ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume LX 22 Number 6, 2012

ASSESSMENT OF A DAILY DEFECATION RATE OF FALLOW DEER UPON A CLOSED POPULATION STUDY

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Received: June 26, 2012

Abstract

KOŠNÁŘ, A., RAJNYŠOVÁ, R.: *Assessment of a daily defecation rate of fallow deer upon a closed population study.* Acta univ. agric. et silvic. Mendel. Brun., 2012, LX, No. 6, pp. 173–180

Many indirect methods of counting even-toed ungulates are based on the principle of accumulating dung in a known area per a unit of time. In order to provide the most accurate assessment of the population size, these methods require the knowledge of daily defecation of the monitored species. The main objective of the study submitted is the assessment of a daily defecation rate of fallow deer based on the monitoring of its closed population. A partial objective is the assessment of the distribution of fallow deer in an enclosed area with a view to biotopes represented. A fallow deer population was studied for the period of three years (2009–2011) in a fenced-in area (8 ha). During this period, dung heaps were counted in forty sites with the total area of 0.8 ha in all seasons of the year. In each season, the sites were cleared, and the dung was counted after a seven-day exposure. This counting was performed twice in each season. Thanks to the precise knowledge of the number of monitored animals, daily defecation rates (DDR) were derived upon the dung found, using a formula for the calculation of population density. Subsequently, the determined DDRs were verified by direct observation. The highest average DDR value calculated from the formula (21.11 ± 0.32 S.E.) was obtained in the summer season. The lowest defecation of fallow deer was established to be in winter (12.34 ± 0.25 S.E.) and early spring (10.61 ± 0.24 S.E.).

Dama dama, defecation rate, fallow deer, pellet groups

Fallow deer belong to the most common species of cloven-hoofed animals in Central Europe (Chapman & Chapman, 1980). Overabundant, this species often causes damages to crops and forest vegetation (Kay, 1993; Mouissie *et al.*, 2005; Gill & Beardall, 2001). Similarly as with other even-toed ungulates, for game management to be performed properly it is necessary to know the population density in the area concerned. For this purpose, numerous counting methods may be used (Putman *et al.*, 2011), many of which are based on accumulating dung in a known area per a unit of time. These indirect counting methods have been successfully used in wooded areas with lower visibility (Aulak & Babinska-Werka, 1990; Acevedo *et al.*, 2008); they may also be utilised in extensive areas with lower human population density and minimum number of field workers (Forsyth *et al.*, 2007). The methods gain a higher accuracy with higher population densities of the species monitored (Neff, 1968). Two factors are recognised as the main sources of potential errors in these methods – dung decomposition time and the **daily defecation rate** (DDR) specified in the number of dung heaps per animal and day (Cederlund *et al.*, 1998; Rönnegård *et al.*, 2008). Errors caused by the pellet disappearance factor may be minimised by a suitable setting of the counting periods (Massei *et al.*, 1998; Tsaparis *et al.*, 2008). In the winter season, decomposition processes are slowed down, and significantly longer periods of time may be selected (Cambell *et al.*, 2004; Therekauf *et al.*, 2008). What is considered more problematic is the use of the correct DDR value. The reason for this is the DDR variation in the time and area of counting, caused especially by the change of food and climatic conditions within the year, activity of the species, and type of habitat (Mitchell *et al.*, 1985; Rogers, 1987; Prokešová *et al.*, 2006). Further important factors affecting the daily defecation rate are the age structure of the herd and proportion of sexes in the population monitored. Studies dealing with the fallow deer DDR have been conducted in Western Europe and the Mediterranean (Bailey & Putman, 1981; Massei & Genov, 1998). Hitherto ascertained values for the fallow deer DDR range between 11.3 and 26.5, but many studies give only winter DDR values (Stubbe & Goretzki, 1991). The objective of this contribution is to assess the fallow deer DDR in various seasons of the year for Central European conditions, and to compare results obtained with available literature.

MATERIAL AND METHODS

Study area

The study area is situated at the town of Písek (49°18' N, 14°8' E) in the southern part of the Czech Republic. The climate in this area is mild, with 550–575 mm precipitation and 7.9 °C average year temperature. The study itself was performed in a deer park of a rectangular shape and area of 8 ha (Fig. 1).

