Wildlife Research

Behavior and spatial use of enclosures by does and fawns of farmed fallow deer in postnatal period

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ABSTRACT

The aim of this study was to determine the hiding preferences of farmed European fallow deer does and fawns in natural sites and artificial shelters during the postnatal period. A total of 270 hours of video surveillance footage showing the behavior of fallow deer fawns in the first 18 days of life were analyzed. The analysis demonstrated that fawns had a preference for the same, specific hideouts in the farm. Artificial shelters made of branches were never used by the offspring during the experiment. Does and fawns exhibited certain preferences for nursing sites, but they were not as specific as the fawns' choices of hiding sites.

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Introduction

Under natural conditions, red deer hinds and fallow deer does leave the herd during the perinatal period and rejoin the herd 1-2 weeks after calving/fawning. During the separation period, the hind/doe chooses a hiding site where offspring will be born and nursed (Chapman and Chapman 1975; Clutton-Brock et al. 1982; Kjellander et al. 2012). Female cervids may exhibit different behaviors in farms, where their natural behavior cannot be freely expressed (Janiszewski et al., 2018). In farms characterized by small enclosures, high stocking density, and an insufficient number of hiding sites, many females are forced to give birth in a small common area. The aforementioned can prevent the formation of healthy bonds between the mother and its offspring, and it can lead to the abandonment of calves/fawns (Asher et al., 1996).

According to the recommendations of the New Zealand Animal (Deer) Welfare Code of 2007, farmers should create a stress-free environment during the perinatal period to reduce calf/fawn mortality and maximize the welfare of hinds/does during calving/fawning and in the first days postpartum. Animal density in calving/fawning enclosures should be reduced before hinds/does go into delivery to enable them to find a safe and quite site for giving birth and nursing their offspring. For the aforementioned requirements to be met, the preferences of hinds/does for hiding sites, where they can give birth and nurse offspring in the first days postpartum, and the spatial use of enclosures should be analyzed in deer farms. The relevant observations will facilitate the arrangement of calving/fawning paddocks, minimize stress, and increase the welfare of mothers and their offspring (Animal Welfare Deer Code of Welfare, 2007).

The aim of this study was to determine the hiding preferences of farmed European fallow deer does and fawns in natural sites and artificial shelters in the first days postpartum.

Materials and methods

The study was carried out in a cervid farm of the Institute of Parasitology of the Polish Academy of Sciences in Kosewo Górne (northeastern Poland; N: 53°48'; E: 21°23′). The behavior of does and fawns was monitored in an enclosure with an area of 1.5 ha. The experimental enclosure was set up remotely from other farm facilities to minimize the influence of human activity on the animals' behavior. Therefore, the obtained results were not burdened with error resulting from human presence. Animal behavior was monitored with the use of two 600TVL outdoor surveillance cameras covering the entire area of the experimental enclosure. Video material was recorded.

The experimental enclosure was divided into several research fields which were marked with different numbers (Figure). Every

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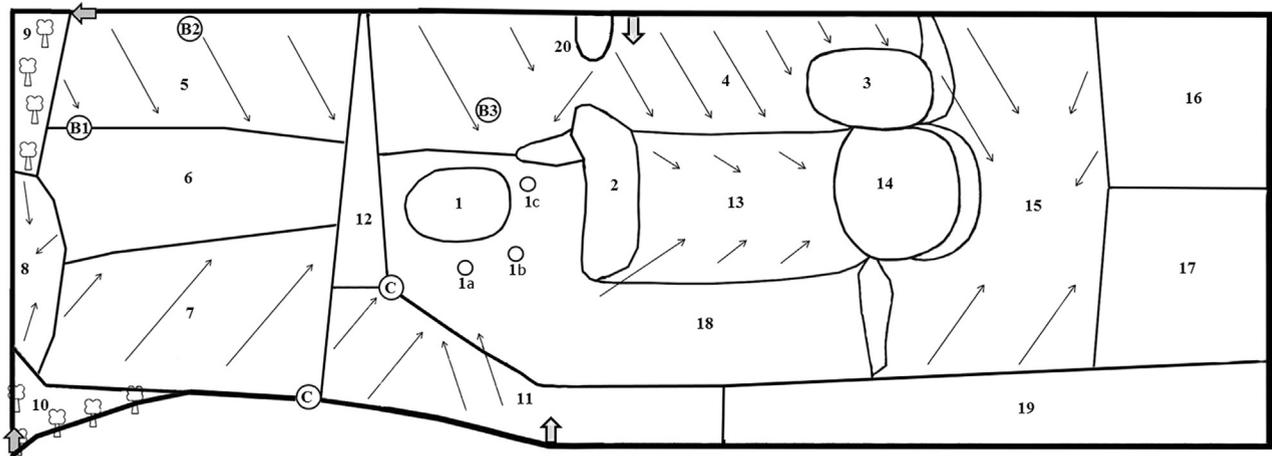*E-mail address:* janisz@uwm.edu.pl (P. Janiszewski).

