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Space Use and Activity Patterns of Red Deer in a Highly Forested and in a Patchy Forest-Agricultural Habitat

András NÁHLIK[a*] – Gyula SÁNDOR[a] – Tamás TARI[a] – Géza KIRÁLY[b]

[a] Institute of Wildlife Management and Vertebrate Zoology, Faculty of Forestry, University of West-Hungary, Sopron, Hungary
[b] Institute of Geomatics and Civil Engineering, Faculty of Forestry, University of West Hungary, Sopron, Hungary

Abstract – Red deer (*Cervus elaphus*) were fitted with GPS collars to estimate their habitat use and feeding ethology. The purpose of the study was to find methods to reduce crop damage caused by deer. The collars were programmed to produce an hourly recording of position. Two different types of habitat were studied: a) An undisturbed and variable habitat (Zala County), b) A less variable area much disturbed by human activities (Sopron mountains). Comparisons were made between 1) the expansion of home range, 2) the intensity of open habitats use, and 3) the activity patterns of marked individuals in the two areas.

The seasonal change of size of the home ranges showed similar dynamics in the two regions. The summer home range was always smaller than the autumn-winter ranges. In Zala County, the winter range often overlapped the summer range. In the Sopron mountain area, there was a definite home range shift. The summer home ranges in the Sopron area were examined using the 60 % Kernel method where differences were usually found between the day and night-time home areas. In the Zala region the phenomenon was not observed. The autumn-winter home range of stags is larger than that of hinds particularly in the summer. Examined with the minimum convex polygon method the difference is even larger than the results obtained from the Kernel method, which focuses on density distribution. This shows that the autumn-winter movements mostly represent rambling and only in a lesser, but still significant extent derive from the real extension of home ranges.

Large differences existed at regional and individual levels regarding the use of the open habitats. The red deer in Zala used the open habitats in a more intensive way than those in Sopron.

The daytime activity of the Sopron stags was less than that of the Zala stags.

red deer/ home range / habitat use / activity patterns

Kivonat – A gímszarvas területhasználata és mozgásaktivitása egy magas erdősültségű és egy mozaikos erdei élőhelyen. Gímszarvasokat jelöltünk GPS nyakörvekkel mozgáskörzetük és élőhely-használatuk becslése, táplálkozás-etológiájuk megismerése céljából annak érdekében, hogy vadkárcsökkentő módszereket fejlesszünk ki. A nyakörveket úgy programoztuk be, hogy óránként mérjenek pozíciókat.

A vizsgálatot két, élőhelyi adottságukat tekintve eltérő területen végeztük: (a) Zala megyében, egy viszonylag zavartalanabb és változatosabb élőhelyi adottságú területen és (b) a Soproni-hegyvidéken egy emberi tevékenység által erősen zavart, kevésbé mozaikos területen. A két területen

* Corresponding author: nahlik@emk.nyme.hu; H-9401 Sopron, POB 132, Hungary

összehasonlítottuk (1) a mozgáskörzetük kiterjedését, (2) a nyílt élőhelyek használati intenzitását, illetve (3) a jelölt példányok mozgásaktivitását.

A mozgáskörzetek nagyságának évszakos változása hasonló dinamikát mutatott a két területen. A nyári mozgáskörzet mindig kisebb volt az őszi-télinél, azonban, míg Zalában a téli leggyakrabban tartalmazta a nyárit, addig a Soproni-hegyvidéken határozott mozgáskörzet-eltolódás volt kimutatható. A soproni területen a nyári mozgáskörzetek 60%-os Kernel módszerrel vizsgálva általában szétszakadtak a nappali és éjszakai mozgáskörzetek különbsége miatt, míg a zalai területen ilyen különbséget nem tapasztaltunk. A bikák őszi-téli mozgáskörzete lényegesen jobban kitágul a nyárihoz képest, mint a teheneké. Ez a változás még nagyobb, ha minimum konvex poligon módszerrel vizsgáljuk, mint, ha a sűrűségi eloszlást is figyelembe vevő Kernel módszert, ami azt mutatja, hogy az őszi-téli elmozdulások nagyobb részt elcsatangolásokból állnak, és csak kisebb, bár szignifikáns mértékben beszélhetünk valós mozgáskörzet kiterjesztésről.

