Acta Agronomica Óváriensis Vol. 62. Különszám I.

THE CHARACTERISTIC OF FOSTERAGE IN A HUNGARIAN GREY CATTLE (*BOS PRIMIGENIUS TAURUS HUNGARICUS*) STOCK

ÁDÁM LENNER[1] – EVELIN TÖRÖK[1] – ISTVÁN KOMLÓSI[2]

[2]University of Debrecen, Faculty of Agricultural and Food Sciences and Environmental Management, Department of Animal Husbandry, Debrecen

[1]The University of Debrecen, Doctoral School of Animal Science

SUMMARY

The concept of fosterage appears in different ways at different organisational levels. The literature mainly describes artificial fostering methods for dairy cattle. For beef cattle, it is only partly used. The aim of our study was to investigate the development, rate, and efficiency of natural fostering in a Hungarian Grey cattle herd of nearly 200 dams at the Szamárháti farm of the Tiszatáj Public Foundation in Hungary.The observation period lasted from 2018 to 2020. During the three years, there were a total of 335 calvings, 79 offspring died, sucklings was recorded in 1173 cases, 16 dams and the consequent development of foster-mothering were described. Our research seeks to reveal whether it makes sense to maintain the foster dam's nursing activity or whether drying off is necessary in the case of natural fostering. The results show that a quarter of dams fostered offspring after losing their calves. The age of the fostered calves were between one day and one month, with their 205 day-adjusted weights 11-29% above the average of the non - fostered ones. The calves of the foster dams also died in one of the following years, which may justify the culling of these individuals. The age of the dams and the number of their calvings varied. In the future, we should also monitor the offspring care of the fostered heifers and the social behaviour of the fostered offspring.

Keywords*:* behaviour, attachment, Hungarian Grey cattle, offspring care, foster cow, fostered offspring

INTRODUCTION AND LITERATURE REVIEW

A defining characteristic of all mammals, including cattle, is that one of the largest energy investments females make in their offspring is through gestation (*Royle et al., 2014)* and lactation *(Waden and Schneider,* 1992*).* The daily energy surplus can then be several times the usual (*Gittleman and Thompson, 1988*), regardless of whether we are talking about a foster dam or a biological mother.

It is possible to determine how the maternal environment affects the offspring—transferring offspring to another dam shortly after birth is a method to detect maternal effects after birth (*Goodenough et al.,* 2010).Several cross-breeding experiments have been used to explain the extent of inherited and learned maternal instincts (*Mateo and Holmes*, 2004). Their experiences with their own mothers can influence the way they treat their offspring. However, early maternal experiences do not modify all behaviours, and they do not affect non-social behaviours. In one study, *Microtus pennsylvanicus* and *M. ochrogaster* vole offspring were exchanged. The two species show fundamentally different maternal instincts when caring for their young. Offspring that received more maternal care also showed more maternal care when nursing their young. (*Mcguidre*, 1988).

Another experiment came to a similar conclusion. Offspring from poorly caring mothers were replaced with ones from mothers offering good maternal care. The offspring of good mothers were crossed with mothers who provided poor maternal care. As adults, pups raised by good mothers handled stress well and females were good mothers. Pups reared by the other group were more aggressive as adults, and females were poor mothers (*Francis et al.,* 1999). The reason behind this is the development of the individual organism. Thecardiovascular, locomotor and central nervous systems of mammals develop during care. It is a critical time. The lactation period of mammals is therefore susceptible to environmental factors, including the role of the mother. As a result, different aspects of maternal behaviour and physiology can influence offspring in ways that have lasting effects on adulthood. Several recent animal studies have shown that maternal influences may partially encode adult activities, with important implications for health and locomotor performance (*Cadneyet al.,* 2021). During early development, the olfactory epithelium of animals is more sensitive to maternal odour, thereby increasing the importance of odour later in development and also strengthening the offspring-mother

bond (*Leon et al.,* 1987; *Leon et al*., 1988; *Leon,* 1983; *Sullivan et al.,* 1986; *Sullivan and Leon,* 1986). The offspring reared by a dam can recognize the smell of their mother, and those reared by a foster cow can recognize the smell of their foster parent.