Figure. Scheme of the experimental enclosure (thin arrows—slope of the surface, C—cameras).

field was characterized by specific terrain features and plant cover, and it could be clearly distinguished from the remaining observation sites. In research field No. 1, three small nettle clusters were additionally identified and marked as 1a, 1b, and 1c (Figure).

The 23 identified research fields were classified into 5 vegetation groups defined for the needs of this study. The percentage of different vegetation types in the experimental enclosure and the corresponding research fields is presented in Table 1.

Boughs and branches of deciduous trees were arranged in three heaps measuring 1.5 m × 1.5 m to determine whether does and fawns would use them as hiding sites. The distribution of artificial shelters (B1, B2, and B3) is presented in Figure.

The behavior of 7 pregnant does of the European fallow deer *Dama dama* was monitored. The does were randomly selected from a larger group of females which had been diagnosed as pregnant based on blood progesterone levels. The females were identified on the basis of an individual number placed on the ear tag attached to the animal's ear. Four of the 7 observed does gave birth to fawns at the beginning of the monitoring period and 3 does—around 3 weeks later. The fawns were identified on the basis of their individual phenotypic traits and on the basis of their mutual relationship with the recognized doe.

Surveillance footage covering the first 18 days postpartum was analyzed in detail. Because fawning was spread over time, the analyzed video footage covered two periods between 15 June and 1 July, and between 6 July and 23 July. In each period, footage was analyzed every other day to produce 9 observation days in each period, that is, a total of 18 observation days. The footage captured between 6 a.m. and 9 p.m. was analyzed to produce a total of 270 observation hours. The surveillance period covering the first 18 days postpartum was established based on published reports

that the hiding behavior of calves/fawns is most clearly manifested during that time. Two to three weeks postpartum, calves/fawns cease to hide in a separate location and they join the herd (Torriani et al., 2006; Wass et al., 2004).

The duration and frequency of various types of activities, such as nursing sessions, have to be observed over long periods. In this study, observations were carried out every other day during daylight hours. The behavior of calves/fawns changes on a daily basis in the first weeks of life (Altmann, 1974; Altmann and Altmann, 2003); therefore, less frequent observations are unlikely to deliver reliable results. The results were analyzed based on ethochronograms that had been developed based on previous studies of animal behavior (Gervasi et al., 2006; Kachamakova and Zlatanova, 2014), with several modifications.

The frequency with which the following hiding sites were used by fawns was analyzed:

- The first hiding site postpartum,
- Hiding site after a nursing session.

The authors also analyzed the frequency with which fawns used hiding sites for nursing sessions (a nursing session was defined as the period during which a fawn remained with its mother, between the time it left its hideout and returned to hiding. During that period, the fawn was nursed and groomed; it played and followed the mother). The frequency with which specific sites were selected by fawns for hiding or nursing was expressed as the percentage of all analyzed hiding and nursing events in the examined period. The frequency of hiding and nursing events was also determined per 100 m^2 of area covered by each type of vegetation relative to the total area covered by that type of vegetation in the experimental enclosure.