A nyílt élőhelyek használatát tekintve nagy eltérések vannak nem csak a két terület között, de a területeken belül az egyes példányok között is. A zalai szarvasok átlagosan sokkal intenzívebben használták a nyílt élőhelyeket, mint a soproniak.

A soproni szarvasok nappali aktivitása lényegesen elmaradt a zalai szarvasokétól.

gímszarvas / mozgáskörzet / élőhely-használat / mozgásaktivitás

1 INTRODUCTION

Research with telemetry equipment on the habitat use and movement of red deer goes back 40 years (Heezen – Tester 1967). In the earlier times use was made of radio telemetry based on triangulation which was also used in Hungary (e.g. Szemethy et al, 1996). The drawback of this method is that it is very expensive and time consuming in studies measuring the position of large herbivores that have a large home range (Kenward 1987). This is why the method is not suitable to examine home ranges over short periods (e.g. monthly or day/night time periods). Another drawback is that it is hard to observe home range shifts, although Georgii (1981) and Kamler et al. (2008) reported successful trials. The definition of habitat use is even more problematic because of the small number and infrequency of observation points. The breakthrough came with the application of GPS telemetry in game biology. This allows observers to get observation data every thirty minutes if required. The aim of this research with GPS telemetry was to estimate the home range, habitat use and patterns of daily activity of red deer. By using knowledge of the feeding ethology and strategy of red deer, methods for the reduction of crop damage can be developed.

2 MATERIAL AND METHODS

Two territories with different habitat characteristics were used in the study. The first in Zala was undisturbed and variable. The altitude of this territory is between 140 and 330 metres above sea level. The climate is a transition to sub-Alpine and to sub-Mediterranean. The habitat is patchy, formed of intensively managed forest with an emphasis on natural regeneration. Agriculture is dominated by maize, clover, oilseed rape and grain crops. The most common forest type is the southern Transdanubian beech forest (*Vicio oroboidi Fagetum*). The distribution of stand forming species is as follows: beech 41%, Turkey oak, respectively sessile oak 41%, Scots pine 12%, others 6%, the main silvicultural activity is selective felling of beech. Collars were fitted on 7 red deer (4 stags and 3 hinds).

The second area was in the Sopron mountains, which has much coniferous forest dominated by spruce and managed under a clearcut system, land use is less fragmented, agriculture being dominated by maize, sunflowers, grain and viticulture. The area is also much disturbed by human activity. The land has a mountain range of medium height with an altitude between 340 and 460 metres above sea level. The Sopron mountains belong to the East Alpine flora domain (Noricum) and the Sopron-Kőszeg flora district (Ceticum). The ratio between coniferous and broad-leaved species in the study area changed to 46:54%, because of preference of decidous species in regenerations and damages by bark beetles (*Ips tipographus*) to spruce trees. In this second territory GPS collars were fitted to 6 deer (1 stag and 5 hinds). One of the hinds subsequently got injured by gunshot on one leg shortly after it was collared, consequently its home range was smaller than that of the other animals although it successfully raised a calf. Therefore this individual was excluded from our calculations of the size of the home ranges.

The collars have two main functions: the transmission of radio signals to faciliate a search for the animal, plus the recording, storage and transmission GPS positions. A separate unit installed on the collar makes it possible to remove the collar from the animal's neck by using a remote controlled signal. This can be done at a predetermined point in time. The collars were programmed to record coordinates every hour. The collars were fitted in February 2005 and 2006 and each of them was dropped of after 1-year work.

