79
Wild-moved	0.85
Captive-bred	0.61

Tab. 5 Carrying capacity (in no. of hamsters) for the different areas in Limburg, the Netherlands.

Area	Acreage	Carrying capacity
Sibbe	50	200
Amby	25	100
Heer	20	80
Sittard	40	240
Puth	45	270
Koningsbosch	20	80
Wittem	20	80
Other		150

sters appeared to be much lower immediately after release, their survival rates were calculated per month following release instead of actual months (table 3).

After correcting for the average number of days the missing hamsters would have survived after disappearing, the number of litters could be determined using the survival-method. Secondly, the number of litters of these 'missing hamsters' were corrected for the BRT. This correction was applied by using a conversion rate (table 4), calculated from the data of the hamsters that did not go missing: the difference in number of litters between both methods was used as the conversion rate. The number of litters that the missing hamsters would have had based on their corrected survival was subsequently multiplied by this conversion rate.

Calculation of population growth

The growth of two hypothetical populations consisting of either 100 wild or 100 captive-bred female animals was calculated using the number of *certain* litters that was determined with the BRT-method. One litter was assumed to consist of 7 juveniles (NIETHAMMER 1982 in ULBRICH & KAYSER 2004) with a sex ratio of 1:1. The juvenile survival during the reproductive season was estimated to be 40%. This number seemed realistic in relation to other juvenile small mammal's survival rates, which were usually around 37-50% (KRAUS et al. 2005). After September, the remaining juveniles were expected to have the same survival rates as wild adult hamsters. Also, juveniles born to captive-bred hamsters were considered "wild" and were thus assumed to have wild survival and reproductive rates. The wild and captive-bred survival rates were taken from table 2 and table 3.

For wild hamsters another calculation of the actual population development was made, using the same survival and reproductive rates, but also including a carrying capacity for each area in Limburg where hamsters live. This carrying capacity was based on observations made in the field (table 5).

Statistics

Data were tested for normality using Shapiro-Wilk. Because all data were not normally distributed, tests with multiple groups were carried out with Kruskall-Wallis independent test, while differences between two groups were tested with the Mann-Whitney U test. All results are presented as Mean ±S.D. unless stated otherwise.

Results

The survival of wild hamsters appeared to be significantly higher than that of wild-moved and captive-bred hamsters (figure 1). With a median of 146,5 days, it became apparent that a lot

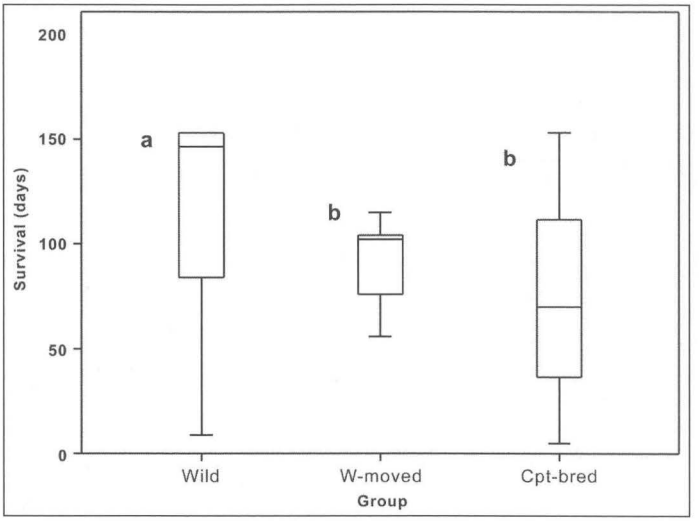

Fig. 1 Box plot of the survival in days between May and September with median and interquartile range for wild, wild-moved and captive-bred hamsters.

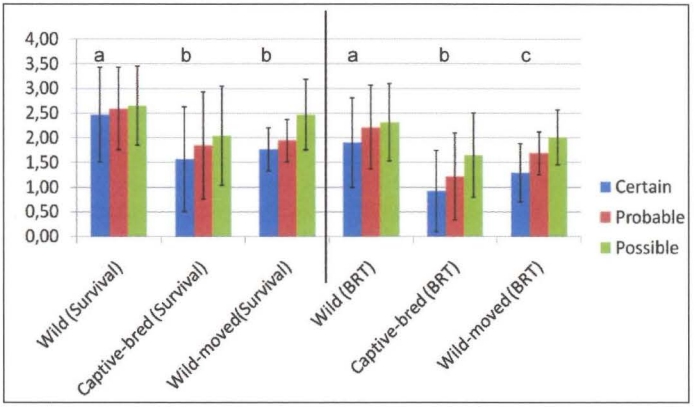

Fig. 2 Number of certain, probable and possible litters produced by Wild, Captive-bred and Wild-moved hamsters based on Survival and BRT.

of wild hamsters survived the entire reproductive season (figure 1). For captive-bred hamsters, the median was about 70 days, with 25% living less then 40 days. Especially immediately after release, a lot of captive-bred hamsters died.

