PREVALENCE OF ENDOPARASITES INFECTION IN FATTENERS DEPENDING ON MAINTENANCE SYSTEM AND SEASON

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Abstract. The study was conducted on four farms localized in Wielkopolska Province, Poland, leading an intense pigs farming in closed cycle (all production groups were housed on the farm). The fatteners were maintained in conventional indoor herds for the whole fattening period, and the farms did not lead organic farming. McMaster method was used for eggs isolation from feces, while flotation was applied in cysts diagnostics from feces.

The infection level of fatteners (n=320), kept on shallow and deep litter in the summer (July/August) and winter (January/February) period in 2013, was established. The occurrence of three varieties of parasites was observed: *Oesophagostomum* spp., *Ascaris suum* and one protozoan – *Balantidium coli*. The most abundant parasite was *Oesophagostomum* spp. The study also demonstrated an increased prevalence on the farms maintaining the animals on shallow litter as compared to deep one. Higher values of selected parasitological indices were noted in the summer (farm C shallow litter 62.5 %, 764 EPG; farm B shallow litter 50 %, 267.5 EPG) as compared to the winter period (farm C 35%, 194.4 EPG, farm B 40%, 215.6 EPG). *Ascaris suum* was the next nematode of the highest extensiveness, i.e. on the level of 20 %. The study also demonstrated the presence of *Ascaris suum* exclusively in two farms – B and C, on shallow litter. The rarest was protozoan *Balantidium coli.* It was isolated and identified only on one farm, during the summer on a shallow litter (12.5 % once 39 mean number of cyst per sample).

Keywords: endoparasites, maintenance system, season, fatteners

Introduction. Diagnostics in terms of parasites invasion in pigs is very rare in Poland, which results from lack of deworming obligation according to the rules of Common Agricultural Policy Reform implemented in the European Union countries. National prevention in the range of alimentary tract parasitic diseases is very often based only on treatment of clinical symptoms (Pejsak, 2007).

The parasites invasion in farm animals causes considerable economic losses related to a decreased feed intake and assimilation, animals performance, tissues damage and reduced daily gains (Kaarma and Mägi, 2001; Michalski, 2007). The intensity of helminthiasis in pigs is closely related to production system. The management manner, as well as production size and type, to a high degree determine the possibility of infections transmission, and, as a consequence, economic losses resulting from pigs helminthiasis (Knecht et al., 2011). The most common parasites observed in the case of pigs in conventional indoor breeding conditions in Poland are two nematodes, i.e. *Ascaris suum* and *Oesophagostomum* spp. In the study by Połozowski et al. (2005), 67.2 % of the population was infected with *Oesophagostomum* spp., while 39.7 % with *Ascaris suum*. The occurrence of *Strongyloides ransomi* and *Balantidium coli* is limited and very rare (Bartosik et al., 2012). In domestic conditions, the highest economic significance is attributed to *Ascaris suum*, *Oesophagostomum* spp., *Trichuris suis*, *Strongyloides ransomi* and the invasions of *Isospora* and *Eimeria* genus coccidia (Nosal et al., 2001).

Eimeriosis is very often noted in the research, and this disease may cause considerable economic losses, even in the case of its subclinical course (Daugschies et al., 1999). *Coccidiosis* is an invasive disease, which in production conditions concerns especially piglets maintained in the piggeries of low zoohygienic standards (high humidity) (Pejsak, 2007).

The season is a significant factor in infection degree evaluation in pig herds, since *Oesophagostomum* spp. (having shorter incubation period) can infect the host faster in case of temperature growth, and is earlier observed in feces. This phenomenon was noticed by Roepstorff et al. (1998), who observed that temperature growth during the summer period causes a mass development of larvae accumulated during the winter. Rarer occurrence of *Ascaris suum* is related to longer embryogenesis and eggs maturation periods.

Low prevalence and mean eggs number per gram of feces may result from a susceptibility of invasive larvae of *Strongyloides ransomi* to the activity of sunshine, low temperature and drying up (Pejsak, 2007).

The high extensiveness in case of *Ascaris suum* results from long-lasting area contamination without preventive activities, which would allow accumulation of eggs (Jolie et al., 1998).

Longevity of invasive eggs in normal conditions of production environment and resistance on disinfection means are the problems in combating *Ascaris suum* (Nosal, 1996). In Norway, the increase in *Ascaris suum* infection extensiveness is also related to cleaning and creation of better conditions for parasites development (increased humidity in the building) as well as mechanical eggs transfer (Roepstorff and Nansen, 1994).

The conducted study determined the presence of alimentary tract parasites in fatteners on four farms depending on maintenance system and season.