The literature mainly describes fostering methods for dairy cattle. It is also partly practiced with beef cattle, but this possibility occurs when the dam has a dead offspring and the mother of the other offspring dies. Attachment is the next step, provided the two calves are close in age. It is also common to use dairy cattle to foster several beef cattle offspring so that one dam can raise several calves. Considering the time invested and the cost of milk powder, it was and is worthwhile to foster (Everitt et al., 1968), not to mention the positive evolution of weaning weight (*Everitt et al.,* 1969).

In one experiment, the dam's offspring were removed two minutes after calving, and then four pre-selected calves were introduced to the dam and smeared with her amniotic fluid - a fast, close bond developed between the dam and the alien offspring. The offspring grew at a steady rate and did not suckle other dams (*Hudson,* 1977). Transferring odour with amniotic fluid and smearing the offspring with horn oil for fostering purposes has been used successfully by many (*Crowley and Darby,* 1971; *Le Neindre and Garel*, 1979; cit *Kent,* 1984), and some have even covered calves with cloth bags and introduced them to an unknown dam by swapping the bags. However, washing the limbs, heads and tails was also considered appropriate in this case (*Herd,* 1988). Fostering is easy for some dams, whereas in the case of others, it is difficult, and some dams are unwilling to show the behavioural attributes of fostering. In any case, fostering is more successful if we pair the dam with the alien offspring immediately after calving. The development of a fostering role is independent of breed, and there is minimal difference in the dam's acceptance during lactation. However, the number of sucklings decreases in the later phase of lactation (*Loberg and Lidfors*, 2001).

It is common practice in dairy cattle farming to separate the offspring from the dam at birth. Nowadays, there are animal welfare concerns associated with the above as it can harm the maternal instincts and social behaviour of heifers in their later life. Different methods are used to maintain both offspring care and milk production among dams. One such method is where the dam and her offspring have continuous, brief, occasional contact (15 minutes, 30 minutes/per occasion) for half a day (day only, night only). It is also common practice for a dam to feed 2-4 offspring so that the other dams only need to

be milked (*Johnsen, et al.*, 2016). For the latter system, foster parent willingness in dams is an important parameter.

There was a difference between the offspring reared on Swedish red cattle milk replacer and mothered calves. The offspring that suckled the dams rested more and ate less fodder and hay; their attachment to the dams was strong, as the mothers also licked the offspring while feeding them (*Fröberg and Lidfors,* 2009). This beneficial effect was present even when the offspring could not suckle, but contact was made (*Johnsen, et al.*, 2015). In addition to developing social skills, the suckling also resulted in more significant weight gain, up to 0.5 kg more per day than in calves raised on milk powder. It should be noted that suckling calves also had a better health status, and it was sufficient to suckle their mothers or foster dams until only 6-8 weeks of age (*Grondahl, et al.*, 2007). This positive effect can be felt even if the dam and her offspring only meet for a very short time. The above methods can also be combined. After weaning at 6-8 weeks of age, the offspring were grouped, four calves were placed under one dam and fostered (*Ellingsen et al.*, 2015; *Johnsen et al.*, 2016). Positive social behaviour and weight gain can be achieved by meeting for as little as 15 minutes twice a day; although health problems (diarrhoea) may occur, the satisfaction of the suckling reflex is fulfilled, unlike in artificially fed calves (*Roth et al*., 2009). The occasional meeting for 15 to 30 minutes is a common practice in the tropics (*Margerison, et al.,* 2002; *Das et al,* 2001; *Fröberg et al*., 2007). Although half-day systems, where the offspring spend 12 hours with their mother, are beneficial, they are very labour-intensive without automation. These data suggest that immediate weaning is not necessarily justified and that fostering may have a vital effect mainly on the subsequent social and maternal behaviour of heifers. In the case of bull calves, weight gain is better during suckling compared to artificial feeding. The authors of the present article could not find any literature on natural fostering processes in cattle. However, we can see that the dams can accept foreign calves artificially, under human influence. No study has addressed whether it is a learned or inherited behaviour when dams show willingness to fosterwithout external influence. The aim of our study was to investigate the development, rate, and efficiency of natural fostering in a Hungarian Grey cattle herd of nearly 200 cows.