Comparisons were made of the extent of the home ranges and the intensity of use of the open habitats in both territories. Activity patterns of the marked individuals were examined by measuring the distances between the hourly coordinates.

The sizes of the home ranges were compared using the minimum convex polygon method and the Kernel method. The former method combines the most distant observation points, producing a plain figure in which "it is impossible to hide." It encloses the largest territory within an irregular polygon. The Kernel method focuses on the density of the observation points defining an index based on the points, giving the probability of whether or not the animal entered a certain cell. Using the points, the seasonal home ranges were determined. There were great seasonal differences in autumn, winter and spring (later shortened to winter) and the summer season, although the two periods were not set to calendar dates, but instead to the seasonal change of the size of the home range of each animal. The basis of the change of the separation was the beginning of the autumn expansion of the home ranges, and the regular construction of the summer home ranges. For stags, the two periods of change took place in August-September and the end of April. For hinds the range change was at the beginning of October and the end of April. Certain individuals showed differences of a few days or weeks.

The differences of the home ranges of hinds and stags within the territories and between these territories were compared by using a t-test. The changes of habitat types and activity patterns were examined with a paired t-test.

3 RESULTS

In the course of the year the change of the size of home ranges showed similar dynamics in the two territories; the summer home range was always smaller than the winter one. Measuring with an MCP in Zala County, the summer home range for hinds was 1,310 ± 700 hectares and the winter range was 2,570 ± 1,130 ha. In Sopron the hinds used 530 ± 415 hectares in summer. In winter it was 1,140 ± 600 ha (*Figure 1*).

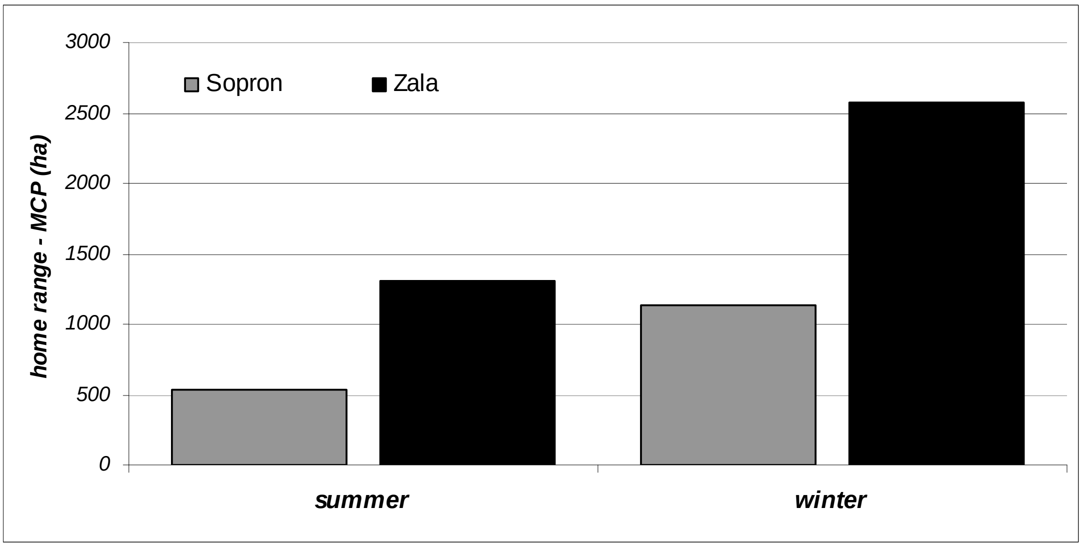

Figure 1. Home ranges of hinds in Sopron and Zala by seasons

The Zala home ranges were obviously bigger. The difference between the summer home ranges was significant ($p = 0.05$). In winter the difference between home ranges was conspicuous, but not significant due to the larger standard deviation. In summer the stags in Zala were moving over 1,500 ± 820 ha. In winter they ranged over 5,310 ± 2,230 ha. In Sopron the home range of the collared stag was 1,180 ha in summer and 4,110 ha in winter (*Figure 2*).