Material and methods. The study was conducted on 320 fatteners from 4 farms localized in Wielkopolska Province during the two seasons: summer (July/August) and winter (January/February) in 2013. The selected farms focus on an intense production of fatteners. The annual production is on the level of 600 heads. The size of the foundation stock is about 30 sows in all analyzed sites. Natural mating system is applied on all the farms. The fatteners were fed ad libitum with complete mixture. The fattening lasted until the pigs reached the body weight of 105–110 kg, and the age of about 5–6 months. The experimental animals were kept in comparable microclimatic conditions and were treated in a comparable manner. The animals on the farms had no access to the yards, and deratisation was not conducted. The study also included the characteristics of farms with respect to: a) fatteners breed/genotype, b) kind of maintenance system, c) frequency of manure removing, d) frequency of hoggery disinfection, d) number of animals in a pen (Table 1).

Table 1. **Parameters characterizing fatteners' maintenance on selected farms**

Feature	Farm A	Farm B	Farm C	Farm D
Breed/Genotype	PL	PLW × PL	PL	PLW × PL
Kind of maintenance system	shallow litter	deep litter	deep litter	shallow litter
Frequency of manure removing	once a day	after 50 days - fattening period	after 75 days - fattening period	once a day
Disinfection frequency	-	after fattening period	after fattening period	-
Number of animals in a pen	20	40	42	25
Description: PLW – Polish Large White; PLW × PL – crossbreeds of Polish Large White and Polish Landrace; PL – Polish Landrace				

Eighty fecal samples were collected on each farm (40 during summer, 40 during winter). The samples were taken from the ground immediately after animals defecation, collected sample size was approximately 10 g of fresh feces. Acquired sample was placed in a test tube with 10% formalin solution to protect the harvested material.

Quantitative method with McMaster chambers application and preliminary feces purification was used for eggs detection and isolation from feces. Lumps of feces weighing 3 g were poured with 42 ml of water and homogenized. Next, the liquid was poured through a sieve to centrifuge test tubes. The precipitate from the sieve was removed, and the liquid was centrifuged for 2 minutes at 1500 rpm. Then the liquid was poured, and 45 ml of NaCl was added to the remaining precipitate. The liquid was then mixed carefully and the chambers were filled. The specimen prepared in this way was examined under Nikon Eclipse E100 light microscope, and the eggs in both chamber fields were counted according to the following formula (Gundłach and Sadzikowski, 2004):

The number of eggs (oocysts) per 1 g of feces = (the number of eggs (oocysts) in both fields of McMaster chamber/2) x 100

Flotation method for detection and isolation of cysts from feces was performed concurrently in order to eliminate potential low infestation. Feces lump was poured with saturated NaCl solution (350g salt per 1 L of water), mixed until homogenous suspension was obtained, and poured through the sieve and funnel to the test tube until convex meniscus was obtained. A cover slip was placed on liquid surface and left for 20 minutes. After that, the cover slip was transferred on a microscope slide and examined (Gundłach and Sadzikowski, 2004).

The eggs found were identified according to their morphology (shape, sheath structure, number and size of blastomeres or larvae presence) and biometry. The identification was done using reports of Thienpont et al. (1986) and Zajac and Conboy (2006). In order to assess the degree of internal parasites infection in pigs, the following parasitological indices were used: prevalence of infection (the ratio of positive samples number to analyzed ones), mean eggs number in 1 gram of feces (EPG) and mean number of cyst per sample. The significance of differences in the degree of parasites invasion on particular farms was determined using Pearson's chi-square test. The normality of distribution was analyzed using Shapiro-Wilk test. The significance level of 0.05 was accepted in statistical tests, and the calculations were done using PASW Statistics 7.0 EN software.

Results. As a result of the study conducted, the two nematodes and one protozoan were identified and isolated (*Ascaris suum*, *Oesophagostomum* spp. and *Balantidium coli*) (Table 2).

The presence of *Oesophagostomum* spp. was demonstrated on all the farms. The highest prevalence was noted on farm C – *Oesophagostomum* spp. 62.5 % (mean eggs number in a sample 764 EPG). The lowest value of that parameter was observed on farm A – 7.5 % (mean eggs number 83.3 EPG). The extensiveness of infection with *Oesophagostomum* spp. was higher during the summer as compared to the winter. *Ascaris suum* was isolated and identified only on two farms. The extensiveness of infection during the summer was higher on farm B – 15 % (mean eggs number 116.7 EPG) as compared to farm C – 12.5 % (90 EPG). During the winter, that nematode was observed only on farm B – 20

% (162.5 EPG). The most rarely present parasite was *Balantidium coli* ciliate that was identified only during the summer period on farm D (prevalence 12.5 % (39 – mean number of cysts per sample). The extensiveness of infection in all the farms was higher during the summer as compared to the winter. During the summer season, three parasites, i.e. *Oesophagostomum* spp., *Ascaris suum* and protozoan *Balantidium coli,* were isolated and identified, while during the winter period *Balantidium coli* presence was not observed. The infections with all nematodes were observed on farm C and that was reflected in the prevalence value that was the highest in the analyzed population – 55 % (Table 3). The lowest number of parasites was observed on farm A – prevalence 5 %. The extensiveness of parasitic invasion or parasitic invasion for all the farms was 31.3 %.