Table 1
Vegetation types in the experimental enclosure

Vegetation type	Research field (number)	Area	
		(%)	(m^2)
Trees	9, 10	6.1	915
Shrubs	20	1.9	285
Herbaceous dicotyledonous plants (such as nettles)	1, 1a, 1b, 1c, 2, 3, 8	11.2	1680
Herbaceous monocotyledonous plants (such as grasses)	4, 5, 6, 7, 11, 12, 13 15, 16, 17, 18, 19	75.9	11, 385
Other	14	4.9	735

Table 2
Hiding sites selected by fawns

Site[a]	The proportion of the hiding site in relation to total area (%)	Hiding site before/during a nursing session (%)[b]	P value	Hiding site after a nursing session (%)[b]	P value	Total frequency (%)[b]	P value
8	3.3	35.2	<0.001	26.8	<0.001	31.3	<0.001
1a	<0.1	27.9	<0.001	26.8	<0.001	27.4	<0.001
1b	<0.1	7.4	<0.001	9.3	<0.001	8.3	<0.001
11	6.7	6.6	1.000	5.6	0.846	6.1	0.894
14	4.9	4.9	1.000	7.4	0.264	6.1	0.443
1	2.1	4.9	0.048	5.6	0.030	5.2	0.005
1c	<0.1	4.1	<0.001	3.7	<0.001	3.9	<0.001
2	3.2	2.5	1.000	4.6	0.405	3.5	0.708
13	5.3	3.3	0.418	1.8	0.183	2.6	0.096
3	2.5	1.6	0.772	2.8	0.751	2.2	1.000
9	3.0	0.8	0.272	2.8	1.000	1.7	0.427
10	3.1	0	0.054	0.9	0.386	0.4	0.017
18	8.3	0	<0.001	0.9	0.003	0.4	<0.001
4	6.0	0.8	0.016	0	0.005	0.4	<0.001
20	1.9	0	0.178	0.9	0.726	0.4	0.136
Total	50.4	100		100		100	

[a] Nursing events were not observed in the remaining sites.
[b] Frequency with which hiding sites were used throughout the experiment.

Statistical computing leading to estimating *P* values were made using Fisher exact test. The calculation includes the number of animals entering the research field and the size of this field in relation to the total area of the experimental enclosure.

Results

Hiding sites

An analysis of the behavior of fallow deer offspring in the postpartum period revealed that fawns had a preference for the same, specific hiding sites in the enclosure (Table 2). In the group of 20 identified research fields, fawns most frequently selected hiding site No. 8 (31.3% of observed cases) and site No. 1a (27.4% of observed cases). Site No. 8 was located in a hollow area in the ground near the fence and trees, and it was covered with tall vegetation (0.5-1 m), mostly grass and nettles. Site No. 1a was a small cluster of relatively tall nettles (around 1 m).

Approximately, 5%-8% of the observed events took place in hiding sites No. 1b, 11, 14 and 1. Site No. 1 was the largest cluster of tall nettles (above 1 m) in the entire experimental enclosure, and it was located in a hollow area in the ground. Site No. 1 was the preferred resting place for all does. The animals could hide there in tall vegetation without being seen from the outside. Site No. 1b was also a cluster of nettles (with the height of around 1 m), and similarly to sites No. 1a and 1c, it was located in the vicinity of research field No. 1. Site No. 11 was covered by herbaceous plants with a height of up to 0.5 m. Site No. 14 was partially covered by straw bales and herbaceous plants, including nettles.

An analysis of video footage revealed that fawns older than 5 days hid inside the nettle cluster (site No. 1) with the mother during nursing. After several minutes (in most observations), fawns would leave site No. 1 and hide in the surrounding nettle clusters (sites No. 1a, 1b, or 1c). Only the oldest fawns (older than 14 days) remained in site No. 1 on their own after the nursing session. In all observed cases, fawns left the mother at the end of the nursing session and selected a hiding site on their own. In several instances, the doe approached the fawn, the fawn stood up, left the hiding site with its mother, and then hid on its own in a different location.

Artificial shelters were built in the farm to determine whether the functionality of farm enclosures could be improved by adding new hiding sites of higher quality. However, an analysis of video footage revealed that none of the artificial shelters made of deciduous tree branches had been used by fawns during the experiment.

Nursing sites

At the beginning of every nursing session, the doe approached a hidden fawn and nursed it in the hiding site. After nursing, the mother and its offspring moved to different locations in the enclosure. During that time, the doe groomed, licked, and played with the fawn. If more than one female nursed its offspring in the vicinity, fawns played together. When fawns were older than 10 days, the mothers spent most of the nursing sessions foraging for food. Fawns stayed close to the mothers and imitated their behavior in some cases.