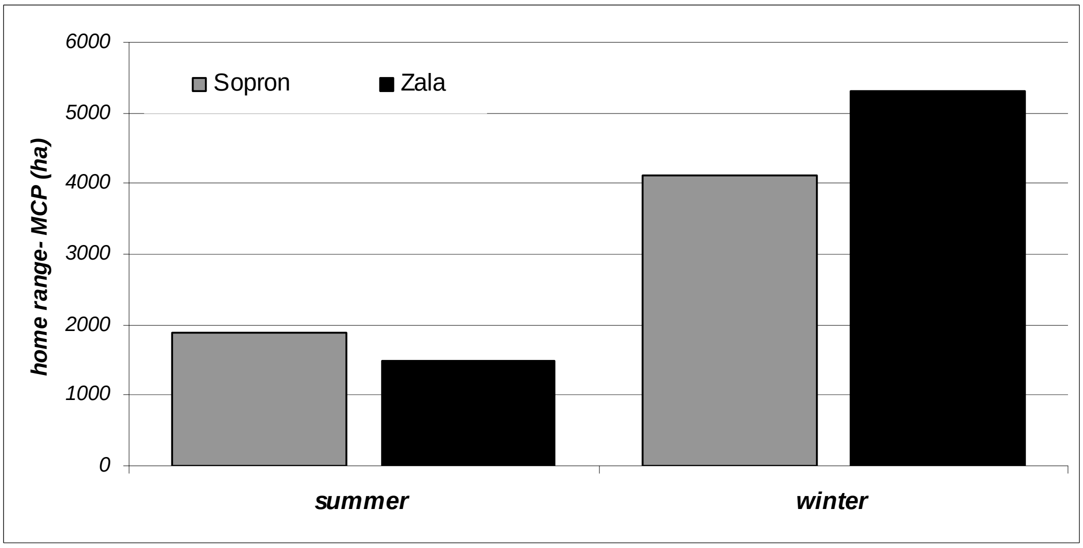

Figure 2. Home ranges of stags in Sopron and Zala by seasons

In Zala the winter home range overlapped the summer range in 5 out of 7 cases. However, in two cases a shift in home range was observed within a certain forested area even if the stags sometimes visited their summer home range during the winter. Red deer moving in higher regions of the Sopron mountains showed a definite home range shift because they were moving toward the foothills at the beginning of winter. There were two exceptions. One hind had a summer home range in the foothills and only expanded its original home range in winter. The other exception was the three legged hind which did not move from its particularly high altitude home range even in winter.

It is striking that in Zala there was no difference between the summer home range of hinds and stags ($p > 0.05$). However, the winter home range of stags was much larger than that of hinds ($p = 0.04$). Examination of the annual home ranges with an MCP method revealed that the average home range of stags (5,307 ha) is larger than that of the hinds (2,576 ha), ($p = 0.02$). When investigated with a 90% Kernel method, the difference was much smaller and was not significant at 1,291 and 705 ha respectively, ($p > 0.05$). In contrast to the MCP method, the Kernel method focuses on the density distribution of points, and consequently the larger home range of stags was mostly due to rambling. The core of their home range did not significantly exceed that of the hinds.

In summer, the daytime home range of the Sopron stags was always smaller than the night-time range ($p = 0.05$). In a number of cases, we observed a shift in the home range, due to the disturbance of the territory (*Figure 3*).