The major part of the park (approx. 6 ha) is covered with cultivated forest vegetation, with beech (*Fagus silvatica*) and spruce (*Picea abies*) as the prevailing tree species (46 and 40%, respectively). In addition, there are other deciduous trees, such as birch (*Betula pendula*) and poplar (*Populus nigra*). The remaining part of the area is formed by a meadow and a small water reservoir. During the study elaboration, the number of fallow deer increased from 11 (2009) to 23 animals (2011). There are two feeding racks in the park, located in opposite ends as prevention against undesired concentration of kept animals in a single spot. These racks were used for the provision of supplemental feed, especially in the autumn and winter seasons. Animals were provided with mangel, grain mixtures, and quality

1: *Schematic illustration fenced area – in the upper left corner shows one of the eight hectare squares with the distribution of monitoring plots*

I: *Representation of both sexes and calves in the herd on 16 July of each year*

Year	Males	Females	Calves
2009	4	7	4
2010	6	9	4
2011	5*	12	6

* In early March 2011 two young males were sold

hay. Mineral licks were available within the park all year round. Despite warning signs, visitors of the park could not be prevented from feeding the fallow deer, mostly with old bread, fruits and vegetables. In order to minimise damages to vegetation caused by the animals peeling it due to insufficient feeding rations, large branches of deciduous trees were brought to the park. The proportion of sexes in the herd during the study elaboration was always in favour of females, rather significantly in the last year (Tab. I).

Pellet groups count, DDR assessment and habitat use

In order to ensure the most accurate possible counting of the dung heaps, the park area was divided into eight 1ha squares, each of them containing five counting areas formed by narrow strips (2 × 100 m). The distance of the end areas from the square edge was 10 m, and the distance between the individual areas was 20 m. The dung heaps were always counted after a seven-day exposure of the areas, twice in each season (spring – 12 and 19 March; summer – 9 and 16 July; autumn – 15 and 22 Oct; winter – 9 and 16 Jan). The areas were cleared before and after each counting. Using a compass, a line running through the middle of the area was drawn and all samples found within 1 m left and right of the line were counted up. Only dung heaps lying inside the area with at least half of their volume were counted.

The DDR was calculated using the formula D/(N*T*A), where D = number of pellet groups found, N = fallow deer density (deer/ha), T = number of days the pellet groups had accumulated, and A = total area sampled (in hectares). In order to verify the DDR values obtained in this way, direct observations of defecation of four animals within the population (two males and two females) were performed in each season. The observation was conducted a day after previous counting-up the areas, began an hour before sunrise and finished an hour after sunset. The defecation frequency of the animals observed was averaged and converted to a time period of a single day. The population density of fallow deer was verified by direct observation before every dung heap counting. The park area allowed the habitat to be divided into three classes only. Class I was characterised as a full-grown, mixed forest. Class II was formed by a transitional zone (ecotone) between the forest and meadow. Class III was represented by meadow vegetation. The areas were situated in a way ensuring their definite assignment to a particular habitat type.

Statistical analyses

For testing the hypothesis of commonality of counted DDR values (observed) with DDR values obtained by direct observation (expected), the χ^2–Goodness–of–Fit analysis was used. Since the data did not show normal division, a nonparametric parallel of ANOVA – Kruskal-Wallis test with a multiple comparison – was selected for testing various levels of the popularity of habitats among the animals. T-tests were used to compare the level of usage of areas located close to the feeding racks and water source with other areas. All calculations were performed in STATISTICA 9 software.

RESULTS

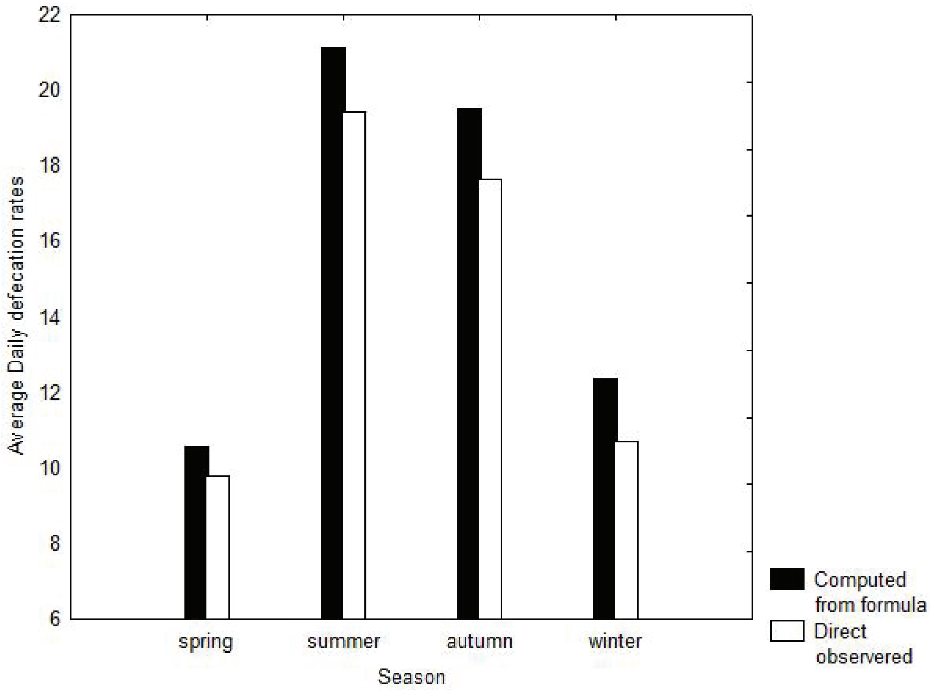
During the study performance, 4,866 dung samples in total were recorded. The highest DDR values recalculated according to the formula during the study were recorded in the summer season (21.11 ± 0.32 S. E. in average). The lowest average DDR value (10.61 ± 0.24 S. E.) was determined for the spring season (Tab. II).

