Praca oryginalna *Original paper*

Changes in the incidence of anoestrus and its clinical forms in dairy cows in north-eastern Poland over the last two decades

WOJCIECH BARAŃSKI, SŁAWOMIR ZDUŃCZYK, MARIANNA ZIELIŃSKA, JULIA KLAJNA

Department of Animal Reproduction with Clinic, Faculty of Veterinary Medicine, University of Warmia and Mazury in Olsztyn, Oczapowskiego 14, 10-719 Olsztyn, Poland

Received 09.06.2026 *Accepted 30.06.2026*

Barański W., Zdunczyk S., Zielińska M., Klajna J.

Changes in the incidence of anoestrus and its clinical forms in dairy cows in north-eastern Poland over the last two decades

Summary

The aim of the study was to evaluate changes in the incidence of anoestrous conditions in several dairy cow herds over the past 20 years in north-eastern Poland. In calving season 2003-2004, 1215 crossbred cows (Polish Black-and-White × Holstein-Friesian) from 8 herds were used. The average milk yield was about 5000 kg per year. In calving season 2023-2024, 942 Holstein-Friesian cows from 5 herds were used. The average milk yield was about 9000 kg milk per year. Anoestrous cows were examined twice by ultrasonography at a 7-10 day interval between days 50 and 60 after parturition. In 2003-2004, anoestrus was observed on average in 33.1% of cows. The main clinical form of anoestrus was silent heat (44.0%), followed by ovarian afunction (43.3%), ovarian cysts (9.2%), corpus luteum pseudograviditatis (2.1%) and persistent follicles (1.4%). In 2023-2024, anoestrus was observed in 43.5% of cows. Silent heat was diagnosed in 41.0%, persistent ovarian follicles in 34.9%, ovarian cysts in 18.0%, ovarian afunction in 4.9% and corpus luteum pseudograviditatis in 1.2% of anoestrous cows. There was a significantly higher incidence of anoestrus ($p < 0.05$) in calving season 2003-2004, compared to calving season 2023-2024. The difference between the two calving seasons in the proportion of ovarian afunction, persistent ovarian follicles and ovarian cysts in anoestrus cows was statistically significant ($p < 0.05$). The study shows that over the past two decades there has been an increase in the incidence of anoestrus in dairy cows and changes in the proportion of its clinical forms, in particular in ovarian afunction, persistence of ovarian follicles and ovarian cysts.

Keywords: cows, anoestrus, clinical forms, milk yield

The early onset of postpartum ovarian function is of great importance for the fertility of dairy cows. Cows that have displayed oestrus once or more before the start of breeding have higher fertility compared with cows inseminated at their first oestrus (10, 37). Postpartum anoestrus is one of the main clinical and economic problems in dairy cows. It is defined as lack of typical oestrus expression in the 60 days after calving (29). In various studies, the incidence of anoestrus postpartum ranges from 20 to 40% (2, 28, 50). Postpartum anoestrus results in increased intervals from calving to conception and causes serious economic losses (33, 45). A meta-analysis of studies on the impact of diseases on the reproductive performance of dairy cows has shown that anoestrus was associated with 26 more days to the first service and with an 18% lower conception rate at the first service, resulting in 41 more days to conception (9).

There are several different clinical forms of anoestrus, namely silent heat, ovarian afunction, persistent follicles, ovarian cysts and corpus luteum pseudograviditatis (23, 29). The prevalence of these forms in different herds depends on energy balance, body condition score (BCS) loss, parity, milk yield, periparturient disorders and calving season (27, 31, 45).

Postpartum anoestrus is still a challenge to bovine practitioners. Treatment options for cows with postpartum anoestrus include hormonal and management strategies, which should be tailored to the type of anoestrus (31, 33). An accurate diagnosis of the type of anoestrus is therefore essential for proper treatment. Rectal palpation remains the most commonly used diagnostic method for examining the reproductive system of cows, but its effectiveness in diagnosing ovarian function is low (19, 34). Ultrasonography is a good tool to make a more reliable diagnosis and to determine a more effective treatment of anoestrus (14).