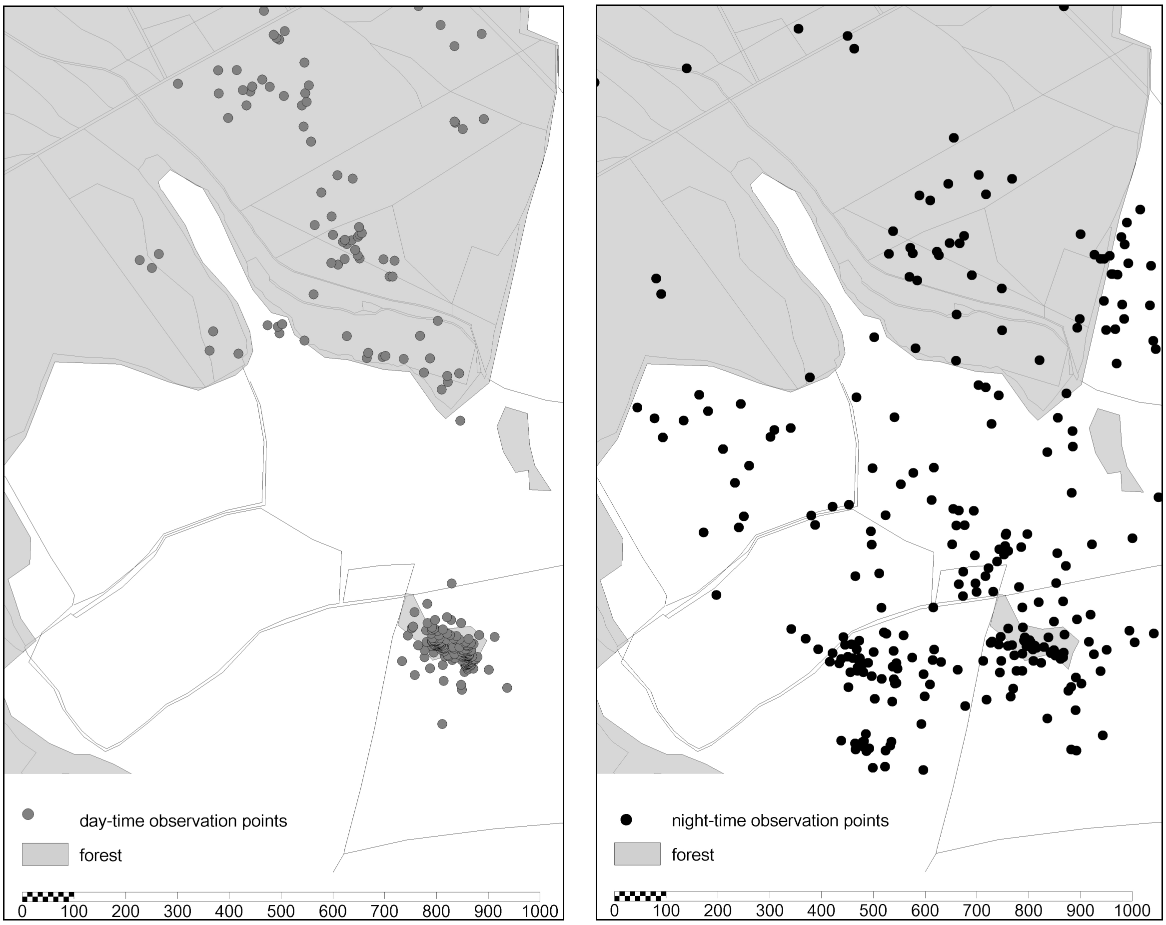

Figure 3. Day and night-time home range of a collared Sopron red deer (daytime observation points, night-time observation points)

In Zala the night-time and daytime home ranges did not differ in most cases.

There were large differences in terms of open habitat use, not only between the two populations, but also between certain individuals within the same population. On average the Zala deer used open habitats in a far more intensive way than the Sopron deer, based on the annual data (42% : 23%). When analysed on a monthly basis, the difference was significant ($p = 0.000$) (*Figure 4*).