When the DDR values of various seasons were compared, summer values were found to differ significantly from winter and spring values, and spring values were found to differ significantly from summer and autumn values (Kruskal–Wallis test: $H\ 3 = 10.3846$, $p < 0.0156$), (Fig. 2).

In a year-by-year comparison of DDR values, no statistically significant differences were found ($H\ 2 = 0.2289$, $p < 0.8919$). The χ^2–Goodness–of–

II: *Average DDR values obtained from formula*

Average values DDR	spring	summer	autumn	winter
2009	10.2598	20.3810	19.3333	12.7619
SE	0.2598	0.3810	0.7619	0.1905
2010	11.2381	21.4286	18.9850	12.5940
SE	0.3810	0.4512	0.2632	0.4135
2011	10.3362	21.5218	20.0932	11.6771
SE	0.1681	0.5901	0.0932	0.2485
2009–2011	10.6113	21.1104	19.4705	12.3443
SE	0.2357	0.3162	0.2945	0.2518



2: *Obtained average values DDR according the season (2009–2011)*

III: *Average values (2 males and 2 females) DDR obtained from direct observation*

Average values DDR	spring	summer	autumn	winter
2009	16.6079	19.0007	16.9616	15.1481
S.E.	8.5747	9.255	8.9803	9.4888
2010	15.9748	23.4108	19.1312	14.986
S.E.	8.2648	13.0424	11.211	7.9748
2011	15.3125	24.4946	23.0636	15.6024
S.E.	7.8959	14.3444	13.3834	8.6163
20092011	15.9651	22.302	19.7188	15.2455
S.E.	3.6162	5.6477	5.1935	3.8994

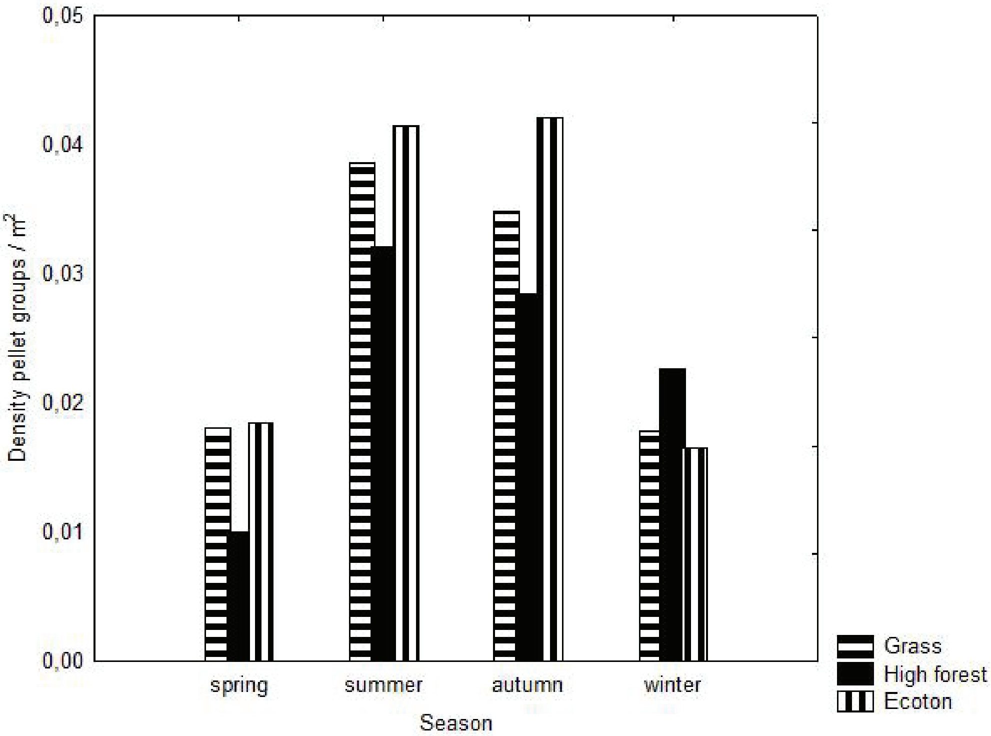
Fit test did not show ($p = 0.4910$) any significant difference between calculated DDR values (observed) and (expected) DDR values obtained by direct observation (Tab. III).

