Hard to stay under cover: Seven years of crop management aiming to preserve the Common hamster (Cricetus cricetus) in the Netherlands

Schwer Deckung zu finden: Sieben Jahre Feldfrucht Management in den Niederlanden mit dem Ziel Feldhamster (Cricetus cricetus) zu schützen

Abstract: Populations of the common hamster (Cricetus cricetus) are declining in Western Europe. Habitat fragmentation and changes in agricultural land use are the main reasons for the decline. In the Netherlands, a species protection plan was adopted in 2000, consisting of a reintroduction program and arrangements to create an interlinked hamster habitat of 500 ha. Now, it is eight years ago since the first hamsters were reintroduced in hamster reserve Sibbe (46 ha). The purpose of this research was to evaluate crop management in this reserve, by analysing the vegetation cover. Results show that on average, 45% of the Sibbe reserve provided sufficient cover for hamsters over the years. The best cover providing crop was alfalfa, as it offered sufficient cover during the longest time span, and provided most hectares with at least 80% cover. The crop that offered sufficient cover earliest in spring was winter oats, so it is recommended to cultivate this crop more frequently. In the Sibbe reserve, harvest was timed early in the season, as the average cover of harvested crops started already to decline from early August. This might negatively affect the development of the second litter. To reach a growing hamster population, at least two litters are required. Consequently, it is recommended to postpone harvest until mid September. More direct research focused on the Dutch hamsters themselves is needed to improve preservation of the Common hamster.


Schlagworte: Feldhamster (Cricetus cricetus), Nageziere, Wiederansiedlung, Prädation, Vegetationsdichte, Vegetationsdeckung, Landwirtschaft, Biodiversität, Habitatfragmentation, Niederlande
Habitat fragmentation and intensive change in agricultural land use lead to biodiversity loss in the Netherlands. The National Ecological Network (EHS) and other nature development plans were adopted to stop this ongoing loss of biodiversity (VAN VEEN et al. 2008). However, some nation-wide protection plans were not specific enough in order to save them from extinction, for example the European common hamster (Cricetus cricetus). In Western Europe, the common hamster only occurs in fragmented populations in Germany, Belgium and France (ULBRICH & KAYSER 2004), and is registered as a strictly protected species in the Habitat Directive (92/43/EEC, 1992, Annex IV). Since common hampsters only dig their burrows in specific soil types (loess or loam), the Dutch population is native to the southern part of the province Limburg, where loess soils are found. The species became threatened between 1970 and 1993, when the population range declined with 74% on average (KREKELS & GUBBELS 1994). The population continued to decline to only a few hamsters in 1999 (KUITERS et al. 2010). Changes in crop use and habitat fragmentation are the main reasons of the decline. The habitat preferred by hamsters consists of cereal parcels, but many of these have been replaced by grassland, maize, and forest. Furthermore, development of residential areas and infrastructure has led to large gaps between habitats, which impede exchange of individuals between parcels (KREKELS 1999).

To preserve the Dutch common hamster population, a species protection plan was launched with the objective to enhance 500 ha interlinked hamster habitat spread across the southern part of Limburg (KREKELS 1999). Additionally, to stop the ongoing population decline, captive-bred hamsters were reintroduced in subareas of this hamster habitat. From 2002 to 2009, a total of 762 hamsters were reintroduced (KUITERS et al. 2010). The population size increased to 1200 hamsters in 2007, but after a crash in 2008 the population size was ca. 600 hamsters in 2009 (KUITERS et al. 2010). Research during the reintroduction project showed that predation was the main cause of death, especially by red foxes (Vulpes vulpes), mustelids (Martes spp.), and common buzzards (Buteo buteo) (LA HAYE et al. 2005). Predation rates were especially high in spring, when hamsters were leaving their burrows after hibernation, and vegetation density was still sparse. Another risky period was after agricultural measurements that reduced cover and food, like mowing or ploughing (LA HAYE et al. 2005).