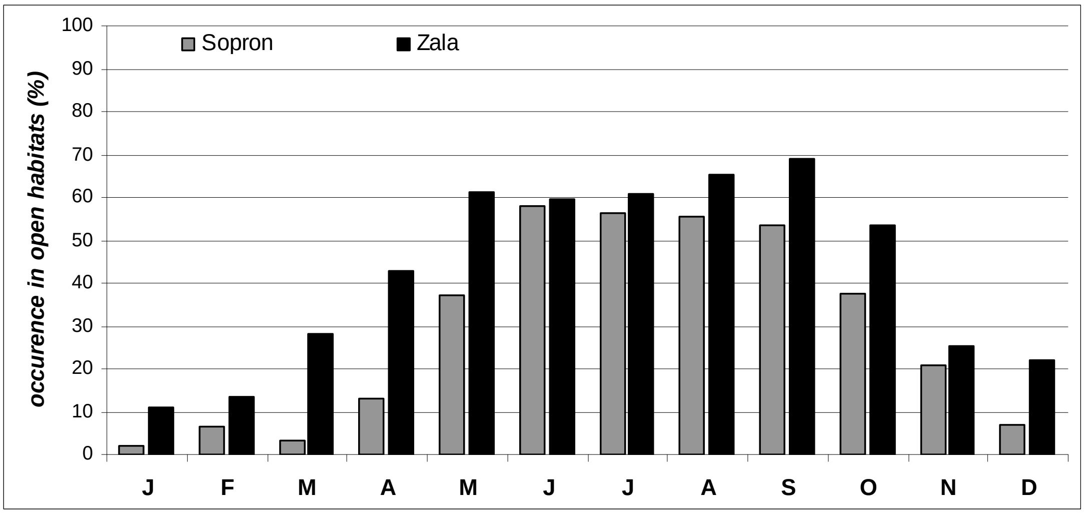

Figure 4. Use of open habitats in the case of Sopron and Zala deer

It was also conspicuous that the hinds used open habitats more often than the stags (p=0.04). The difference was particularly striking in summer during the period of antler growth.

The daily activity of the Sopron deer was less than the Zala deer both in summer and in winter (p= 0.000). The greatest difference in activity was in the winter daylight hours (*Figure 5*).

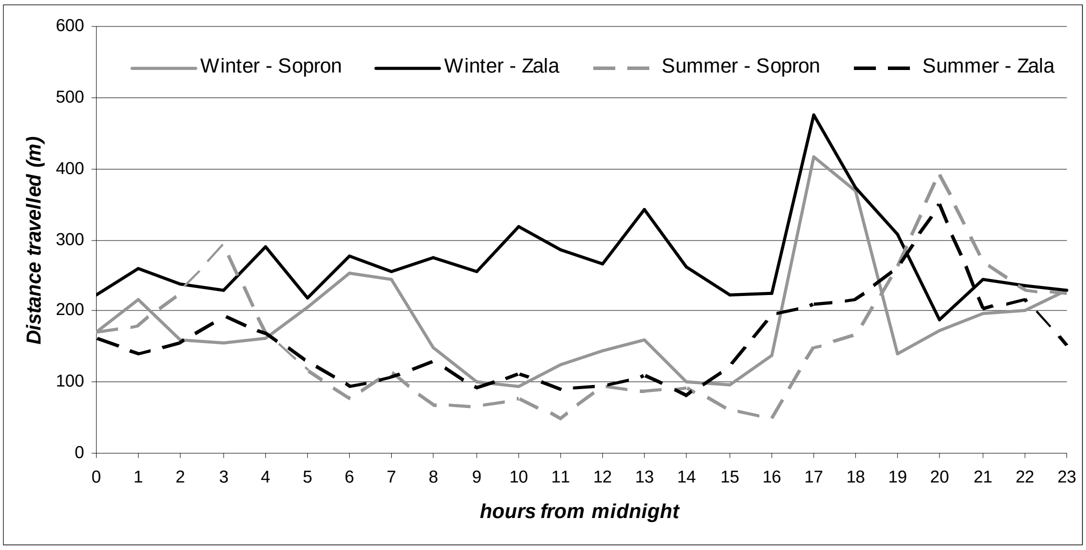

Figure 5. Daily activity patterns of Sopron and Zala deer

This was due to less cover and more disturbances. There were two activity peaks in summer in both territories. The smaller one was in the early dawn hours, the other in the late evening hours. In winter there was no dawn activity peak, but there was an evening peak.