However, using the same test, conclusive differences ($p = 0.001$) were detected between observed defecation of males and females, when males showed roughly half the DDR values compared to females during the whole duration of the study. The biggest difference in observed defecation was recorded in autumn 2011. The average DDR in females in that season reached 38.8390 ± 1.9610 S. E., while the same value in males was significantly lower: 10.1502 ± 1.3698 S. E.

The evaluation of the usage of individual biotopes (Fig. 3) throughout the years as well as seasons showed no significant preference of any of the monitored biotopes (Kruskal-Wallis test: $H\,2 = 2.1807$, $p < 0.3361$).

The same result was obtained in the testing of biotope preferences in the spring (Kruskal–Wallis test: $H\,2 = 6.4812$, $p < 0.0391$) and summer seasons only (Kruskal–Wallis test: $H\,2 = 3.8002$, $p < 0.1496$). In summer, the animals clearly preferred full-grown forest to the least used ecotone. However, the intensity of usage of the meadow sites did not differ significantly from the other two biotopes (Kruskal–Wallis test: $H\,2 = 7.1274$, $p < 0.0283$). In autumn, the preferences regarding full-grown forest and ecotone were opposite. With the meadow sites, no statistical difference from the other biotopes was found (Kruskal–Wallis test: $H\,2 = 6.9334$, $p < 0.0312$).

The performed comparison of average densities of dung around the feeding racks and in other areas in all the years and season showed no significant difference in their usage (t–test, $p < 0.14$). On the other hand, similar testing in individual seasons clearly verified a higher density of dung around the feeding racks in winter (t–test, $p < 0.05$) and spring (t–test, $p < 0.02$). The comparison of dung density around the water reservoir and in other areas showed no preferences of the reservoir throughout



3: *Biotopes use in different season according average density of pellet groups per m² (2009–2011)*

the years and seasons (t–test, p < 0.39). The same comparison within individual seasons showed a significantly higher density of dung around the reservoir only in the summer season (t–test, p < 0.01).

DISCUSSION

Throughout the year, significant changes in the DDR occur in cloven-hoofed animals. One of the main reasons of these changes is considered to be the changing of the seasons which influences not only the ethology of the species (rut, calve delivery), but especially the food availability and composition (Stubbe & Goretzki, 1991). In the study submitted, the highest DDR values were observed in the summer and autumn seasons. On the contrary, the lowest DDR values were recorded in winter and early spring. The inconclusiveness of difference between the summer and autumn DDR values was probably caused by the time closeness of the data counting–up (July and October), and thus by mild climatic changes. A similar explanation may also be considered for the winter (December) and spring (March) DDR values. Out of the calculated average DDR Values for 2009–2011, the highest one (21.11 ± 0.32 S. E.) was determined for the summer season. However, Bailey & Putnam (1981) in their study conducted in England in July and August gave a significantly lower value: 11. 3. However, the higher DDR value, compared to the results from Great Britain, could be caused by a different proportion of sexes in monitored herds or a higher proportion of calves (Rogers, 1987). On the other hand, Mayle *et al.* (1996) gave values between 24-29 DDR for the summer season. For winter defecations, literature gives significantly higher values compared to the recorded ones (12.34 ± 0.25 S. E.). In geographically close Germany, Stubbe & Goretzki (1991) determined the winter DDR value as 23.6. A slightly higher DDR value for fallow deer was assessed by Massei & Genov (1998) in central Italy. Their average DDR value from December and January was 26.5 pellet groups per animal per day. The higher results of the authors mentioned may be explained, at least partially, by their focus on wild animals. In the study submitted, the population was enclosed within a relatively small area of 8 ha, and thanks to supplemental feeding was not forced to seek food actively. According to Irby (1981) and Mitchell *et al.* (1985), the DDR values in ungulates may significantly drop concurrently with the physical activity of the animals. Thus, animals living in small enclosed areas mostly show lower DDR values than open populations (Rogers, 1987). Observed DDR values were, on the whole, higher than values calculated from the formula (although no conclusive difference was found). However, the credibility of the observed DDR values was strongly limited by the time during which the observations could be conducted. Particularly in the winter season and with worsened climatic conditions, the observation time was significantly shorter. The lower DDR in males when compared to females could be caused by the various ages of the animals (Mayle *et al.*, 2010). Males were seven years old on average, but females only three years old. Generally it is assumed that younger animals defecate more often (Stubbe & Goretzki, 1991). Further, males could be affected by a lower food intake during the rut (Husák *et al.*, 1986). Although Collins & Urness (1981) questioned the possible use of dung counting methods for determining biotope preferences in small cervids, Ferreti *et al.* (2010) used this method successfully for comparing biotope preferences in fallow deer and roe deer. During the study, significant differences in the use of biotopes were detected only in the autumn and winter seasons, when the intensity of using the ecotone zone and full-grown forest was different. This finding is probably closely related not only to the food supply, but also to possibilities of finding cover (Wahlstrom & Kjellander, 1995; Miyashita *et al.*, 2008), and basically corresponds to knowledge obtained in related species of even-toed ungulates (Mysterud & Østbye, 1995; Barančeková *et al.*, 2009; Ferreti *et al.*, 2010).