Due to the small population size, population dynamics of common hamsters in the wild are not well documented, so theoretical models were developed to make predictions. Results from individual-based model studies emphasize that survival of female hamsters is especially important for hamster population growth (based on KUITERS et al. 2010). Hence, an analysis was done of which crop offered enough cover for the longest period. Secondly, it was assumed that survival of females is enhanced by sufficient cover early in spring (based on SWINNEN 2010). Consequently, the increase in cover of each crop was determined for the spring period, and the best cover providing crop in spring was distinguished. The third assumption was that the timing of harvest determines how many litters can be born each year (HARPENSLAGER 2009; SWINNEN 2010). Therefore, the average harvest time of each crop was investigated to see whether females could produce two litters in a year. Finally, the best cover providing crops were distinguished, and the optimal crop combination was examined and evaluated.

Material and Methods

Area description

The Sibbe reserve is part of a subarea belonging to Mergelland-West in the Dutch province Limburg. The total size of the Sibbe habitat is 153 ha, of which 48 ha consists of reserve (BAKKER & VAN NOORDEN 2007). A small part of the reserve (2 ha) is cultivated as grassland, which is incompetent as hamster habitat. On the remaining 46 ha, crops are cultivated that are preferred by hamsters, consisting mostly of alfalfa (33%) and cereals (67%) (MUSKENS et al. 2005). These crops are cultivated under restricted conditions. Winter cereal crops are only partly harvested in order to ensure cover and food availability. Furthermore, ploughing dept is restricted to 30 cm to prevent demolition of burrows. Agricultural management is carried out by collaboration between researchers and the reserve manager (MUSKENS et al. 2005). In total, 14 different crops were cultivated over the years 2003 to 2009, but not every crop was cultivated every year. The crop names and the cultivation periods are shown in Table 1.

Crop condition survey

Starting from spring 2003, the average height (cm) and cover (%) were registered of all parcels in the Sibbe reserve. In total, there were 54 parcels, of which some were divided into separate parts. The mean area per parcel was 0.55 ha (SD=0.03). The cover and height data were collected by selecting three spots per parcel where the cover and height resembled the overall field. The height was determined by using measurement tape, and the cover was visually estimated. Specific conditions were registered as well, like the date of sowing, mulching, harvest, ploughing, and the percentage of weeds. These data were collected in a dataset, ordered by height (cm) and cover (%) per crop type per parcel (in ha). In total, 142 surveys were done from 2003 to 2009. As this study focuses on the period from spring until autumn, only the surveys between the first of March and the 30th of November were used in the analysis. During this period, a total of 125 surveys were done with a mean of 17.8 (SD=3.2) a year, and with a frequency of one survey in every 2.1 weeks (SD=1.2).

Analysis

For statistical analyses, SPSS version 16 was used. All error bars in graphs indicate standard deviations. Data with normal distributions were analysed by using independent t-tests or ANOVA; data with deviating distributions were analysed by Mann Whitney U tests. The crop data were categorised in half-month periods. Additionally, the data were split into the categories ‘harvested
Tab. 1 Overview of crops cultivated in the Sibbe reserve from 2003 to 2009. It is also indicated which crops were harvested or not, and a line (-) signifies that this crop is not important for hamster conservation.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Period of cultivation (years)</th>
<th>Harvested (yes/no)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>7</td>
<td>Yes</td>
</tr>
<tr>
<td>Winter wheat</td>
<td>7</td>
<td>Yes</td>
</tr>
<tr>
<td>Black garden radish</td>
<td>6</td>
<td>No</td>
</tr>
<tr>
<td>Winter rye</td>
<td>5</td>
<td>Yes</td>
</tr>
<tr>
<td>Spring barley</td>
<td>4</td>
<td>Yes</td>
</tr>
<tr>
<td>Flax</td>
<td>4</td>
<td>No</td>
</tr>
<tr>
<td>Oats</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>Oats-barley mix</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>Spring wheat</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>Mustard</td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td>Winter oats</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>Spring rye</td>
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<tr>
<td>Winter barley</td>
<td>1</td>
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<td>Spelt wheat</td>
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<tr>
<td>Spelt</td>
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<tr>
<td>Oats</td>
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<tr>
<td>Mustard</td>
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<td>Winter barley</td>
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<tr>
<td>Alfalfa</td>
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<td>Spelt wheat</td>
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crops' and 'unharvested crops'. Exceptions were data of alfalfa, black garden radish, winter barley, spring rye, spelt wheat, mustard, and flax, because these crops were not harvested, or in the case of alfalfa, mown regularly (Table 1). The minimum percentage of cover that hamsters require was set on 80% (LA HAYE, pers. comm.). Expert judgement showed that lower cover percentages do not lead to complete concealment of underlying objects, so predators would easily detect a roaming hamster.