Table 2. **Frequency of parasites occurrence on farms depending on the season**

Farm	Season	Specification		*Ascaris suum*	*Oesophagostomum* spp.	*Balantidum coli*	Total
A	Summer (n=40)	%		nd	7.5	no	7.5
		EPG	mean ± SD	nd	83.3 ± 57.7	no	83.3 ± 57.7
			Me (x_{min}–x_{max})	nd	50 (50–150)	no	50 (50–150)
	Winter (n=40)	%		nd	2.5	no	2.5
		EPG	mean ± SD	nd	50.0	no	50.0
			Me (x_{min}–x_{max})	nd	50	no	50
B	Summer (n=40)	%		15.0	50.0	no	57.5
		EPG	mean ± SD	116.7 ± 68.3	267.5 ± 288.0	no	263.0 ± 283.7
			Me (x_{min}–x_{max})	100 (50–200)	175 (50–1100)	no	200 (50–1200)
	Winter (n=40)	%		20.0	40.0	no	50.0
		EPG	mean ± SD	162.5 ± 240.2	215.6 ± 163.0	no	237.5 ± 275.2
			Me (x_{min}–x_{max})	75 (50–750)	150 (50–550)	no	150 (50–1250)
C	Summer (n=40)	%		12.5	62.5	12.5	75.0
		EPG	mean ± SD	90.0 ± 65.2	764.0 ± 634.0	39.0 ± 26.2 *	-
			Me (x_{min}–x_{max})	50 (50–200)	700 (50–3200)	40.0 (5–75) *	-
	Winter (n=40)	%		nd	35.0	no	35.0
		EPG	mean ± SD	nd	196.4 ± 111.7	no	196.4 ± 111.7
			Me (x_{min}–x_{max})	nd	175 (50–450)	no	175 (50–450)
D	Summer (n=40)	%		nd	12.5	no	12.5
		EPG	mean ± SD	nd	120.0 ± 103.7	no	120.0 ± 103.7
			Me (x_{min}–x_{max})	nd	100 (50–300)	no	100 (50–300)
	Winter (n=40)	%		nd	10.0	no	10.0
		EPG	mean ± SD	nd	75.0 ± 28.9	no	75.0 ± 28.9
			Me (x_{min}–x_{max})	nd	75 (50–100)	no	75 (50–100)

Description: % – prevalence of infection; EPG – number of eggs per 1 gram of faeces; * number of cysts per sample; SD – standard deviation; Me – median (together with minimum and maximum values); n – number of samples examined; nd – not detected; no – no cysts were detected in a given sample

Table 3. **Prevalence of parasites on selected farms**

Farms	Maintenance system	Prevalence (%)
A (n=80)	deep litter	5.0
B (n=80)	shallow litter	53.8
C (n=80)	shallow litter	55.0
D (n=80)	deep litter	11.3
Total (n=320)		31.3

Description: n – number of samples examined

The most abundant parasite was *Oesophagstomum* spp. (Figs 1 and 2). The study demonstrated higher prevalence and average number of eggs (EPG) on farms keeping the animals on shallow litter as compared to deep one. Also higher values of selected parasitological indices were noted in the summer (farm C shallow litter – 62.5 %, 764 EPG; farm B shallow litter – 50 %, 267.5 EPG) as compared to the winter period (farm C – 35 %, 194.4 EPG, farm B – 40 %, 215.6 EPG).

Next nematode of the highest extensiveness on the level of 20 % was *Ascaris suum*. The study demonstrated the presence of *Ascaris suum* exclusively on two farms – B and C, on shallow litter (Figs 3 and 4). The highest mean number of eggs was observed on farm B during the winter (20 %, 162.5 EPG), while the lowest value was noted during the summer on farm C (12.5 %, 90 EPG).