In recent decades, the milk yield of cows has been increasing rapidly. This is accompanied by a marked decline in the fertility of the dairy cows (4, 17). This results in a shortened length of the productive life of animals, which directly affects the economics of the dairy industry (44). The reduced fertility is mainly due to an increase in postpartum ovarian dysfunctions, poor expression of oestrus, defective oocytes/embryos and uterine infection (4, 21).

In Poland the average milk yield increased from 3900 L per cow in 2003 to 6800 L per cow in 2023 (11, 12). Along with the increase in milk yield, a decrease in the fertility of cows in Poland was observed (25, 41). However, there are no data on the prevalence of clinical reproductive disorders in dairy cows with increasing milk yields in Poland over the long period. Thus, the aim of the present study was to evaluate changes in the incidence of anoestrus and its clinical forms over the last two decades in dairy cows in north-eastern Poland.

Material and methods

The study was conducted in several dairy herds in north-eastern Poland as part of clinical practice, so there was no need for consent from an Ethics Committee for Animal Experiments. The herds were included in the Herd Health Programme (1) and visited at an interval of 7-10 days. Anoestrous cows were examined twice by ultrasonography in a 7-10 day interval between days 50 and 60 after parturition. Cows with normal cyclical changes in the ovaries were classified as having silent heat. Ovarian afunction was defined as small ovaries with follicles of < 5 mm in diameter without a corpus luteum on both examinations. Persistent follicles were defined as follicular structures of > 8 mm in diameter without a corpus luteum on both examinations. Ovarian cysts were defined as follicular structures with a diameter of > 25 mm in the absence of a corpus luteum on both examinations. Corpus luteum pseudograviditatis was defined as the presence of a corpus luteum associated with pyometra on both examinations.

A total of 2157 cows from 2 calving seasons were used. In calving season 2003-2004, 1215 crossbred cows (Polish Black-and-White × Holstein-Friesian) from 8 herds were used. The average milk yield was about 5000 kg per year. Two herds were kept in tie stalls, and the other six were kept in free stalls. During the summer season, the cows were fed green fodder, grass silage and concentrate. During the winter season, their feed consisted of grass silage, maize silage, concentrate and vitamin and mineral supplements. In calving season 2023-2024, 942 Polish Black-and-White Holstein-Friesian cows from 5 herds were used. The cows were housed in loose-type barns with cubicles and fed a total mixed ration based on grass silage, maize silage, concentrate, as well as vitamin and mineral supplements. Oestrus was detected visually by herdsmen twice a day during milking. The average milk yield was 9000 kg of milk per year.

Statistical analysis was performed using GraphPad Prism version 10.00 (GraphPad Software, San Diego, CA, USA). The differences in the incidence of anoestrus and its clinical forms were analysed using Fischer's exact test. The level of significance was set at $p < 0.05$.

Results and discussion

The average incidence of anoestrus for calving periods 2003-2004 and 2023-2024 is presented in Figure 1. There was a significantly higher incidence of anoestrus ($p < 0.05$) in 2023-2024 (43.5%) compared to 2003-2004 (33.1%).

The incidence of different clinical forms of anoestrus for 2003-2004 and 2023-2024 is presented in

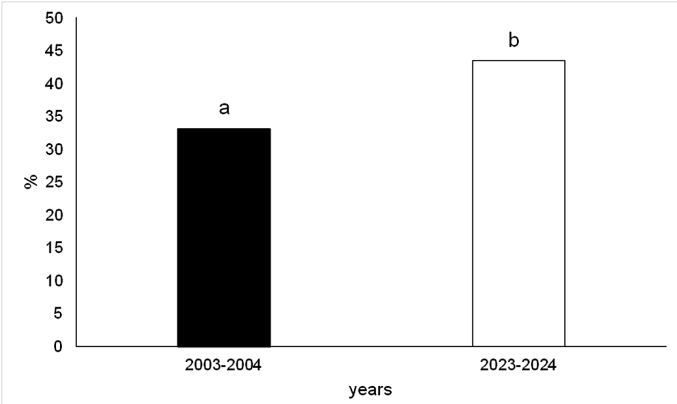

Fig. 1. The average incidence of anoestrus in dairy cows calving in 2003-2004 and 2023-2024. Different superscript letters indicate statistical significance at p < 0.05