MATERIALS AND METHODS

The site of the research was the Szamárháti farm, owned by the Tiszatáj Public Foundation in Hungary. Calving habits of nearly 200 dams in the herd was recorded between 2018 and 2020.

In 2018, between 8 January and 18 June, 76% of the 196 dams calved. One hundred thirty-seven sucklings were recorded over 35 days. 24% of dams calving live offspring needed help to establish an initial bond with their calves because of attachment problems. Problems include inactivity of the offspring, later activation of the suckling reflex, or painful touching of the overly tight, sensitive udder. In the latter case, the calf was able to stand up and was guarded by its dam, but she kicked its calf during suckling. There were 7 miscarriages and 19 other offspring deaths. As a result, 26 cows had the opportunity to foster alien offspring. Of the 26 cows, 23 %, i.e., 6 dams fostered offspring (*Table 1*).

In 2019, between 2 January and 15 July, 64% of the 169 dams calved. 433 sucklings were recorded over 48 days. 33% of dams that calved alive offspring needed help to establish an initial attachment with them. The problems were the same as in 2018. There were 4 miscarriages and 22 other cases of offspring mortality. As a result, 26 cows had the opportunity to foster alien offspring. Of the 26 cows, 15%, i.e., 4 cows fostered offspring (*Table 1*).

In 2020, between 7 December 2019 and 4 June 2020, 47% of 172 cows calved. 603 sucklings were recorded over 65 days. 25% of dams that calved alive offspring needed help to establish an initial attachment with them. The problems were the same as in 2018 and 2019. The lack of human intervention would have resulted in higher calf mortality. There were 4 miscarriages and 23 other cases of offspring mortality. As a result, 27 cows had the opportunity to foster alien offspring. Of the 27 cows, 22%, i.e., 6 dams fostered offspring (*Table 1*).

During the three years, a total of 335 calvings occurred, 79 offspring died, 1173 cases of sucklings were recorded, 16 dams and the consequent development of foster-mothering were described.

Table 1. Presentation of data specific to the investigation period

Year	2018	2019	2020
Investigation period	08 01-18 06	02 01-15 07	07 12 2019-04 06 2020
Number of investigated days	35	48	65
Sucklings	137	433	603
Number of dams calved	149	108	80
Number of miscarriages	7	4	4
Other offspring mortality	19	22	23

Considerably more interactions and dam-calf pairs were observed, as we did not know in advance which offspring would die and, as a result, which dam would start fostering. Cows that lost their calves on the observed day were observed several times for a minimum of one hour.

Behavioural elements of both dam and offspring were recorded during the fostering process. Behaviours included vocalisation, sniffing, licking and suckling. The time of death of the foster dam's offspring was accurately recorded, as well as the time of the first interaction with the fostered offspring. Several times during the observation periods, sucklings for the dam and the alien offspring were recorded. Attention was also paid to the fact that the offspring suckled both their mother and the foster dam, and the foster dam did not feed any other offspring. The age and number of calves of the dairy cows were extracted from the existing database (Riska programme, ENAR). We also recorded their later calvings and foster care successes. The collection and processing of data were carried out using Microsoft Excel.

RESULTS AND DISCUSSION

The proportion of foster dams and the way they started to foster were explored during the three years. Over the three years, the number of observation days was increased in the calving season each year, which resulted in an increase in the number of suckling occasions recorded. The number of observation days almost doubled between the first and the third year, while the number of sucklings recorded quadrupled. Fewer observation days are sufficient to reveal the number of foster dams, as nearly the same number of

foster dams were recorded in all three years. If a foster dam is attached to alien offspring, she will not nurse another calf until weaning. It was possible to collect as much data as possible on foster dams, considering the ENAR registration system. The age of the dams and the number of their calvings varied (*Table 2*). The oldest was 16, and the youngest was 7. The oldest dam had the highest number of calvings(9), but it can be seen that the dam was also fostering after her first calving (2018/B). Two of the foster cows died in the following years. The animal with No. 2018/D was subject to emergency slaughter on 27.03.2021 due to a leg fracture. Another one with No. 2019/H died during the calving season of the year following the observation, due to prolapsus vaginae graviditatis during calving. The remaining 14 dams are still alive.