To analyse which crops provided enough cover for the longest period of time, the period (in days) was determined per crop during which cover was equal to or above 80%. In this analysis, spelt wheat, mustard, and flax were left out, because these crops were only cultivated for short periods in a year and were of no significant importance for hamster preservation. Additionally, the sample sizes of winter barley, spring rye, and oats-barley mix were also too low for this analysis. It was assumed that hamsters are active from early May until late September (SCHMELZER & MILLESI 2008), which is ca. 150 days. This is the minimum period in which sufficient cover should be available for hamsters. To determine the increase of cover provided by each crop in spring, the average cover of crops per half-month period was calculated over the seven survey years. By checking when each crop reached the 80% threshold, the earliest cover-providing crop could be distinguished.

To find out whether females could produce two litters before harvest, the average harvest time of crops was calculated over the seven survey years. While it was assumed that Dutch hamsters hibernate from November until April (KUITERS et al. 2010), exact data about reproduction are lacking. In Austria, the first litters emerged aboveground in late-May, and the second litter emergence peak occurred in mid August. No active females were seen after the end of September (SCHMELZER & MILLESI 2008). However, recent research in the Netherlands showed that females and juveniles are still active in October (pers. comm., MUSKENS 2010). The gestation time was 18 days in Germany (NIETHAMMER 1982, cited in ULBRICH & KAYSER 2004). Furthermore, HARPENSLAGER (2009) assumed that it takes ca. 40 days to raise a litter, according to data from MILLESI (unpublished data 2009). This is followed by 23 days before the second litter is born (SWINNEN 2010). Assuming that Dutch females emerge in early May, and are immediately fertilised, then the first litters are born around the 18th of May. These litters become independent 40 days later, which is around the 27th of June. Twenty-three days later, the second litter is born around the 20th of July. Forty days later, the second litter becomes independent around the 29th of August. These estimated days were used in the analysis to find out if females can still reproduce twice in parcels that are harvested.

Results

In the Sibbe reserve (46 ha), the area with sufficient cover (at least 80%) did not differ significantly per year within the period from May 1st until September 30th (ANOVA: F=2.15; P=0.06; see Figure 1). To show variation between years, the area (ha) with at least 80% cover is shown in three of the seven years (2005, 2008, 2009) in relation to time in half months (Figure 2). In 2009,
the largest area with sufficient cover was measured (maximum 41.6 ha, 89% of the reserve). The year 2008 had an intermediate cover, with a slow increase of the area with at least 80% cover in spring, and an early decrease in autumn. In 2005, the smallest area with sufficient cover was recorded (together with 2006). The years that are not shown had patterns laying in between of 2005 and 2008.

In the Sibbe reserve, 33% of the parcels (not area!) were cultivated with alfalfa, and 67% with cereals. Figure 3 shows the average area (%) with sufficient cover occupied by alfalfa, cereals and the remaining crops in time (half month periods, from March until November). The average area of cereals with a cover of 80% was not significantly different from alfalfa (Mann Whitney U: \[ Z = -1.23; P = 0.23 \]). Until mid August, the average area covered by alfalfa and cereals overlapped in size, but after this period, the area of cereals decreased, while the area of alfalfa relatively stayed at the same level until the end of September.

**Fig. 3** The average area (%) in relation to time (half months) that was occupied by crops that had 80% cover or more in the years 2003 to 2009. The ‘cereals’ category represents the summation of area occupied by wheat, barley, rye, oats, oats-barley mix, and spelt wheat. The category ‘others’ represents the area of black garden radish, flax, and mustard.