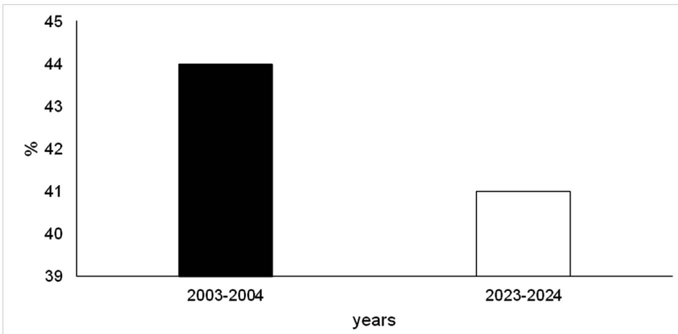

Fig. 2. The average incidence of silent heat in anoestrous dairy cows calving in 2003-2004 and 2023-2024

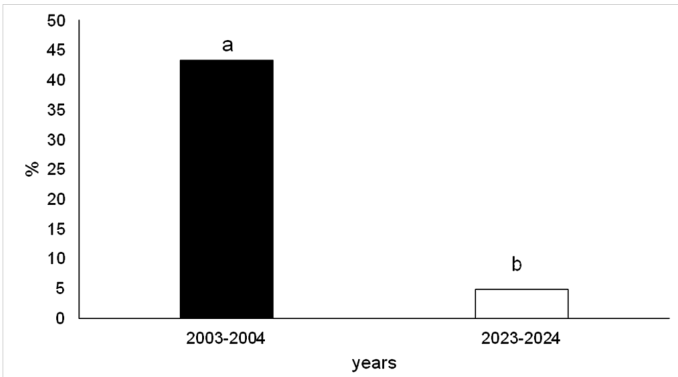

Fig. 3. The average incidence of ovarian afunction in anoestrous dairy cows calving in 2003-2004 and 2023-2024. Different superscript letters indicate statistical significance at p < 0.05

Figures 2-6. In 2003-2004, the main clinical form of anoestrus was silent heat (44.0%), followed by ovarian afunction (43.3%), ovarian cysts (9.2%), corpus luteum pseudograviditatis (2.1%) and persistent follicles (1.4%). In 2023-2024, silent heat was diagnosed in 41.0%, persistent ovarian follicles in 34.9%, ovarian cysts in 18.0%, ovarian afunction in 4.9% and corpus luteum pseudograviditatis in 1.2% of anoestrous cows. The difference between calving periods 2003-2004 and 2023-2024 in the incidence of ovarian afunction, persistent ovarian follicles and ovarian cysts was statistically significant ($p < 0.05$).

There are several classifications of anoestrus types in cows. In this study, the classical classification of clinical types of anoestrus was used: silent heat, ovarian afunction, persistent follicles, ovarian cysts and corpus luteum pseudograviditatis (23, 29). Peter et al. (30) proposed to divide anoestrus into four types (I, II, III and IV) on the basis of functional states of follicular and luteal developments: type I with growth of follicles only to emergence (< 4 mm), type II with follicle growth to deviation size (< 9 mm), type III with follicle growth to ovulatory size (10 to 20 mm) or larger (cysts), and type IV with a prolonged life of the corpus luteum.

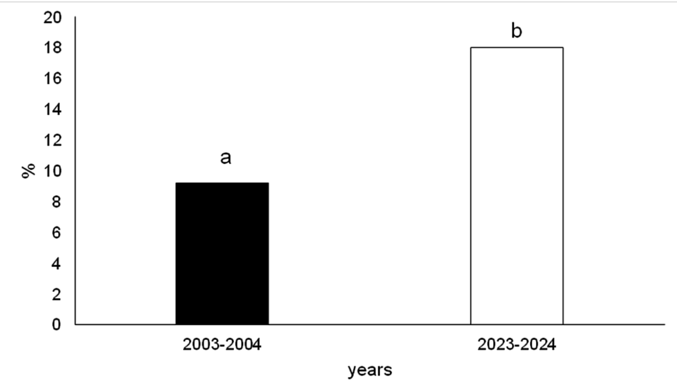

Fig. 4. The average incidence of ovarian cysts in anoestrous dairy cows calving in 2003-2004 and 2023-2024. Different superscript letters indicate statistical significance at p < 0.05