Foster dams were followed up in the years after they became foster parents. Of the sixteen foster dams, 7 calved offspring by 2021, in different years. One of these calvings was successful; in the other 6 cases, the offspring died again, but the dams showed no willingness to foster alien offspring the next time (*Table 2*). For this reason, it is worth culling such dams.

The process of fostering is characterised by the dam's maternal instinct to try to find a foreign offspring after the loss of her offspring. In five cases, we were able to observe the process of the foster cow's adoption. The foster dams did not approach other alien offspring, consistently following only the chosen one. The other 79 dams that lost their offspring showed no intention to foster. At the time of recording the first suckling contact between the fostered offspring and the dam, the age of the offspring varied between 1 day and 1 month (*Table 2*). The onset of attachment is certainly earlier, as suckling is the strongest level of contact. If we observe the time of mortality of the foster dam's offspring and compare it to her interaction with the first alien offspring, we find that in 9 cases of the three years, the fostering occurred within a week of the offspring's death. In one case, the fact of fostering was recorded a month later. It does not imply that fostering took place at that time, only that no attachment between the foster dam and the calf was described before that time. During the fostering period, the dams were given a choice of several offspring of similar age, but they consistently followed one offspring. They would sniff, make nasal sounds towards the offspring, and if it stopped, they would lick it. The mother of the offspring watched the fostering process and did not interfere. These reasons are worth examining later. A relatedness or similar odour may be assumed to motivate the dam to foster, as similar experiments in other mammals have already demonstrated this

(*König,* 1994; *Boulet et al*., 2009; *Todrank and Heth*, 2003; *Tzur et al*., 2009). In one case, no calving was recorded, but the dam fostered and nursed the offspring until it was weaned. It is thought that a fox or a golden jackal may have taken her newborn offspring.

Moreover, in another case, where the dam's offspring died later, the mother did not suckle it. Instead, she fostered another offspring while her offspring stole milk from other nursing cows. In the case of the dam, the first contact with the alien calf was recorded almost a month after the death of her own calf. She was in the lactation phase, so it can be assumed that contact was established earlier but was not recorded during our observations, or she may have been nursing other offspring as her milk must have dried up by this time, but no other contact was described during the observations (*Table* 2). The only time out of the 16 fostering occasions that the cow miscarried in 2018 and 2019 occurred just once, and she fostered foreign calves in both years. Thus, it can be said that out of the 16 fostering cases of 15 foster dams were partially followed up.

In 2018, the average of the corrected 205-days weight for the 91 weaned calves 136 kg (133 kg for heifers, 140 kg for bulls). In 2019, the average of the corrected 205-days weight for the 72 weaned calves was 143 kg (139 kg for heifers, 147 kg for bulls). In 2020, the average of the corrected 205-days weight for the 50 weaned calves was 166 kg (165 kg for heifers, 169 kg for bulls). The fostered calves had a 11-29% higher weaning weight than their gender average contemporaries. The exception was one offspring in 2018, which weighed below average for health reasons. It suckled its mother until weaning (*Table 2*). The calf rearing ability of the cows prone to fostering was also successful in the following years (2019; 2020). There were six calvings in the following two years, 5 dams nursed above average offspring, while one calf had a below-average weaning weight. Of the dams that lost their calves during the three years studied (2018-2020) and did not foster, 45% calved and successfully reared calves in the following calving season. 13% gave birth to offspring, but the calves died again, and 42% did not calve.

In 2021, none of the dams calved, which allowed their offspring to be fostered in previous years.

Overall, fewer observation days (30-40 days) are enough to reveal the proportion of foster dams within a calving season. The foster dams suckle and nurse their calves until weaning. As supported by previous literature, the calves that suckled two mothers had a higher-than-average weaning (Everitt et al., 1969). If a foster dam lost its calf again in the

next calving season, it might not have become a foster dam again. The foster cows also differed in the number of calves and their age (*Table 2*).