CONCLUSION

The knowledge of daily defecation is crucial for calculating population densities with methods of counting-up accumulated dung of the population monitored in a given environment. Unfortunately, the precise assessment of the daily defecation rate in open populations is highly problematic. The DDR assessment in closed populations brings a number of problems related to the simulation of natural behaviour of monitored animals and their natural food. Furthermore, DDR values may be strongly affected by the age structure of the herd as well as by the existing proportion of sexes. Despite these imperfections, this is still one of the most frequently used methods of DDR quantification in individual species. The study results confirmed the findings from previously conducted works on the fluctuation of daily defecation rates throughout the year. However, the significant differences detected between winter and summer DDR values could be caused in this case by the small size of the deer park and supplemental feeding. A lower physical activity of the observed population in the winter season probably led to the overall lower defecation of individual animals. This fact partially limits the use of the assessed DDR values for counting-up in an open space. On the other hand, supplemental feeding of wild population in the times of shortage is still widespread in a number of European countries, including the Czech Republic. In spite of this, it would be appropriate to conduct a similar observation of open populations in the Czech Republic. That could significantly contribute to obtaining an accurate DDR. For the future, it would be also appropriate to assess the DDR for other species of cloven-hoofed animals. As a result, obtaining these values could bring an expansion of methods assessing population densities of animals based on dung counting.

SUMMARY

The daily defecation rate is an important part of the calculation of population densities of even-toed ungulates in methods based on the collection of dung heaps. This article brings the results of a three-year observation (2009–2011) of a fallow deer population in an 8 ha deer park. Throughout the study duration, the counting of dung heaps was conducted in forty areas in total (strips 2 × 100 m each), twice in each season. These areas were cleared seven days before every counting, thus the exposure time of the areas was known. Further, each area was included in one of three biotope classes (full-grown forest, meadow, ecotone strip). Since the population density of the closed population was known, precise daily defecation rates could be subsequently determined by a back-calculation from a formula for assessing population densities. In order to verify the values obtained, a direct observation of daily defecations in four selected animals (two males and two females) was conducted a day after the counting-up of all areas. This observation always began one hour before sunrise and finished one hour after sunset. The values obtained were converted to a period of 24 hours. Upon calculation, the following DDR values were determined for individual seasons: spring 10.61 ± 0.24 (S.E.); summer 21.11 ± 0.32 (S.E.); autumn 19.47 ± 0.32 (S.E.); winter 12.34 ± 0.25 (S.E.). Although the values obtained by direct observation were slightly higher, no statistically conclusive difference was found between them and those calculated from the formula: test χ^2–Goodness–of–Fit ($p = 0.4910$). During the study, the animals showed no preferences of any of the biotope classes (Kruskal–Wallis test: H 2 = 2.1807, $p < 0.3361$). Only in the autumn season, a more frequent use of the ecotone zone compared to the full-grown forest was recorded (Kruskal–Wallis test: H 2 = 6.9334, $p < 0.0312$). In the winter season, the situation was entirely opposite (Kruskal–Wallis test: H 2 = 7.1274, $p < 0.0283$). During winter, a higher density of dung was detected around the feeding racks than in other areas (t–test, $p < 0.05$). The same result was also obtained in early spring (t–test, $p < 0.02$). A higher density of dung was also recorded during the summer season in areas close to the water reservoir (t–test, $p < 0.01$).

Acknowledgement

We would like to thank Internal Grant Agency of Czech University of Life Sciences for financial support. (This work was supported by the grant IGA FLD No. 20124320).

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