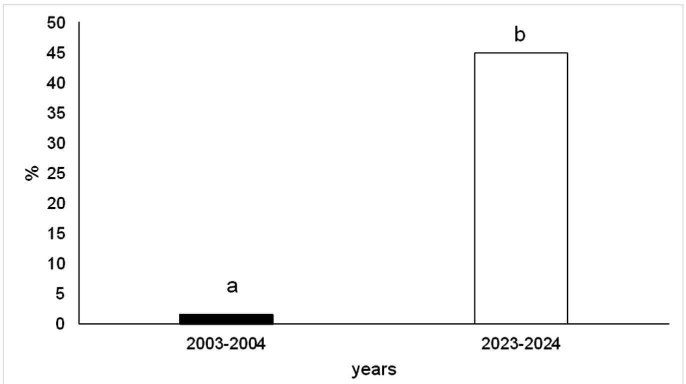

Fig. 5. The average incidence of persistent follicles in anoestrous dairy cows calving in 2003-2004 and 2023-2024. Different superscript letters indicate statistical significance at p < 0.05

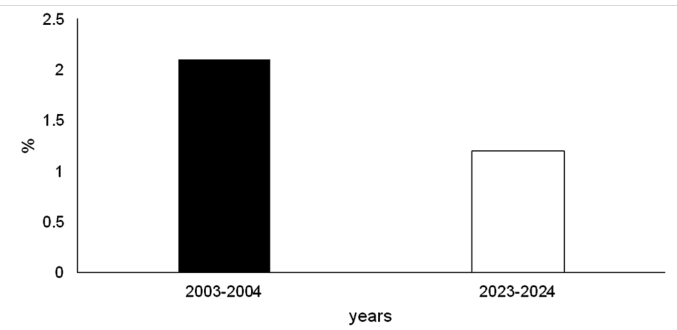

Fig. 6. The average incidence of corpus luteum pseudograviditatis in anoestrous dairy cows calving in 2003-2004 and 2023-2024

The postpartum anoestrus was found in 33.1% of cows in calving period 2003-2004 and in 43.5% of cows in 2023-2024. The difference in the incidence of anoestrus between these calving periods was significant ($p < 0.05$). The high incidence of anoestrus in high-yielding cows has also been observed by other authors (2, 28, 50). It is difficult to compare the incidence of anoestrus in different studies because of differences in defining anoestrus and in diagnosis methods. Rectal palpation is the main method used for the clinical evaluation of ovarian function in cows, but its accuracy is low (20, 34). Precise diagnosis of ovarian function requires repeated ultrasound examinations or progesterone determination in blood or milk at time intervals of 7 to 10 days (13, 49).

Between 2003-2004 and 2023-2024 the incidence of ovarian afunction decreased significantly ($p < 0.05$) from 43.3% to 4.9% of anoestrous cows. The cows were considered to suffer from ovarian afunction when only follicles of < 5 mm in diameter without a corpus luteum were detected in two consecutive examinations 7-10 days apart. Ovarian inactivity with poor follicular growth and a low progesterone level until day 50-60 postpartum is also referred to as true anoestrus (29), anoestrus type I (30) or anovulation type I (46). The pathophysiology of this condition is not well understood. It is presumed that undernutrition and severe energy deficit may cause this condition through a lack of essential gonadotropin support to sustain follicular growth (3). A negative genetic relationship was also demonstrated between milk yield and the resumption of cyclicity after parturition (43). The lack of ovarian cyclicity affects about 25% of dairy cows by day 60 after calving, but in some herds the incidence of acyclicity can reach up to 40% (26, 37, 45, 49). Risk factors for delayed cyclicity include periparturient disorders, BCS loss associated with severe negative energy balance, parity, season of calving, management, mastitis, lameness and heat stress (6, 31, 45). The significant decrease in the incidence of ovarian afunction between 2004-2004 and 2023-2024, despite increased milk yield, was probably related to improvement in housing conditions and nutrition of cows.