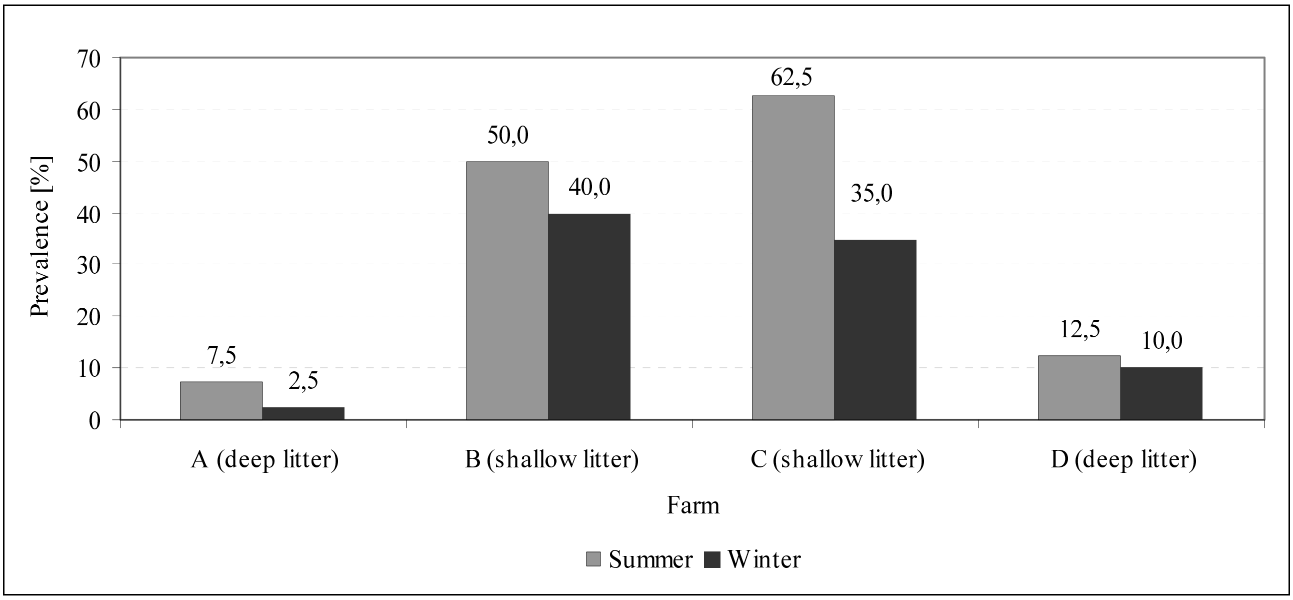

Fig. 1. **Prevalence of *Oesophagostomum* spp. infection in fatteners depending on maintenance system and season**

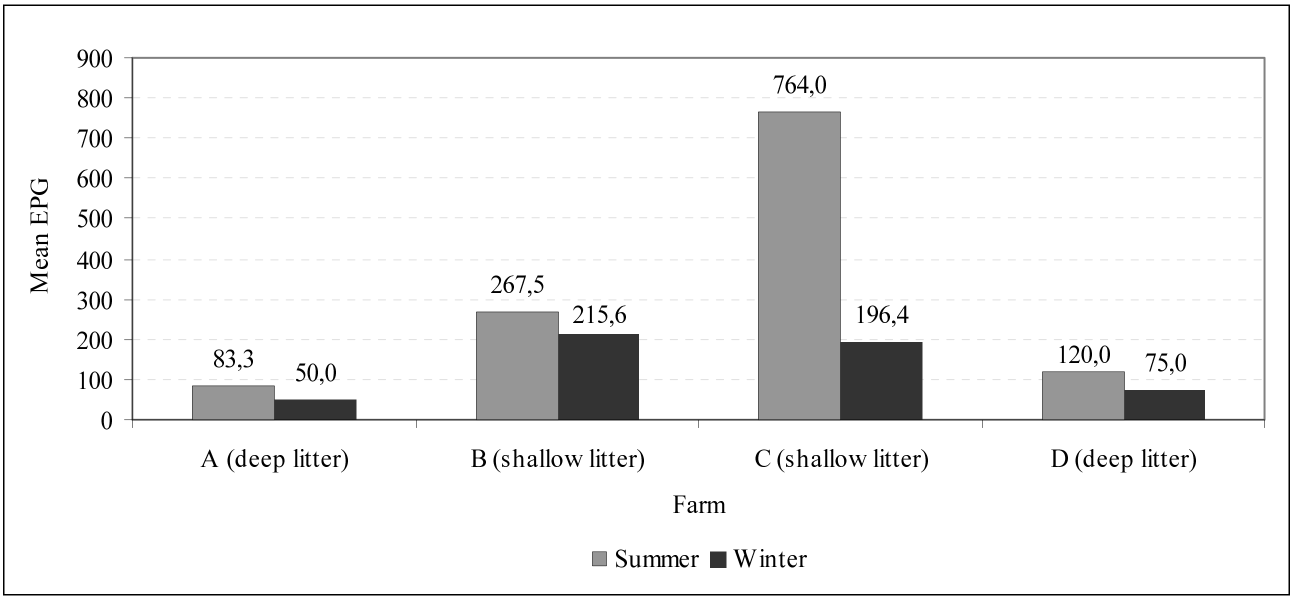

Fig. 2. **Mean number of *Oesophagostomum* spp. eggs in the sample depending on maintenance system and season**

Balantidium coli was the rarest alimentary tract parasite, it was isolated and identified only on one farm during the summer on shallow litter (12.5 %, 39 mean number of cysts per sample). The level of parasites invasion on the analyzed farms in two maintenance systems (shallow and deep litter) during the summer and winter, measured by infection prevalence, appeared to be significant statistically and was confirmed by Pearson's chi-square test for summer (χ^2=53.651; d=1; p=2.394*10^{-13}) and for winter (χ^2=28.515; d=1; p=9.3*10^{-8}), respectively.