The number of litters that captive-bred, wild and wild-moved hamsters produced on average was determined using both the total survival and the BRT (figure 2). Based on the total survival, the captive-bred individuals were able to raise 1.57±1.07 *certain* litters, whereas the wild-moved hamsters were able to raise 1.76±0.44 and the wild animals 2.47±0.96 *certain* litters. Using the BRT, the number of litters produced by wild hamsters would be 1.90±0.91, for wild-moved 1.39±0.58 and for captive-bred hamsters 0.92±0.82. Also, when the probable and possible litters are included, the number of litters reaches an average of 2-2,5 for wild, 1,5 – 2 for captive-bred and 1,5-2,5 for wild-moved (figure 2).

With both methods it appeared that wild hamsters produce, on average, 1 litter more than captive bred individuals. The difference between these two groups was found to be significant for both methods. The wild-moved hamsters differed significantly from both the wild and the captive-bred using the method based on the BRT. Using the survival-method, wild-moved only differed significantly from the wild hamsters and not from the captive-bred.

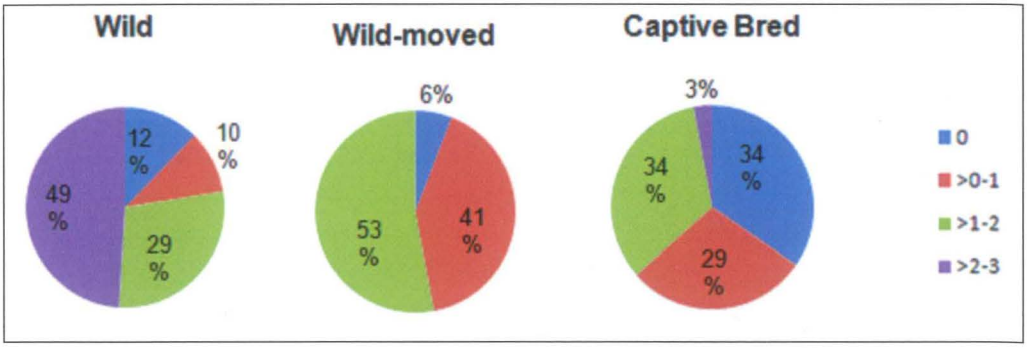

Fig. 3 Percentage of wild and captive-bred hamsters with 0, >0-1, >1-2 and >2-3 certain litters.

Almost 80% of the wild hamsters was found to be able to produce more than 1 *certain* litter (based on the BRT), while only 50% of the wild-moved and 37% of the captive-bred hamsters could have more than 1 litter (figure 3). Also, a lot of wild hamsters (49%) seemed to produce more than 2 litters, whereas hardly any of the captive-bred individuals (3%) and none of the wild-moved hamsters were able to achieve this (figure 3). Of all captive-bred hamsters, 35% could not produce any litters at all, while only 12% of the wild and 5% of the wild-moved hamsters appeared to be unable to produce 1 or more litters (Figure 3).

Population growth

Using the BRT-method, wild hamsters were found to produce an average of 1,90 *certain* litters per year. This means that 100 adult females produce 190 litters with, on average, 665 female juveniles. Of these juveniles 266 will survive until the end of the reproductive season. In May, 151 of the 266 juveniles will have survived the hibernation period and made it to adulthood. Of the 100 adult females of the previous year, 33 are also still alive in May. This means that the population has grown from 100 to 184 females over the course of 1 year. In the course of three years this growth could, theoretically, continue exponentially, reaching a number of over 600 female hamsters in 3 years (figure 4).

The same calculation for captive-bred hamsters using their survival (table 3 for adults, table 2 for offspring) and average number of *certain* litters (0.92 for adults, 1,9 for their offspring), results in an initial population decline of 13%. However, captive-bred offspring is wild, and thus has the same reproductive rate as the wild hamsters in the example above, which leads to a growing population from the second year on (figure 4).

The problem with modern agriculture is that hamsters have limited time due to early harvest, and will probably only be able to raise one litter. A population of 100 adult females living on

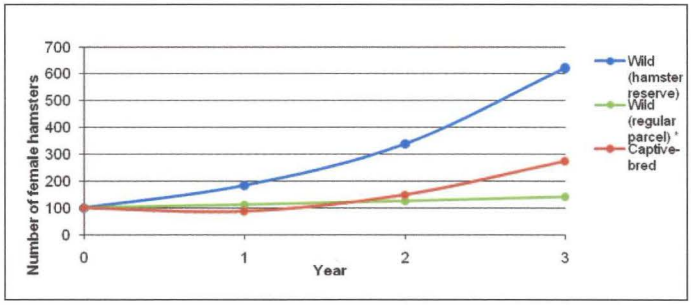

Fig. 4 Calculated population growth during 3 years for populations of 100 wild (hamster reserves), wild (regular managed parcels) and captive-bred (hamster reserves) hamsters based on the number of certain litters.