Another clinical form of anoestrus, the incidence of which has changed significantly between the two calving periods, was the persistence of ovarian follicles. A dominant follicle is established but fails to ovulate and becomes a persistent follicular structure. The clinical form of anoestrus corresponds to anoestrus type III (31). This condition appears to result from the lack of an LH surge due to insensitivity of the hypothalamus to the positive feedback effects of estradiol (31, 46). Persistence of ovarian follicles is a very commonly reported cause of anovulation in high yielding cows. Persistent follicles with a diameter from 9 mm to 24 mm were found in 80% of anovulatory cows (13). In another study, 67.4% of anovulatory cows had follicles with diameters from 8 mm to 17 mm (22). The risk factors for this type of anovulation were a low BCS resulting from a negative energy balance in early lactation, the prevalence of multiple diseases and a longer dry period (13, 22). The increase in the incidence of persistence of ovarian follicles is of great clinical importance. Under field conditions, the ovarian follicular status is usually diagnosed on the basis of a single rectal or ultrasound examination. This may lead to a high rate of misdiagnosed and incorrectly treated animals (40). Therefore cows with persistent follicles are usually misclassified as cyclic.

Persistent follicular structures may become follicular cysts (> 25 mm). In the present study, the incidence of cystic follicles increased from 9.2% to 18.0% ($p < 0.05$) between 2003-2004 and 2023-2024. In other studies, the incidence of cystic ovarian follicles in high-yielding anovulatory cows ranged from 11% to 33% (13, 22). Factors such as increased milk yield, metabolic disorders, stress, uterine infection and lameness are associated with a high incidence of cystic ovarian degeneration. In addition, a genetic predisposition may be involved (42). Many cystic ovarian follicles develop during the early postpartum period and regress spontaneously (30, 42). However, the probability of cows having cystic follicles during the pre-service period was much greater in those with cysts early postpartum (16). Follicular cysts are dynamic structures and may develop into luteal cysts or regress after the ovulation of another follicle (30). Follicular and luteal cysts can be differentiated by means of ultrasonography. Follicular cysts have a thin wall (< 3 mm), whereas luteal cysts have a thicker wall (> 3 mm) (5). In the present study, all cysts were follicular. This result agrees with another study (13). Luteal cysts are found more often later during lactation (5, 36).

Further, type II anoestrus has been distinguished, characterized by abnormal follicular development followed by regression of follicles (31). Atresia of the follicle results in the emergence of a new follicular wave. It commonly occurs in the early postpartum period in lactating dairy cows and suckled beef cows. This form of anoestrus was not found in our study, in line with the findings of other studies (22).

Silent heat is regarded as one of the most prominent and costly infertility problems on dairy farms affecting about 40-60% of anoestrous cows (23, 48). Cows suffering from silent heat are not seen in heat although they are cycling regularly. Silent heat is also referred to as suboestrus and includes both cows with undetected oestrus and those not showing signs of oestrus (29). In our study silent heat accounted for more than 40% of cows not seen in heat within 60 days after calving. The difference between the two calving periods was not statistically significant ($p \geq 0.05$). Similarly, no relationship between milk yield and oestrus behaviour was reported (7). However, reports on the relationship between the level of milk production and the expression and intensity of oestrus are not consistent. Other studies reported that the duration of oestrus in high yielding cows is often shortened, and the expression of oestrus in such cows is poor (4, 15). In high yielding cows, the lipid mobilisation during the early stages of lactation can lead to the release of progesterone stored in adipose tissue, which suppresses the expression of oestrus (18, 38).

Under field conditions, it is difficult to differentiate between the lack of oestrus expression and suboestrus. In the present study, oestrus was detected visually by herdsmen three times a day during milking in the two calving periods. The effectiveness of visual heat detection varies considerably from 90% to less than 50% of detected oestrus (35). Oestrus detection rates depend on the skills of herdsmen, the timing, duration and frequency of visual observations, as well as on which behaviours are monitored (8).

The incidence of corpus luteum pseudograviditatis in anoestrous cows was low in both calving periods (1.2-2.1%). This is a failure of the normal corpus luteum to regress despite the absence of pregnancy and is therefore also described as a prolonged luteal phase or a persistent corpus luteum. This condition is usually associated with inflammatory diseases of the uterus or the presence of mummified fetus (23, 47). As in our study, a low incidence of corpus luteum pseudograviditatis (1.8%) was reported elsewhere (24). A higher incidence of prolonged luteal phase (20%) was found in postpartum high yielding cows in Belgium (26). The reasons for the variation may be related to differences in environmental and management factors.