Discussion. Połozowski et al. (2005) analyzing 11 farms from Wielkopolska region confirmed the presence of *Oesophagostomum* spp. and *Acaris suum* in fatteners. The presence of *Oesophagostomum* spp. was dominant in the study, while *Acaris suum* was observed only in 7.1 % of animals. *Balantidium coli* was not identified. Similar results were obtained by Järvis and Mägi (2008) who analyzed 8 farms (size from 13 to 87 pigs in foundation stock). They demonstrated the presence of nematodes that were isolated and identified in the present study, i.e. *Oesophagostomum* spp. with prevalence of 74 %, and *Acaris suum* on a level of 48 %.

The study by Knecht et al. (2011, 2012) conducted on fatteners also demonstrated the presence of *Oesophagostomum* spp., *Ascaris suum*. Moreover, the authors also observed the presence of *Strongyloides ransomi*.

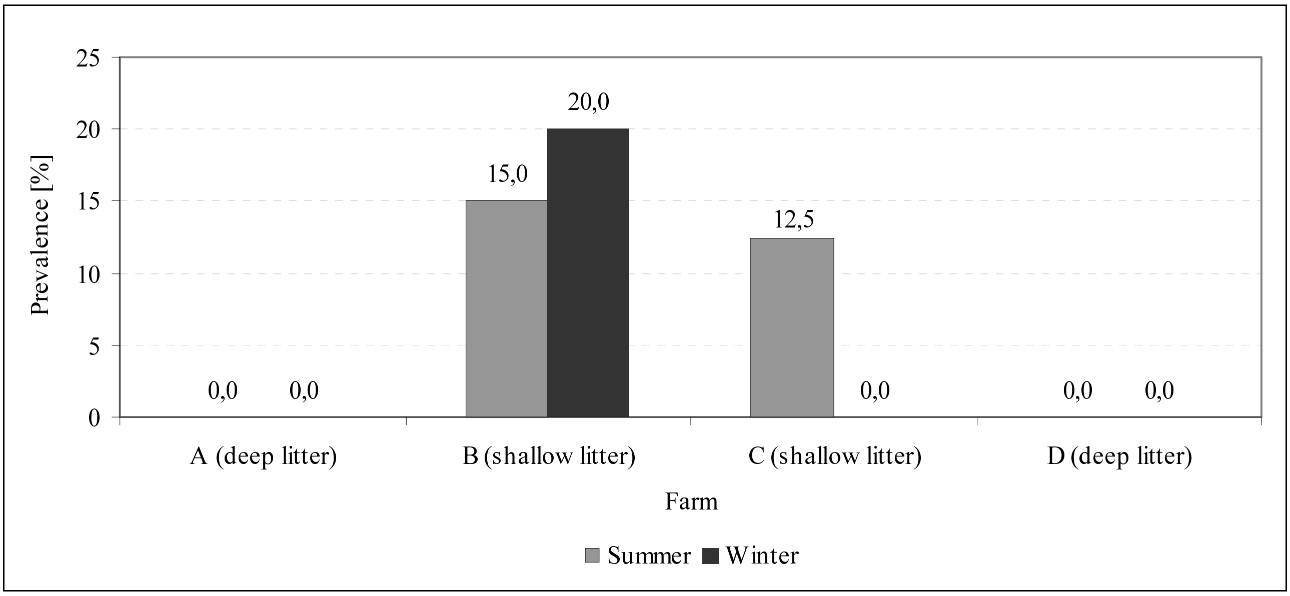

Fig. 3. **Prevalence of *Ascaris suum* infection in fatteners depending on maintenance system and season**