*Table 2.*Data on foster dams and the process of fostering

2018							
Date of calving	Death of offspring	First suckling date of fostered calf	Age of calf (days)	Gender	Weaning weight (kg)	Calving in 2019	Calving in 2020
28.01.2018	22.12.2019	07.02.2018	28	male	156	yes, the calf is alive	-
29.01.2018	05.02.2018	03.02.2018	12	male	208	-	yes, the calf died
04.02.2018	04.02.2018	05.02.2018	1	male	180	-	yes, the calf died
?	?	18.03.2018	22	female	166	yes, calf died	-
06.04.2018	06.04.2018	06.04.2018	1	female	131	yes, calf died	-
15.04.2018	17.04.2018	14.05.2018	10	female	181	-	yes, the calf died
2019							
01.01.2019	01.01.2019	21.01.2019	31	male	183		-
18.01.2019	19.01.2019	19.01.2019	2	female	156		yes, the calf died
14.02.2019	14.02.2019	14.02.2019	4	female	153		-
06.04.2019	06.04.2019	17.04.2019	19	male	180		-
2020							
16.12.2019	18.12.2019	07.01.2020	21	female	165		
16.12.2019	20.12.2019	02.01.2020	20	male	215		
18.12.2019	24.12.2019	27.12.2019	17	female	219		
26.12.2019	26.12.2019	31.12.2019	8	female	176		
07.01.2020	12.01.2020	14.01.2020	15	female	188		
16.01.2020	16.01.2020	18.01.2020	4	female	190		

CONCLUSION

No sources on the natural ability of cattle to foster have been found in the online literature databases, which would have been a basis for comparison. The researchers have primarily studied artificial, human-assisted fostering, especially in dairy herds. Our research followed three calving seasons (2018-2020) to analyze what percentage of dams that calved but lost their calves could naturally foster a foreign calf without human intervention. In the three calving periods, we observed 1173 observations to ensure that the relationship between the foster cow and the foreign calf and the relationship between the mother and her own calf was maintained. It can be stated that, the foster cows consistently nursed one alien offspring until weaning. Nearly a quarter of the dams that lost their calves fostered calves each year. The age and calving order of the foster dams varied, so it cannot be concluded that the older dams have a stronger tendency to foster. In observing the natural calving process, we have found that if a dam fosters in one year, she does not foster again in the next calving season, even if she loses her calf again. It raises questions about the heritability of the tendency to foster. One dam was an exception, as she fostered in successive calving seasons after losing her calf. In several cases, the dams that lost its offspring were nursing the alien calf within a few days, but some dams only a month later. The dam that lost her calf showed a different calving

success rate in the following calving season. This fact does not justify the immediate culling of a dam that has lost its calf. The calves that suckled two dams all along had a 11-29% more than the average corrected weight of 205 days, so there was no justification for drying the dams. In the future, it would be advisable to monitor the process of milking, the behaviour of non-fostering cows, the offspring care of the foster heifers and the social behaviour of the fostered offspring in more detail. Furthermore, it is worth investigating whether the natural fostering behaviour is inherited or learned and whether it varies from breed to breed regarding the different conditions under which animals are kept.

ACKNOWLEDGEMENT

Authors would like to thank the workers of Tiszatáj Foundation for permitting me to make the observations on the Szamárhát Farm in Kesznyéten, Hungary. The publication is supported by the EFOP-3.6.3-VEKOP-16-2017-00008 project. The project is co-financed by the European Union and the European Social Fund.

A DAJKASÁG JELLEMZŐJE EGY MAGYAR SZÜRKE MARHA (*BOS PRIMIGENIUS TAURUS HUNGARICUS*) ÁLLOMÁNYBAN

LENNER ÁDÁM [1] – TÖRÖK EVELIN [1] – KOMLÓSI ISTVÁN [2]

[2]Debreceni Egyetem, Agrár- és Élelmiszertudományi és Környezetgazdálkodási Kar, Állattenyésztési Tanszék, Debrecen