The increase in the incidence of anoestrus and changes in the proportion of its clinical forms was associated with the substitution of Polish Black-and-White cows by Holstein-Friesian cows (holsteinization) and selection for milk production. An antagonistic relationship exists between genetic merit for milk yield and reproduction (32). High yielding cows are predisposed to a greater degree of negative energy balance in early lactation. This can lead to body condition loss, metabolic diseases, ovarian disorders and inflammatory diseases of the uterus (3, 45). Elevated metabolic activity in high yielding dairy cows increases steroid metabolism and reduces circulating oestrogen concentrations (46). Of great importance is the interaction of genetic factors with other risk factors for anoestrus, such as nutrition, management and housing conditions (21, 22, 27).

In conclusion, over the past two decades there has been an increase in the incidence of anoestrus in dairy cows in north-eastern Poland and changes in the proportion of its clinical forms, in particular in ovarian afunction, persistence of follicular structures and ovarian cysts. This trend can be attributed to both genetic and environmental factors and their interactions. Accurate diagnosis is key in managing these conditions.

References

1. *Barański W., Zduńczyk S., Janowski T., De Kruif A., Opsomer G., Dewulf J.*: Dairy herd health-care program (in Polish). Med. Weter. 2005, 61, 14-18.
2. *Bretzinger L. F., Tippenhauer C. M., Plenio J. L., Heuwieser W., Borchardt S.*: Effect of transition cow health and estrous expression detected by an automated activity monitoring system within 60 days in milk on reproductive performance of lactating Holstein cows. J. Dairy Sci. 2023, 106, 4429-4442.
3. *Crowe M. A., Diskin M. G., Williams E. J.*: Parturition to resumption of ovarian cyclicity: comparative aspects of beef and dairy cows. Animal 2014, 8 (Suppl 1), 40-53.
4. *Dobson H., Smith R., Royal M., Knight Ch., Sheldon I.*: The high-producing dairy cow and its reproductive performance. Reprod. Domest. Anim. 2007, 42 (Suppl 2), 17-23.
5. *Douthwaite R., Dobson H.*: Comparison of different methods of diagnosis of cystic ovarian disease in cattle and an assessment of its treatment with a progesterone-releasing intravaginal device. Vet. Rec. 2000, 147, 355-359.
6. *Dubuc J., Duffield T. F., Leslie K. E., Walton J. S., LeBlanc S. J.*: Risk factors and effects of postpartum anovulation in dairy cows. J. Dairy Sci. 2012, 95, 1845-1854.
7. *Eerdenburg F. J. van, Karthaus D., Taverne M. A. M., Merics I., Szenci O.*: The relationship between estrous behavioral score and time of ovulation in dairy cattle. J. Dairy Sci. 2002, 58, 1150-1156.
8. *Eerdenburg F. J. van, Loeffler H. S., van Vliet J. H.*: Detection of oestrus in dairy cows: a new approach to an old problem. Vet. Q. 1996, 18, 52-54.
9. *Fourichon C., Seegers H., Malher X.*: Effect of disease on reproduction in the dairy cow: a meta-analysis. Theriogenology 2000, 53, 1729-1759.
10. *Galvão K. N., Frajblat M., Butler W. R., Brittin S. B., Guard C. L., Gilbert R. O.*: Effect of early postpartum ovulation on fertility in dairy cows. Reprod. Domest. Anim. 2010, 45, 207-211.
11. *GUS*. Statistical Yearbook of the Republic of Poland (in Polish), 2004, Warsaw.
12. *GUS*. Statistical Yearbook of the Republic of Poland (in Polish), 2024, Warsaw.
13. *Gümen A., Guenther J. N., Wiltbank M. C.*: Follicular size and response to Ovsynch versus detection of estrus in anovular and ovular lactating dairy cows. J. Dairy Sci. 2003, 86, 3184-3194.