The years that are not shown had patterns laying in between of 2005 and 2008.

**Fig. 4** Average number of days over the years with 80% cover or more. The dotted line indicates 150 days, which is the period from May 1\(^{st}\) until October 1\(^{st}\). The error bars indicate standard deviations. The star indicates a significant difference (Winter wheat; Mann Whitney U test: \[ Z = 2.13; P = 0.041 \]).

**Number of days with sufficient cover**

To see which crop offered sufficient cover for the longest period, the average time (in days) a crop offered at least 80% cover was calculated (Figure 4). Data of harvested crops were split from data of unharvested crops, as harvest affects the cover provided by crops. The minimum required period is pointed out by a dotted line (150 days, from May 1\(^{st}\) until October 1\(^{st}\)), and the error bars indicate the standard errors. Crops without error bars were sown in one year and harvested in the other (e.g. oats and winter oats). The results of this analysis show that alfalfa provided sufficient cover for the longest period (µ=166.3 days; SD=28.5). Two other crops that reached the 150 days on average, were black garden radish and winter rye. On average, unharvested winter wheat and spring barley did not reach 150 days. However, error bars indicate that winter rye and winter wheat reached the same number of days as alfalfa in some years. The number of days with at least 80% cover remained below 150 days for spring rye, oats, winter oats, and spring wheat. Of the harvested crops, only winter rye provided cover for 150 days in one year, although on average, the number of days remained on 120 days (SD=30.0).

**Increase of cover in spring**

To distinguish the earliest cover-providing crop in spring, the increase of average cover (%) per crop over the seven years was analysed in the first months of spring. No statistical tests could be executed, because the sample size varied per crop from zero to seven years. The results could be categorised in three groups: early, intermediate, and late cover providers. The first group only contained winter oats, which reached 80% cover in early May. The second group was represented by oats-barley mix and oats (mid May), followed by winter wheat and winter barley (mid June). Spring barley, spring rye and spring wheat were grouped in the last category, as they did not reach the 80% threshold at all, but reach their maximum in mid June to early July. Four of the representatives are shown in Figure 5, with winter oats as the earliest crop, oats-barley mix and winter barley as intermediate crops, and spring wheat as the latest crop.

**Effect of harvest on cover**

In the next analysis, the average harvest time was determined for the harvested crops (see Table 1 for the overview) over the seven years. By comparing the average cover (%) on unharvested parcels with average cover on harvested parcels, the loss of cover due to harvest could be measured (Figure 6). Until the end of July, there was no significant difference between average cover provided by harvested and unharvested crops, but there was from early August until early
October (Mann Whitney U test; Aug 1st: Z=-2.75, P=0.04; Aug 15th: Z=-2.49, P=0.01; Sept 1st: Z=-3.13, P=0.001; Sept 15th: Z=-3.13, P=0.001; Oct 1st: Z=-3.00, P=0.001). The error bars of harvested crops indicate the large spread and dissimilar harvest times. (Ng standard deviation!)

Fig. 6 The average cover (%) of all crops taken together, from May until October. The average cover of unharvested (black line) and harvested (grey line) parcels is shown against time (half months). The dotted line indicates the 80% threshold. The grey bar shows the time range of the second (2) litter. Stars show significant differences between harvested and unharvested crops.

Fig. 7 Average cover (%) provided by five harvested crops (winter barley, winter wheat, winter oats, oats, and oats-barley mix) from early May until early October, in half-month periods. The grey bar (2) indicates the period when the second litter would be raised.

Fig. 8 Variation in average cover (%) of winter rye in different years, shown in half month periods from early May until the end of October. The grey bar (2) indicates the period in which the second litter would be raised, and error bars indicate the standard deviation.