4 DISCUSSION

The size of the home range of deer species may be determined by several factors. These are food supply and the habitat which provides the food, (Said – Servanty 2005), population density (Kjellander et al. 2004), the season, the sex of the deer, feeding style and body mass (Mysterud et al. 2001). In this investigation, the differences between the home ranges of both stags and hinds were significant and the seasonal change in the size of the home range was also proven. In flat territory the presence of large predator species resulted in smaller home ranges as recorded by Kamler et al. (2008). The ratios of the home ranges of the two sexes and the seasonal changes in the size of home ranges as recorded by Kamler were similar to those of this study. The size of the winter home range was significantly larger than the summer range in both territories.

Studies in France by Hamman et al. (1997) and Klein and Hamman (1999) described smaller home ranges of red deer than was observed in this study. Investigating the movement of the stags, Klein and Hamman (1999) found that the core-area of the range of older stags had several centres, an observation confirmed by results from this study. This was also the case for hinds. In the disturbed Sopron territory, one of the causes of the split of core-areas was the difference between night-time and daytime home ranges. In this area the summer daytime home range of deer was always smaller than the night-time range. In Zala there was no such difference between daytime and night-time home ranges. As with the French data, the main reason for the split of core-areas was defined by biological cycles (antler growing, rutting and the late rutting season), as well as the summer/winter home range shift.

In both territories seasonal changes to the home range were observed. This was more characteristic in the mountainous terrain near Sopron. In Zala, the home range shift was less common. In Sopron an exception was the movement of the hind that was close to the foothills in summer. If there is a shallow blanket of snow, the mountain deer which are not provided with supplementary feeding, have a characteristic pattern of behaviour, using the superior food supply found in habitats in non-forested valleys. In contrast the deer provided with supplementary feeding are more closely bound to a particular location, choosing to make their home range adjacent to a feeding site (Schmidt 1993). In case where home range shift was observed, the feeding places were used in a more intensive manner, unlike the deer that have a very localised pattern of ranging behaviour and can more easily use a local food supply (Luccarini et al. 2006). This means the home range shift is not only a characteristic of animals in a complex forest-agricultural habitat as examined by Szemethy et al. (2003) and Bíró et al. (2006). Furthermore the shift of home range is not only a characteristic of red deer in mountainous terrain, but it is also found in areas of low relief and in forested terrain, although to a lesser extent. The difference in the size of the action radius between the home ranges in Sopron (2.1 ± 0.3) and Zala (6.8 ± 3.0) was much smaller than the above mentioned studies, which had the values of 8.9 ± 2.1.

In this study the home range of stags was larger than that of the hinds, but the difference was much smaller when we investigated with an MCP method than with a 90 % Kernel method. The latter method did not show significant difference. This shows that within the home range of stags there was a particular core which was used more frequently. The positions were less common outside of this area. These areas were less frequently used by stags because of their habit of rambling. The conclusion is similar if we look at the research of Kamler et al. (2007), who examined the daily movement of hinds and stags and did not find a significant difference in their daily home ranges, although the stags had a slightly larger range. At the same time 12% of the hinds' annual home range and 3% of the range of stags was used every day. This also proves that the stags' home ranges include areas that are used in a less intensive way. It would appear that the difference of body mass of the two sexes might influence the size of home ranges, but this does not prove the significant difference between their home ranges as shown by the MCP method. The variation may be explained by the behavioural differences of the two sexes because stags moved within large areas between the summer home range, the area used in the rutting season, and from there towards their winter range.