14. *Hanzen C., Pieterse M., Szenci O, Drost M.*: Relative accuracy of the identification of ovarian structures in the cow by ultrasonography and palpation per rectum. Vet. J. 2000, 159, 161-170.
15. *Lopez H., Satter L. D., Wiltbank M. C.*: Relationship between level of milk production and estrous behavior of lactating dairy cows. Anim. Reprod. Sci. 2004, 81, 209-223.
16. *López-Gatius F., Santolaria P., Yániz J., Fenech M., López-Béjar M.*: Risk factors for postpartum ovarian cysts and their spontaneous recovery or persistence in lactating dairy cows. Theriogenology 2002, 58, 1623-1632.
17. *Lucy M. C.*: Reproductive loss in high-producing dairy cattle: where will it end? J. Dairy Sci. 2001, 84, 1277-1293.
18. *Lüttgenau J., Purschke S., Tsousis G., Bruckmaier R. M., Bollwein H.*: Body condition loss and increased serum levels of nonesterified fatty acids enhance progesterone levels at estrus and reduce estrous activity and insemination rates in postpartum dairy cows. Theriogenology 2016, 85, 656-663.
19. *McDougall S., Rhodes F. M.*: Detection of a corpus luteum in apparently anoestrous cows by manual palpation, transrectal ultrasonography and plasma progesterone concentration. N. Z. Vet. J. 1999, 47, 47-52.
20. *McLeod B. J., Williams M. E.*: Incidence of ovarian dysfunction in post partum dairy cows and the effectiveness of its clinical diagnosis and treatment. Vet. Rec. 1991, 128, 121-124.
21. *Mee J. F.*: Temporal trends in reproductive performance in Irish dairy herds and associated risk factors. Ir. Vet. J. 2004, 57, 158-166.
22. *Monteiro P. L. J., Gonzales B., Drum J. N., Santos J. E. P., Wiltbank M. C., Sartori R.*: Prevalence and risk factors related to anovular phenotypes in dairy cows. J. Dairy. Sci. 2021, 104, 2369-2383.
23. *Mwaanga E. S., Janowski T.*: Anoestrus in dairy cows: causes, prevalence and clinical forms. Reprod. Domest. Anim. 2000, 35, 193-200.
24. *Nakao T., Moriyoshi M., Kawata K.*: The effect of postpartum ovarian dysfunction and endometritis on subsequent reproductive performance in high and medium producing dairy cows. Theriogenology 1992, 37, 341-349.
25. *Neja W., Jankowska M., Sawa A., Bogucki M.*: Analysis of milk and reproductive performance of the active population of cows in Poland. J. Cent. Eur. Agr. 2013, 14, 91-101.
26. *Opsomer G., Coryn M., Deluyker H., de Kruif A.*: An analysis of ovarian dysfunction in high yielding dairy cows after calving based on progesterone profiles. Reprod. Domest. Anim. 1998, 33, 193-204.
27. *Opsomer G., Gröhn Y. T., Hertl J., Coryn M., Deluyker H., de Kruif A.*: Risk factors for post partum ovarian dysfunction in high producing dairy cows in Belgium: a field study. Theriogenology 2000, 53, 841-857.
28. *Opsomer G., Laevens H., Steege N., de Kruif A.*: A descriptive study of post partum anoestrous in nine high-yielding dairy herds in Flanders. Vlaams Diergeneeskd. Tijdschr. 2000, 69, 31-37.
29. *Opsomer G., Mijten P., Coryn M., de Kruif A.*: Post-partum anoestrus in dairy cows: a review. Vet. Q. 1996, 18, 68-75.
30. *Peter A. T.*: An update on cystic ovarian degeneration in cattle. Reprod. Dom. Anim. 2004, 39, 1-7.
31. *Peter A. T., Vos P. L., Ambrose D. J.*: Postpartum anestrus in dairy cattle. Theriogenology 2009, 71, 1333-1342.
32. *Pryce J. E., Coffey M. P., Brotherstone S.*: The genetic relationship between calving interval, body condition score and linear type and management traits in registered Holsteins. J. Dairy Sci. 2000, 83, 2664-2671.
33. *Rhodes F. M., McDougall S., Burke C. R., Verkerk G. A., Macmillan K. L.*: Invited review: treatment of cows with an extended postpartum anestrous interval. J. Dairy Sci. 2003, 86, 1876-1894.