[1]Debreceni Egyetem, Állattudományi Doktori Iskola

ÖSSZEFOGLALÁS

A dajkaság fogalma különböző szervezeti szinteken, eltérő módon jelenik meg. Az online szakirodalomban elsősorban tejelő szarvasmarháknál alkalmazott mesterséges dajkásítási módszerekről lehet olvasni. Húsmarhánál ez csak részben gyakorlat. Vizsgálatunk célja az volt, hogy a Tiszatáj Közalapítvány Szamárháti tanyáján egy közel 200 anyaállatból álló szürke szarvasmarha állományban a természetes dajkásítás kialakulását, mérétkét és hatékonyságát kiderítsük. A megfigyelési időszak 2018 és 2020

közé esett. A 3 év alatt összesen 335 ellés történt, 79 ivadék hullott el, 1173 alkalommal került feljegyzésre ivadékgondozási eset, 16 dajkatehenet írtunk le és ennek folyományaként a dajkásítás kialakulását. Kutatásunkkal azt igyekeztük feltárni, hogy van-e értelme a dajkát ivadékgondozási folyamatban tartani, vagy a szárazra állítása szükséges. Az eredmények azt mutatják, hogy a szürke marha tehenek negyede dajkásított ivadéka elvesztése után. A dajkásított borjak kora jellemzően 1 nap és 1 hónap közé esett, 205 napra korrigált súlyuk az átlagot 11-29%-kal is meghaladta. A dajkatehenek borjai a következő évek valamelyikében is elhullottak, ami indokolhatja ezen egyedek kiselejtezését. A dajkatehenek kora, elléseik száma eltért egymástól. A jövőben figyelemmel kellene kísérni a dajkásított üszők szociális viselkedését és borjúnevelési viselkedését.

Keywords*:* viselkedés, kötődés, magyar szürkemarha, utódgondozás, dajkatehén, dajkásított ivadék

REFERENCES

Boulet, M. – Charpentier, M.J. – Drea, C.M. (2009): Decoding an olfactory mechanism of kin recognition and inbreeding avoidance in a primate. BMC Evol Biol 9:281

Das, S.M. – Redbo, I. – Wiktorsson, H. (2001): Behaviour of Zebu and crossbed cows inrestricted suckling groups. Appl. Anim. Behav. Sci. 72, 263–270.

Cadney, M. D. - Schwartz, N. E. – McNamara, M. P. - Schmill, M. P. – Castro, A.A. - Hillis, D. A. - Garland Jr., T. (2021): Cross-fostering selectively bred High Runner mice affects adult body mass but not voluntary exercise, Physiology & Behavior 241, 113569

Crowley, J.P. - Darby, T.E. (1971): A method of fostering calves for multiple suckling systems. Amin. Prod., 13:382

Ellingsen, K. – Johnsen, J.F. – Schjøll, A. – Grøndahl, A.M. – Mejdell, C.M. (2015): Kalvestelli norsk og svensk økomelkproduksjon. Resultater fra en spørreundersøkelse. Norwegian Veterinary Institute, Oslo (Veterinærinstituttets rapportserie16-2015).

Everitt, G.C. – Phillips, D.S.M. – Whiteman, D.P. (1968): Suckling: effects on the calf and the cow. Proc. Ruakura Farmers' Conf. Week, 1968: 158.

Everitt, G.C. – Evans, S.T. – Franks, M. (1969): Genetic and environmental effects on beef production. Proc. N.Z. Sot. Anim. Prod., 29: 147.

Francis, D. – Diorio, J. – Liu, D. – Meaney, M. J. (1999): Nongenomic transmission across generations of maternal behavior and stress responses int he rat, Science, 5;286(5442):1155-8

Fröberg, S. – Aspegren-Guldorff, A. – Olsson, I. – Marin, B. – Berg, C. – Hernandez, C. – Galina, C.S. – Lidfors, L. – Svennersten-Sjaunja, K. (2007): Effect of restrictedsuckling on milk yield, milk composition and udder health in cows andbehaviour and weight gain in calves, in dual-purpose cattle in the tropics. Trop. Anim. Health Prod. 39, 71–81.

Fröberg, S. – Lidfors, L. (2009): Behaviour of dairy calves suckling the da min a barn with automatic milking or being fed milk substitute from an automatic feeder in a group pen, Animal Behaviour Science, 117, 150-158

Gittleman, J. L. – Thompson, S. D. (1988): Energy allocation in mammalian reproduction. Integr. Comp. Biol. 28, 863–875

Grondahl, A. M. – Skancke, E. M. – Mejdell, C. M. – Jansen, J. H. (2007): Growth rate, health and welfare in a dairy herd with natural suckling until 6-8 weeks of age: a case repot, Acta Veterinaria Scandinavica 49, 16