Discussion

According to KUITERS et al. (2010), presence of sufficient cover is the most important factor for crop management in common hamster conservation areas. If the density of a crop is too low, hamsters are easily seen by predators, and predation is the main cause of death for common hamsters in the Netherlands (LA HAYE et al. 2005). In this study, the percentage of cover in a hamster reserve (46 ha) was analysed by using a dataset of the years 2003 to 2009. It was assumed that at least 80% cover was required to successfully conceal a hamster. On average, only ca. 43% (SD=8.5) of the Sibbe reserve was sufficiently covered over the years from early May until and September (Figure 1). In 2009, the average area with 80% cover was higher (62%, SD=2.4), although this difference was not significant. In 2005 and 2006, the smallest area with enough cover was recorded, which was on average 37% (SD=11.7). These results show that an essential part of the Sibbe reserve was not sufficiently covered during the breeding season / reproduction each year.

Crops & cover

Of all crops, alfalfa parcels contributed most to the area with 80% cover (Figure 3). This was measured by the sum of all of the cereal parcels. However, from August, the area covered by cereals started to decrease. This was caused by the harvest regiment in the Sibbe reserve, as many cereal parcels were already harvested in August (Figure 7). Conversely, alfalfa was mown in May and early June, where after it soon grew back.

Alfalfa also was the crop that provided at least 80% cover for the longest time period (Figure 4). These results emphasise the importance of alfalfa in a hamster habitat. Other crops that provided sufficient cover for at least 150 days were black garden radish and winter rye. Black garden radish is used as a natural inhibitor of weeds (KUITERS et al. 2010). This crop is sown in May, so it only provides cover in summer. This signifies that black garden radish could play an important role in the period when hamsters are preparing for hibernation (July until early November). Unharvested winter rye and winter wheat also provided sufficient cover for at least 150 days, although the average number of days lay just below 150 days for winter wheat. Spring barley, oats, winter oats, and spring wheat only reached the 80% threshold for shorter periods than 150 days. It is clear that harvested crops provide cover for shorter periods of time than unharvested crops, although the difference was only significant for winter wheat. So, hamsters living in parcels that are harvested, probably had relatively shorter periods with cover and food. Parcels with alfalfa, black garden radish, and unharvested parcels of winter rye and winter wheat were suitable habitats for hamsters, as they provide 80% cover during much longer periods.

Hibernation

The number of days a crop can provide 80% cover depends on the moment it reaches this threshold for the first time. This moment was determined for each crop in spring. The crop that reached the threshold earliest was winter oats (in early May, Figure 5). Oats and oats-barley mix followed half a month later, while the remaining winter crops (winter rye, winter barley, winter wheat) reached the 80% level in early June. The spring crops reached sufficient cover even later, in early July.

The exact moment when hamsters emerge after hibernation is unclear for the Dutch population. KUITERS et al. (2010) state that hibernation takes from November until April, but it can take longer or shorter. In Austria, where hamsters live in an urban environment, the first females...
left their burrows in late March (SCHMELZER & MILLES 2008). This was also found in two studies in Germany (WOLLNIK & SCHMIDT 1995; WEINHOLD 1999). However, results from another study in Germany showed that the first hamsters emerged in early May (ULBRICH & KAYSER 2004). If Dutch hamsters emerge in March or April, there would be too less cover in the Sibbe reserve to protect them against predation. The fastest growing crop (winter oats) reached the 80% threshold in early May, while there was only 66% cover in mid April (Figure 5). The other crops provided even less cover in this time of year. It might be an interesting experiment to cultivate winter oats in a large part of the Sibbe reserve to see if it has a positive effect on spring survival, and the overall reproduction rate.

**Effect of harvest**

The analysis of the harvest dates per crop showed that cover on harvested parcels already was significantly lower than on unharvested parcels in early August, and this divergence further in time (Figure 6). This means that on average, harvested parcels of the Sibbe reserve were not offering enough cover and food for hamsters during the time the second litter was raised (from July 22nd until August 29th). When looking at the average cover per harvested crop, it seems that the 80% cover threshold was not reached during the period when the second litter was raised. However, the example of winter rye (Figure 8) showed that cover varied between years, and in two of the five cultivation years, cover remained at a high level even after the second litter would be raised.