More than 10% of all nursing sessions were held in sites No. 9, 18, and 1 (Table 3). Site No. 9 (selected in 13.3% of all nursing sessions) was a cluster of trees situated on elevated terrain near the fence. Animals that were startled during nursing would hide in site No. 9 where they observed their surroundings. Site No. 9 was frequently used by does and fawns during nursing possibly because it was located in the vicinity of site No. 8, a popular hiding site selected by

Table 3
Sites most frequently selected by does and fawns for nursing sessions

Site	The proportion of the site in relation to total area (%)	Frequency of use (%)[a]	P value
9	3.0	13.3	<0.001
18	8.3	12.4	0.005
1	2.1	10.6	<0.001
8	3.3	9.9	<0.001
10	3.1	8.6	<0.001
4	6.0	6.5	0.643
6	6.0	6.3	0.780
5	6.0	5.7	0.852
11	6.7	3.6	0.006
13	5.3	3.6	0.109
19	6.0	3.6	0.029
14	4.9	3.2	0.096
20	1.9	3.0	0.077
1a	<0.1	2.7	<0.001
7	6.7	2.3	<0.001
2	3.2	1.5	0.029
1c	<0.1	0.8	0.001
15	8.7	0.8	<0.001
16	6.3	0.6	<0.001
12	3.6	0.4	<0.001
17	6.3	0.4	<0.001
1b	<0.01	0.2	0.316
3	2.5	0.2	<0.001
Total	100	100	

[a] Frequency with which sites were used throughout the experiment.

Table 4
Types of vegetation most frequently visited by does and fawns

Vegetation type	Fawn hiding site			Nursing site		
	Total events	Events/100 m^2	P value	Total events	Events/100 m^2	P value
Trees	5	0.55	0.015	115	12.57	<0.001
Shrubs	1	0.35	0.136	16	5.61	0.077
Herbaceous dicotyledonous plants	188	11.19	<0.001	136	7.68	<0.001
Herbaceous monocotyledonous plants	22	0.19	<0.001	242	1.99	<0.001
Other	14	1.90	0.443	17	2.31	0.096

fawns. Site No. 18 (selected in 12.4% of all nursing sessions) was located in a hollow area in the ground. It was densely covered by nettles and relatively tall grass. Does and fawns frequently visited site No. 18 because it enclosed popular fawn hiding sites No. 1a, 1b and 1c (Table 2, Figure). After nursing their offspring in hiding sites selected by fawns, does would walk a small distance, after which, a second nursing session usually took place.

Nursing sessions were also frequently held in site No. 8 (nearly 10% of all analyzed events). Site No. 1 was more frequently used for nursing when offspring were older than 10 days. Older fawns spent up to several hours per day with their mothers in site No. 1.

Popularity of hiding sites with different vegetation cover

The theoretical number of events per 100 m^2 of area covered by each type of vegetation in the experimental enclosure was calculated to determine does' and fawns' preferences for different types of vegetation (Table 4).

Fawns had a clear preference for herbaceous dicotyledonous plants as hiding sites, and more than 11 hiding events were observed per 100 m^2 of this vegetation type (Table 4). Most does and fawns opted for trees (more than 12.5 events/100 m^2), herbaceous dicotyledonous plants (7.68 events/100 m^2), and shrubs (5.61 events/100 m^2) as the preferred nursing sites. Although shrubs were the least abundant type of vegetation that accounted for only 1.9% of total enclosure area, they were important places of contact between does and their offspring.

Discussion

The perinatal period is a critical time in deer farms. Farm enclosures where does give birth and nurse their offspring have to be suitably arranged to prevent the loss of neonate deer (Wass et al., 2003). In overcrowded fawning paddocks, fawns hiding in the grass may be accidentally trampled, pregnant does or does that miscarried may "steal" other mothers' offspring, does that unsuccessfully search for isolated fawning sites may miscarry, pace along the fence line and attempt to cross the fence. Fence-line pacing is often a sign that a female will shortly go into labor (Asher et al., 1996, 2014; Pollard et al., 1998; Wass et al., 2003). The intensity of fence-line pacing increased when humans were present near the enclosure (Pollard et al., 1998) and in small and overcrowded paddocks (Asher et al., 1996). This type of behavior is generally indicative of stress, and it should prompt breeders to improve the animals' welfare. Fawning paddocks should be sufficiently large, they should be provided with an adequate number of hiding sites, and animal density inside paddocks should be low (Pollard and Stevens, 2003; Wass et al., 2004).