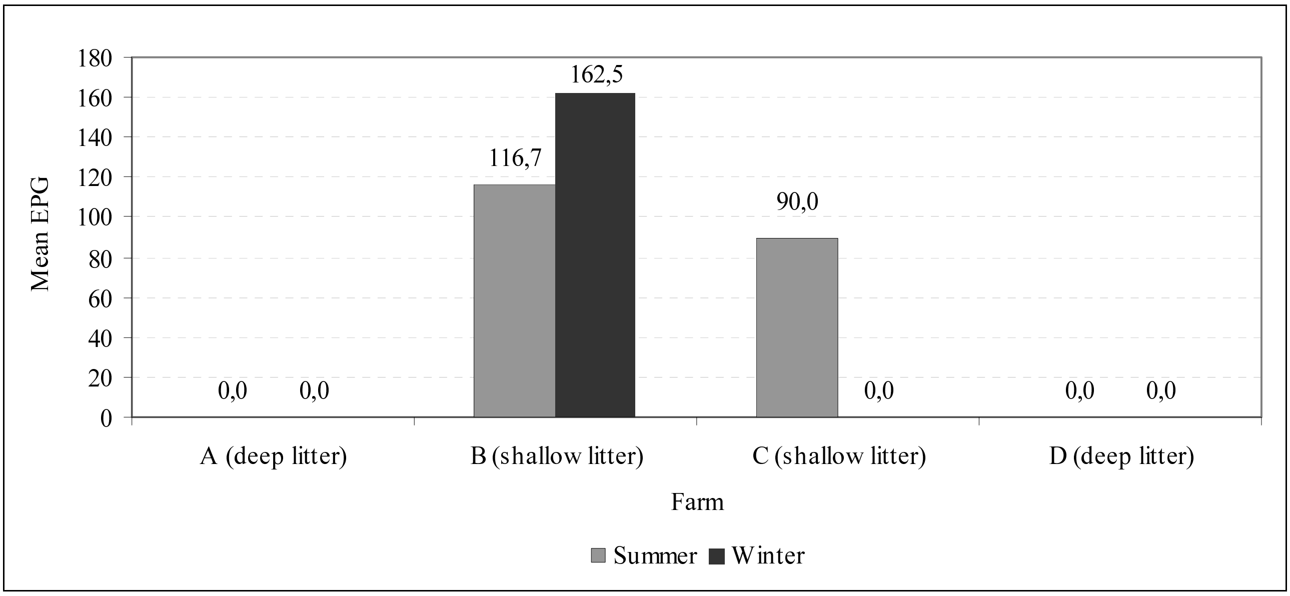

Fig. 4. **Mean number of *Ascaris suum* eggs in the sample depending on maintenance system and season**

Roepstorff and Nansen (1994) claim that application of antiparasitic drugs should not be the only preventive procedure. Their application in intensive indoor herds should be integrated with management and production system in order to achieve optimum effect and to avoid resistance against nematodes.

Nansen and Roepstorff (1999) demonstrated that genus and species differentiation among pig parasites is lower due to the change from pigs housing in backyard system (access to the yards) on an intensive indoor farming. The authors also observed that piglets infested with *Strongyloides ransomi* are resistant on re-invasion after they had been ill. Unlike in the case of *Oesophagostomum* spp., its occurrence may be observed more often in older animals, which may be a reason of lower immunogenicity of this species (Thamsborg et al., 1999).

Higher extensiveness of nematode *Oesophagostomum* spp., on the level of 20–100 %, was demonstrated in the study on Danish pigs population (Nwoha and Ekwurike, 2011).

The most frequent presence of *Oesophagostomum* spp. was also observed in the study by Knecht et al. (2009) who noted the highest prevalence of that nematode species – 20 %. This nematode was also predominant over *Ascaris suum* in the study conducted by Nosal and Eckert (2005). More frequent occurrence of that species results from drug resistance observed in *Oesophagostomum* spp. In the study conducted in other countries, the highest prevalence of *Oesophagostomum* spp. over *Ascaris suum* was also noted. Joachim et al. (2001) demonstrated the same species diversity in the research on fatteners (prevalence for *Oesophagostomum* spp. – 27.5 % while for *Ascaris suum* - 10.5 %), and also Beloeil et al. (2003) observed the most frequent occurrence of *Oesophagostomum* spp. in the analysed population (mean eggs number in 1 g was 400). Different results were presented by Carstensen et al. (2002); *Oesophagostomum* spp. was the second parasite observed in fatteners population (14 %). The authors observed however the relationship between the presence of that parasite and season. They demonstrated seasonal effect on the prevalence of parasites in fatteners ($P<0.0001$) (Carstensen et al., 2002). The fatteners kept on shallow litter were characterized by higher prevalence for *Oesophagostomum* spp. as compared to animals kept on deep litter. The traditional system of shallow litter farming requires an everyday (or periodical) removing of polluted litter and an introducing of new one. That system is characterized by high humidity and low temperature in a hoggery as compared to deep litter system (Kozera et al., 2009). These factors may affect the hygienic state both of bedding and animals, and may considerably increase the values of selected parasitological indices in the analyzed hoggeries. The system of deep litter maintenance is considered as an ecological maintenance method and involves the periodical addition of litter according to the needs. The maintenance of fatteners on the so called bio-beddings increases animals thermal comfort (pigs kept in such environmental conditions are characterized by higher resistance and health status) (Klocek et al., 2008), that may affect the extensiveness of parasites occurrence in the analyzed population.

Fatteners maintained on deep litter demonstrated lower infestation level compared to the animals maintained on a shallow litter. Romaniuk (1979) observed that in an initial period of maintenance on deep litter, the bedding favors pigs infestation and only after a few weeks, when suitable manure amount is accumulated, it starts to destroy parasites development forms.

Roepstorff and Jorsal (1990) noted that *Oesophagostomum* spp. presence both in sows and fatteners is significantly higher in hoggeries with litter bedding. Also *Strongyloides ransomi* may develop in this kind of systems (Murrell, 1986). Ziomko (1998) mentioned lower extensiveness of *Ascaris suum* occurrence in modern hoggeries (grate).