Harvest does not only influence hamsters during this development phase of the second litter, but also thereafter, when immature hamsters start to diverge and look for a suitable place to dig a burrow (KUITERS et al. 2010). In the model of ULBRICH & KAYSER (2004), it was assumed that juveniles spend maximum 10 days to build their own burrow after they have left

**Fig. 9** Schematic diagram of the development of grain plants during the course of the year (Graph: M. ANTHEUNISSE).

**Fig. 10a** Hamsters need good cover for their survival. This field has a cover of less than 50% and is unsuitable for hamsters.

**Fig. 10b** Spring is a dangerous period and the more cover the better. This field had a cover of ca. 60%, but hopefully cover will increase during the course of the season.

**Fig. 10c** The cover of this field is just around the 80% and will not increase any more. It is suitable for hamsters, but more cover should have been better.

**Fig. 10d** An unharvested field with 100% cover: very good for hamsters. The hamsters can forage freely in the cover, without the fear of being taken by a bird of prey.

**Fig. 10e** Hamsters need cover and profit from a good agricultural management. Weeds are not necessary, a 100% cereal crop is fine for hamsters.
are required. Consequently, it is highly recommended to postpone harvest until mid September.

Survival
Although a large amount of data exists about the whereabouts of the Dutch reintroduced hamsters, there was insufficient data available related to the effect of crop condition on the survival chances of the hamsters. The current assumption that population growth of hamsters is negatively influenced by insufficient cover, is based on data about hamsters that were lost or found dead during GPS surveys. It remains unclear what the direct relation is between survival of hamsters and crop condition in the Sibbe area. A study focused on different species (fat sand rat, Anomys obesus) showed that foraging tactics of females differed between a habitat with dense and tall grass (high cover percentage), and a habitat consisting of an open terrace (Tchabovsky et al., 2001). Animals under dense cover were less vigilant, rested more, moved more slowly, and spent more time above ground than animals on the open terrace. Hamster studies like these can help to support the assumption that at least 80% cover is needed to protect a hamster against predation.

Reintroduction
The presence of predators inside reintroduction sites has been a hampering factor in other reintroduction projects as well (e. g. Vancouver Island marmot Marmota vancouverensis, (AALTONEN et al. 2009), and water vole Arvicola terrestris (MOORHOUSE et al. 2009). According to (VAN WIJEREN 2006), only sufficiently large reintroduction populations might overcome the predation pressure, while smaller ones would fall short. The author advises that in predator rich reintroduction sites, a single reintroduction of a specified size is preferable to multiple reintroductions of the same total number of individuals. In the Netherlands, hamsters were reintroduced in populations ranging from 32 to 72 individuals (µ=51.1; SD=13.1; KUITERS et al. 2010). Whether these numbers were large enough to overcome the predation pressure remains to be answered.

Improvement of management
To improve crop management in the future, it is recommended that crops should not be harvested until mid September, so that the survival chances of the second litter can be optimised. In spring, winter cereals have proven to be the earliest crops that provide sufficient cover. Especially winter oats should be sown frequently, so that hamsters can profit of a more dense vegetation during hibernation. Black garden radish is a good cover provide: in summer, as this crop starts growing relatively late, but it provides sufficient cover until the end of autumn. Additionally, it is advised to start more direct research focusing on hamsters, instead of using data about burrow counts and the number of dead hamsters found. If these recommendations are integrated into the new management regime, hamsters will most likely stay undercover.

Conclusion
This study showed that on average, only 45% of the Sibbe reserve provided sufficient cover for hamsters. The best cover providing crop was alfalfa, as it offered sufficient cover during the longest time span (µ=186 days; SD=28.5), and provided most hectares with at least 80% cover. The year with the highest cover (µ=80% and SD=15%) was winter oats, so it is recommended to cultivate this crop more frequently. In the Sibbe reserve, harvest was timed early in the season, as the average cover started already to decline from early August. This might negatively affect the development of the second litter. To reach a growing hamster population, at least two litters are required. Consequently, it is highly recommended to postpone harvest until mid September.

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References