The spatial arrangement of calving/fawning paddocks with a sufficient number of high-quality hiding sites is a very important consideration in deer farming, and it should be closely monitored during research studies. Pregnant females should have access to isolated sites where they can hide from the remaining members of the herd. In natural habitats, deer give birth in dense clusters of grass, reed, nettles, and ferns where offspring are nursed in the first days postpartum (Pollard and Stevens, 2003).

The results of this study corroborate the observations made by Clutton-Brock and Guinness (1975) who found that nursing hinds avoid open spaces and cross them carefully and quickly. According to Wass et al. (2003), farmed hinds have to be provided with a sufficient number of hiding sites in the perinatal period. Ideally, hiding sites should have natural plant cover (shrubs, nettles, ferns, tall grass), but artificial shelters can also be arranged. This is a very important consideration because a shortage of isolated areas where females can hide from other members of the herd causes stress and increases the risk of labor complications and neonatal deaths. The results of the present study are consistent with the observations made in red deer farms (Hodgetts et al., 2002; Wass et al., 2004). The cited authors noted that in farms with an abundance of natural hiding sites (tall herbs, trees, and shrubs), calves always choose natural hideouts over artificial shelters (pine branches or artificial structures with different shapes). Calves use alternative shelters only when farm enclosures are deficient in natural hiding sites and when grass is short (Hodgetts et al., 2002; Wass et al., 2004).

When all calving/fawning sites are occupied, females may give birth in less preferable locations near the fence or in open areas where offspring will be exposed to various risks (Mattiello, 2009). According to Hodgetts et al. (2002), hiding sites increase the welfare of neonate deer. The type (natural or artificial) and shape of hideouts are also important. In their study, calves were more likely to select artificial structures with a single wall in the center of the enclosure rather than tunnel-shaped shelters. Despite the aforementioned, young deer always had a preference for natural hiding sites (nettles, ferns) over artificial structures. In overpopulated enclosures with an insufficient number of hiding sites, calves can be licked, sniffed, trampled, and kicked by other hinds. As a result, young deer become stressed, and they pace the fence line where they can be accidentally trampled on by adult females. The injuries inflicted by aggressive hinds and the attempts to cross the fence in search of a better hiding site often have fatal consequences.

One of the most important issues that emerge from our observations is that the hiding site is selected by the offspring rather than the mother. Similar results were reported by other authors (Hodgetts et al., 2002; Svartholm, 2010; Wass et al., 2004). However, in a study by Kjellander et al. (2012), hiding sites in natural habitats were chosen by the doe, not the offspring.

Audigé et al. (2000) studied the factors that enhanced the survival rates of farmed red deer calves between birth and separation from the mother. Most neonatal deaths were observed in the perinatal period or in the first weeks postpartum. The survival of offspring was significantly influenced by the mother's health before birth, malnutrition, and a limited number of hiding sites due to overpopulation, weather conditions, and the presence of stags in enclosures occupied by hinds and calves (negative influence). Calf survival rates were higher in farms, where human caretakers visited calving paddocks in the perinatal period to detect labor complications and other problems.

Conclusions

Fallow deer never use artificial shelters in farms when there are an adequate number of natural hiding sites where does can give birth and nurse their offspring. Hiding sites are selected by fawns, and the mother merely guides its young to a different location if the chosen shelter does not provide the offspring with a sense of security. The animals have a preference for sites covered by natural herbaceous plants with a height of approximately 1.0 m (nettles or grass).

The results of this study have practical implications. Our findings can be used by farmers to prepare suitable calving/fawning paddocks in deer farms, which will improve animal welfare and reduce perinatal mortality.

Acknowledgments

Ethical considerations

This study used videotaped observations of farmer fallow deer. All procedures performed in other studies with fallow deer were in accordance with the ethical standards of University of Warmia and Muzury in Olsztyn, Poland, and Committee on research ethics. This article does not contain any studies with human participants performed by any of the authors.

Conflict of interest

Authors declare that there is no conflict of interest.

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