Another nematode characterized by the highest extensification was *Ascaris suum*. The presence of *Ascaris suum* was also observed in the study conducted by Eijck and Borgsteede (2005). The presence of that parasite was noted in 21 % of pigs from free-range farming and only in 3.22 % of pigs from traditional farming system. *Ascaris suum* was also observed by Popiołek et al. (2009) who analyzed parasites infection in pigs on two farms. The prevalence of that species was the second, both on farm A and B, and it was 3.57 % and 6.45 %, respectively. With invasion intensity of *Ascaris suum* exceeding the level of 1350 EPG, strong diarrhea may be observed in animals, leading to dehydration of the organism and significantly affecting some morphological blood parameters (Wieczorek et al., 2006). Quite different results were presented by Haugegaard (2010). They demonstrated the presence of *Oesophagostomum* spp. in 15 %, while *Ascaris suum* in 76 % – mean egg number was on the level of 1651 EPG. The presented values were higher as compared to the population analyzed in the present research. The highest presence of *Ascaris suum* was observed in the study by Carstensen et al. (2002), and that was the parasite that occurred the most often in the analyzed population. The prevalence in fatteners was on the level of 18–50 %. The authors also observed the seasonal effect on the occurrence extent of this nematode and the interaction between the factors discussed. The conditions in two farming systems affect the presence of *Ascaris suum*. The study by Paluszak et al. (2003) also confirms such a relationship. The authors suggested that the temperature above 55 ºC observed in biomass stored, leads to eggs inactivation in external layer of deep litter with daily eggs loss of 1.27 %. *Balantidium coli* rarest parasite is common in this population but its prevalence is different all over the world: 47.2 % in China, 25 % in Iran (among wild boars), 33.3 % in Venezuela and 55.1 % in the United States (Solaymani-Mohammadi et al., 2006). Common presence of *B. coli*, i.e. even in 57 % of the population, was observed in Danish study. Fatteners and pigs up to the age of one year are usually infected. The presence of *Balantidium coli* in the study is lower as compared to other parasites invasions (Schuster and Ramirez-Avila, 2008). The study by Hassan et al. (2010) demonstrated the presence of that ciliate in 88 samples (64.7%). The obtained results demonstrate that ciliate is commonly present on the farms, and thus the index of infection of people staying with animals may be high. Seasonal changeability of parasites infection may be related to animal age and maintenance system. Roepstorff (1991) also demonstrated the relationship between infection extensiveness and mean eggs number. The highest infection, like in the present study, was observed for *Oesophagostomum* spp. and *Ascaris suum* during the summer. *Oesophagostomum* spp. (having shorter incubation time) infects the host faster with an increase of the temperature, and is quicker observed in coproscopic samples. That phenomenon was observed Roepstorff et al. (1998) who noted that the temperature increase during the summer causes a mass development of eggs accumulated during winter. Rarer presence of *Ascaris suum* is connected to longer embryogenesis period and eggs maturation to invasive stage.

Conclusions

1. The study demonstrated the presence of two nematodes and one species of protozoan (*Oesophagostomum* spp., *Ascaris suum, Balantidium coli*). The extensiveness of infection on all the farms was higher during the summer as compared to the winter. Three parasites, i.e. *Oesophagostomum* spp., *Ascaris suum* and *Balantidium coli*, were isolated and indentified in the summer season, while the presence of *Balantidium coli* was not observed during the winter.

2. The highest prevalence of 62.5 % was noted for *Oesophagostomum* spp., and lower for *Ascaris suum* 20.0 %. The rarest occurring parasite was *Balantidium coli*

with prevalence of 12.5 %.

3. Fatteners kept on shallow litter were characterized by higher prevalence as compared to animals kept on deep litter.

4. The level of parasites invasion on examined farms in two maintenance systems (shallow and deep litter) during the summer and winter, measured by prevalence, was significantly differentiated for the summer (χ^2=53.651; d=1; p=2.394*10^{-13}) and winter season (χ^2=28.515; d=1; p=9.3*10^{-8}).

References

1. Bartosik J., Górski P., Batorska M., Tokarska G., Klockiewicz M. Ekstensywność i intensywność występowania pasożytów jelitowych u świń w gospodarstwie stosującym program profilaktyczny. Roczniki Naukowe Polskiego Towarzystwa Zootechnicznego. 2012. 8(3). P. 45–53.

2. Beloeil P. A., Chauvin C., Fablet C., Jolly J. P., Eveno E., Madec F., Reperant J. M. Helminth control practices and infections in growing pigs in France. Livestock Production Science. 2003. 81. P. 99–104.

3. Carstensen L., Vaarst M., Roepstorff A. Helminth infections In Danish organic swine herds. Veterinary Parasitology. 2002. 106. P. 253–264.

4. Daugschies A., Imarom S., Bollwahn W. Differentiation of porcine *Eimeria* spp. by morphologic algorithms. Veterinary Parasitology. 1999. 81(3). P. 201–210.