34. *Ribadu A. Y., Ward W. R., Dobson H.*: Comparative evaluation of ovarian structures in cattle by palpation per rectum, ultrasonography and plasma progesterone concentration. Vet. Rec. 1994, 135, 452-457.
35. *Roelofs J. B., López-Gatius F., Hunter R. H. F., van Eerdenburg F. J. C. M., Hanzen C.*: When is a cow in estrus? Clinical and practical aspects. Theriogenology 2010, 74, 327-344.
36. *Rudowska M., Barański W., Zduńczyk S., Tobolski D., Janowski T.*: Effect of progesterone-releasing intravaginal device on reproductive performance of cows with cystic ovarian follicles after puerperium. Pol. J. Vet. Sci. 2019, 22, 489-494.
37. *Santos J. E., Rutigliano H. M., Sá Filho M. F.*: Risk factors for resumption of postpartum estrous cycles and embryonic survival in lactating dairy cows. Anim. Reprod. Sci. 2009, 110, 207-221.
38. *Schopper D., Claus R.*: Progesterone concentrations in milk fat around ovulation in the dairy cow: differences between observed and silent heat. Zuchthyg. 1986, 21, 237-240.
39. *Schopper D., Schemer R., Weiler U., Claus R.*: Influence of milk yield on the fertility of dairy cows postpartum: evaluation of progesterone profiles. Reprod. Domest. Anim. 1993, 28, 225-235.
40. *Shephard R. W.*: The sensitivity and specificity of single manual examination tests for detection of corpora lutea in the ovaries of non-cycling cows. Aust. Vet. J. 2005, 83, 572-566.
41. *Siatka K., Sawa A., Piwczyński D., Bogucki M., Krezel-Czopek S.*: Factors affecting first insemination success in Polish Holstein-Friesian cows. Anim. Sci. Pap. Rep. 2018, 36, 275-285.
42. *Vanholder T., Opsomer G., de Kruif A.*: Aetiology and pathogenesis of cystic ovarian follicles in dairy cattle: a review. Reprod. Nutr. Dev. 2006, 46, 105-119.
43. *Veerkamp R. F., Oldenbroek J. K., Van Der Gaast H. J., Van Der Werf J. H. J.*: Genetic correlation between days until start of luteal activity and milk yield, energy balance, and live weights. J. Dairy Sci. 2000, 83, 577-583.
44. *Vries A. de, Marcondes M. I.*: Review: Overview of factors affecting productive lifespan of dairy cows. Animal 2020, 14 (Suppl. 1), 155-164.
45. *Walsh R. B., Kelton D. F., Duffield T. F., Leslie K. E., Walton J. S., LeBlanc S. J.*: Prevalence and risk factors for postpartum anovulatory condition in dairy cows. J. Dairy Sci. 2007, 90, 315-324.
46. *Wiltbank M. C., Gümen A., Sartori R.*: Physiological classification of anovulatory conditions in cattle. Theriogenology 2002, 57, 21-52.
47. *Wiltbank M., Lopez H., Sartori R., Sangsritavong S., Gümen A.*: Changes in reproductive physiology of lactating dairy cows due to elevated steroid metabolism. Theriogenology 2006, 65, 17-29.
48. *Yániz J., Lopez-Gatius F., Bech-Sabat G., Garcia-Ispierto I., Serrano B., Santolaria P.*: Relationships between milk production, ovarian function and fertility in high-producing dairy herds in north-eastern Spain. Reprod. Domest. Anim. 2008, 43 (Suppl 4), 38-43.
49. *Zduńczyk S., Janowski T., Raś A., Barański W.*: Accuracy of ultrasonography and rectal palpation in the diagnosis of silent heat in cows compared to plasma progesterone concentration. Bull. Vet. Inst. Pulawy 2009, 53, 407-410.
50. *Zduńczyk S., Mwaanga E. S., Małecki-Tepicht J., Barański W., Janowski T.*: Plasma progesterone levels and clinical findings in dairy cows with post-partum anoestrus. Bull. Vet. Inst. Pulawy 2002, 46, 79-86.

Corresponding author: Wojciech Barański, Oczapowskiego 14, 10-719 Olsztyn, Poland; e-mail: wojbar@uwm.edu.pl