The characteristics of the habitat, namely the forest cover ratio of the home ranges influenced the frequency of use of the open habitats. The disturbance of the area also played a role. Forest cover is important in the protection against predation (Wolff and Van Horn, 2003) and against human disturbance. At the same time the forest also provides thermal protection (Cook et al. 1998; Porter et al. 2002). These factors make it probable that in highly forested but disturbed areas the home range is smaller. These findings correlate very well with the results from this study.

It is also known that the quantity of the feed supply has a negative influence on the size of the home range, while the quality of the feed positively influences the size of the range (Saether and Andersen 1990; Mysterud et al. 2001). When feed is abundant, required dry matter intake is achieved with reduced ranging activity, but when feed quality is lower, the time required for rumination is extended. Taking account of these factors it is striking that the home range and daily activity of the deer in the Sopron study area was smaller than that of the deer in Zala, especially since the body mass and antler size was smaller in the Sopron deer than in the deer in Zala. The habitat of the Zala deer was less uniform, supplying feed in patches where it was found in larger quantities. These results make it probable that the reasons for the smaller Sopron home ranges are due to the following facts: a larger proportion of forested area, less variable habitat, more disturbances, habitat with lower quality and smaller quantity of available feed. Future research could possibly prove the effect and the weighting of these factors.

Hinds frequent the open habitats more than the stags, especially in the summer antler growing period and this supports the empirical experience of the reclusive behaviour of stags at this time.

The fact that the daily activity of the Sopron deer lagged behind the deer in Zala both in summer and in winter and especially in the early dawn hours, can be explained by more cover and more human disturbance in the Sopron region. In the Bavarian Alps Georgii (2004) found a bi-modal daily rhythm (two activity peaks) which was very similar to the results in this study.

Kamler et al. (2007) have drawn attention to the importance of human disturbance influencing the activity patterns of deer. In a primeval forest without human influences, they did not find activity peaks at dawn and dusk. Kamler stated that the activity of deer in undisturbed forests is defined by natural factors of precipitation, temperature, nutrition and rumination.

5 CONCLUSIONS

When home ranges of red deer expand in autumn there is an increased risk of crop damage over a larger area. Consequently from autumn to spring the objective should be to limit deer movements through the use of supplementary feeding, which should be distributed as far as possible from the forest habitats that are susceptible to damage. This is very important because the scattered data from this study also support the statement of McCorquodale (1993) that, when there is a deep blanket of snow, deer change their strategy, become sedentary and less selective about their food, increasing the danger of the browsing of seedlings. Results from previous investigations (Náhlik 2002) have shown that the incidence of browse damage was greatly increased when herbaceous plants of reforestations were covered by snow or in consequence of total removing of undesirable tree and shrub species during weeding.

The small daily home range of the Sopron deer have shown that red deer have a reduced pattern of movement during the day when there is more human disturbance, than at night. Activity patterns were similar in both territories. Increased disturbance and a consequent decrease in daily home ranges result in increased browse damage. This is because the deer are not able to move out of their hiding areas during the daytime. Consequently they have to feed in stands which provide resting place i.e. often in stands formed by saplings or pole-size trees. A similar problem occurs when heavy snow cover limits the movement of deer. In both cases game managers can help by snow ploughing, the provision of supplementary feed of a suitable quality and by seeking to reduce human disturbance.

Although in the highly forested Sopron area there are deer that spend their entire lives at higher altitudes within the forest, even in winter moving only to the edge of the forest, red deer usually choose a summer home range that includes an agricultural area with an adequate food supply. The risk of deer damage to agricultural crops is much greater in habitats adjacent to agricultural mosaic territories. If there are areas of land in private ownership or there is land that may be rented, also being suitable for use as ’game fields’, the strategic sowing of attractive fodder crops may help in drawing deer away from cultivated areas.

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