Herd, R. M. (1988): A Technique for Cross – Mothering Beef Calves which does not affect Growth, Animal Behaviour Science, 19, 239-244

Johnsen, J. F. – de Passille, A. M. – Mejdell, C. M. – Boe, K. E. – Grondahl, A. M. – Beaver, A. – Rushen, J. – Weary, D. M. (2015): The Effect of nursing ont he cow- calf bond, Animal Behaviour Science, 163:50-57

Johnsen, J. F. – Zipp, K. A. – Kalber, T. – de Passillé, A. M. – Knierim, U. – Barth, K. Mejdell, C. M. (2016): Is rearing calves with the dam a feasible option for dairy farms? – Current and future research, Animal Behaviour Science, 181, 1-11

Kent, J. P. (1984): A note on multiple fostering of calves ont o nurse cows at a few days post – partum, Animal Begaviour Science, 12, 183-186

König, B. (1994): Fitness effects of communal rearing in house mice: the role of relatedness versus familiarity. Anim Behav 48:1449–1457

Leon, M. (1983): Chemical communication in mother-young interactions. In J. Vandenbergh (Ed.), Pheromones and Mammalian Communication, Academic, New York, 1983, pp. 39-77

Leon, M. – Coopersmith, R. – Lee, S. – Sullivan, R. M. - Wilson, D. A. – Woo, C. C. (1987): Neural and behavioral plasticity induced by early olfactory learning. In Perinatal

development: a psychobiological perspective (ed. E. Krasnegor, E. Blass, M. Hofer & W. Smotherman), pp. 145^167. New York: Academic Press.

Loberg, J. – Lidfors, L. (2001): Effect of stage of lactation and breed on dairy cows' acceptance of foster calves, Animal Behaviour Science, 97-108

Margerison, J. K. – Preston, T. R. – Phillips, C. J. C. (2002): Restricted suckling of tropical dairy cows by their own calf or other cows' calves, American Society of Animal Science, 80:1663-1670

Mateo, J. M. - Holmes, W. G. (2004): Cross-fostering as a means to study kin recognition. Animal Behaviour68:1451–1459.

McGuire, B. (1988): The effects of cross-fostering on parental behavior of meadow voles (*Microtus pennsylvanicus*). *Journal of Mammalogy* 69:332–341.

Neindre le, P. - Garel, B. (1979): Adoption d'un deuxihme veau par des vaches plusieurs jours apds la mise-bas. Ann. Zootech. 28, 231-234.

Royle, N. J. – Smiseth, P. T. – Kölliker, M. (2014): The Evolution of Parental Care, Oxford University Press. In: Oxford

Roth, B. A. – Barth, K. – Gygax, L. – Hillmann, E. (2009): Influence of artifical vs. mother – bonded rearing on suckling behaviour, health and weight gain in calves, Animal Behaviour Science, 119, 143-150

Sullivan, R.M. – Hofer, M.A. – Brake, S.C. (1986): Olfactoryguided orientation in neonatal rats is enhanced by a conditioned change in behavioral state, Dev. Psychobiol., 19 (1986) 615-623.

Sullivan, R.M. – Leon, M. (1986): Early olfactory learning induces an enhanced olfactory bulb response in young rats, Dev. Brain Res., 27 (1986) 278-282.

Todrank, J. – Heth, G. (2003): Odor–genes covariance and genetic relatedness assessments: rethinking odor-based "recognition" mechanisms in rodents. In: Slater PJB, Rosenblatt JS, Snowdon CT, Roper TJ (eds) Advances in the Study of Behavior, vol 32. Academic Press, pp 77–130

Tzur, S. – Todrank, J. – Juergens, A. – Nevo, E. – Heth, G. (2009): Odour–genes covariance within a natural population of subterranean Spalax galili blind mole rats. Biol J Linn Soc 96:483–490

Wade, G.N. – Schneider, J.E. (1992) Metabolic fuels and reproduction in female mammals. Neurosci Biobehav Rev 16:235–272

Address of the authors:

Lenner Ádám

Debreceni Egyetem Állattenyésztési Tudományok Doktori Iskola

4032 Debrecen Böszörményi út 138

E-mail cím: lenner.adam@agr.unideb.hu