* based on the survival of wild hamsters in hamster reserves

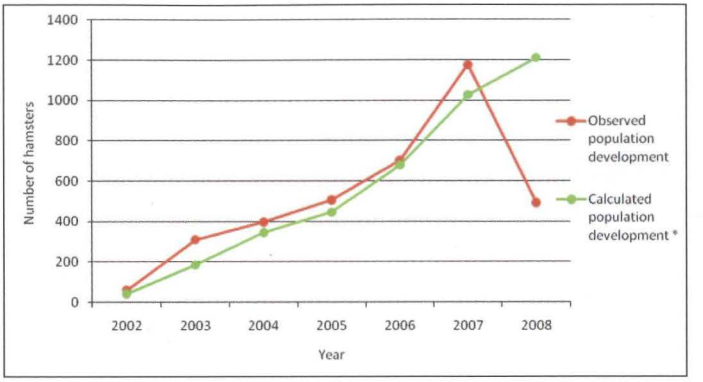

Fig. 5 Observed and calculated population development (both males and females) in Limburg, the Netherlands.

*Based on a defined carrying capacity per area

these fields would thus produce a maximum of 100 litters with 350 juvenile females. Of these 350 juveniles, 79 will survive until the start of the next season, along with 33 of the original adult females. The population will thus consist of 112 females and is growing slightly. However, in following years, the growth rate will not increase, and the population will remain approximately stable (figure 4).

The calculations presented in Figure 4, however, assume that the population can grow exponentially. In reality, there is a certain limit to the number of hamsters that can live within one area. Including this carrying capacity, it is possible to predict a more realistic development of the populations in Limburg. Using the reproductive rates that were determined in this study and the survival rates from table 2 and table 3, a population growth was calculated that almost perfectly matched the observed population size that was measured in the field (figure 5). Besides reproduction, yearly releases of captive bred hamsters also contribute to the observed rise in population sizes.

Discussion and Conclusion

Although GRULICH (2003) reported that hamsters were able to raise 4-5 litters annually, most other studies found an average of 1-2 litters (TAUSCHER et al. 2008, FRANCESCHINI-ZINK & MILLESI 2008). In this study, a higher average (on average 0.5 litter more for each group) was found using the survival method. However, since this method does not include movements, it is less realistic than the method that uses the BRT. It is useful to see the difference between those two methods. The survival method shows the number of litters that is theoretically possible during the period of a living hamster. Comparing this to the BRT method shows how much time a hamster "loses" by moving around, leading to less litters than there could have been based on the total survival.

Using the BRT method, an average number of litters of 1.9 per season was found for wild hamsters, which is in accordance with literature. For the captive-bred hamsters, however, the average number of litters produced was only 0.9 and for wild-moved 1.4. This difference can be explained by looking at the survival. Wild (incl. wild-moved) hamsters generally live longer, which gives them more time to reproduce. The reason that wild-moved hamsters have less offspring is mainly due to the fact that they were released into their new area later in the season, giving them less time to reproduce. Both wild and wild-moved hamsters did not move around as much as captive-bred hamsters. Moving around strongly increases the chance of predation, which also explains the higher mortality rates of captive-bred hamsters. Even though their survival is low, captive-bred hamsters can form the basis of a healthy wild population, because their offspring will be born in the wild and thus have higher survival and reproductive rates, as was shown in the calculation of population growth (figure 4).

Both the captive-bred and the wild hamsters should be able to develop a growing population, based on the calculations in this study. However, in the example both populations appeared to grow exponentially, which is obviously not very realistic. Therefore, a carrying capacity was included in the calculations as well as the additional releases of captive-bred hamsters into the wild, resulting in a more realistic development that actually matches the real population development quite well. Between 2007 and 2008 a population crash can be observed in the actual population size, which was probably due to the very small mice populations at that time, causing predators to switch to hamsters.

Almost all hamsters used in this study were found inside hamster reserves where hamster-friendly management, most notably delayed mowing/harvesting or no mowing/harvesting at all, was applied. Because in these areas cover and food were available throughout the reproductive season, the hamsters could have been able to raise the expected 2 litters. When hamsters live on regular, conventional, managed parcels, cover disappears around July, which means that they would probable only have time to raise one litter. In the calculation it appeared that one litter a year would result in a fairly stable population. However, in this example, calculations were carried out using survival rates of hamsters living on hamster friendly managed fields. Survival rates are thought to be the same for both management regimes, until the crops are harvested. Without cover, hamsters will not stay on those parcels and will either get predated or move to a parcel where crops are still present (KAYSER et al. 2003 in KUPFERNAGEL 2008). Outside hamster-friendly managed reserves it would thus not be possible to maintain a stable population without continuous migration of hamsters from the reserves to the conventional managed parcels.

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