5. Eijck I. A .J. M., Borgsteede F. H. M. A. Survey of Gastrointestinal Pig Parasites on Free-range, Organic and Conventional Pig Farms in the Netherlands. Veterinary Research Communication. 2005. 29. P. 407–414.

6. Gundłach J. L., Sadzikowski A. B. Parazytologia i parazytozy zwierząt. Warszawa. PWRiL. 2004. P. 425–429.

7. Hassan A. I. A. H., Hyung-Kyu J., Yu Y., Changhee N., Young-Ha L. Intestinal parasite infections in pigs and beef cattle in rural areas of Chungcheongnam-do Korea. Korean Journal Parasitology. 2010. 48(4). P. 347–349.

8. Haugegaard J. Prevalence of nematodes in Danish industrialized sow farms with loose housed sows in dynamic groups. Veterinary Parasitology. 2010. 168. P. 156–159.

9. Järvis T., Mägi E. Pig ednoparasites In Estonia. Veterinarmedicinas Raksti. 2008. P. 54–58.

10. Joachim A., Dülmer N., Daugschies A., Roepstorff A. Occurrence of helminths in pig fattening units with different management systems in Northern Germany. Veterinary Parasitology. 2001. 96. P. 135–146.

11. Jolie R., Bäckström L., Pickney R., Olson L. Ascarid infection and respiratory health in feeder pigs raised on pasture or in confinement. Swine Health and Production. 1998. 6. P. 115–120.

12. Kaarma A., Mägi E. Some epizootological features of pig nematodoses in Estonia. Journal Agriculture Science. 2001. 12. P. 93–99.

13. Klocek Cz., Madej T., Mielczarek A. Obserwacje zachowania się tuczników utrzymanych w dwóch rodzajach kojców ściołowych. Acta Scientiarum Polonorum. 2008. 7(3–4). P. 35–44.

14. Knecht D., Jankowska A., Zaleśny G. The impact of gastrointestinal parasites infection on slaughter efficiency in pigs. Veterinary Parasitology. 2012. 184. P. 291–297.

15. Knecht D., Popiołek M., Jankowska A. Poziom zarażenia pasożytami wewnętrznymi świń w gospodarstwie drobnotowarowym. Zeszyty Naukowe UP we Wrocławiu Zootechnika. 2009. 575. P. 149–156.

16. Knecht D., Popiołek M., Zaleśny G. Does meatiness of pigs depend on the level of gastro-intestinal parasites infection? Preventive Veterinary Medicine. 2011. 99. P. 234–239.

17. Kozera W., Karpiesiuk K., Falkowski J. Wpływ systemu utrzymania i żywienia na behawior rosnących świń. Acta Scientiarum Polonorum. 2009. 8(4). P. 21–32.

18. Michalski M. Straty ekonomiczne powodowane inwazjami pasożytniczymi u zwierząt i sposoby ich wyceny. Medycyna Weterynaryjna. 2007. 63(6). P. 643–647.

19. Murrell K. D. Epidemiology, pathogenesis, and control of major swine helminth parasites. Food Animal Practice. 1986. 2. P. 439–454.

20. Nansen P., Roepstorff A. Parasitic helminths of the pig: factors influencing transmission and infection levels. International Journal for Parasitology. 1999. 29. P. 877–891.

21. Nosal P. Profilaktyka i stosowane metody zwalczania robaczyc u świń. Przegląd Hodowlany. 1996. 2. P. 11–13.

22. Nosal P., Eckert R. Pasożyty przewodu pokarmowego w zależności od wieku i warunków produkcyjnych. Medycyna Weterynaryjna. 2005. 61(4). P. 435–437.

23. Nosal P. The influence of intestinal nematode infection on the productivity of gilts at pig testing stations. Wiadomości Parazytologiczne. 2001. 47(4). P. 675–680.

24. Nwoha R. I. O., Ekwurike J. O. Prevalence of gastrointestinal nematode parasites in intensively managed pigs of different ages and sexes in Umuahia city of Abia State. International Research Journal of Biochemistry and Bioinformatics. 2011. 1(6). P. 161–167.

25. Paluszak Z., Ligocka A., Olszewska H. Inaktywacja jaj *Ascaris suum* w kompostowych osadach pościekowych. Medycyna Weteterynaryjna. 2003. 59(2). P. 154–156.

26. Pejsak, Z., Ochrona zdrowia świń. PWR. Poznań. 2007. P. 398–435.

27. Połozowski A., Zieliński J., Zielińska E. Influence of breed conditions of breed conditions on presence of internal parasites in swine in small- scale management. Electronic Journal of Polish Agricultural Universities Veterinary Medicine. 2005. 8(1). P. 15.

28. Popiołek M., Knecht D., Boruta O., Kot M. Effect if breeding conditions, phenology, and age on the occurence of helminths in pigs. Bulletin of the Veterinary Institute in Pulawy. 2009. 2. P. 213–220.

29. Roepstorff A. Transmission of intestinal helminths in Danish sow herds. Veterinary Parasitology. 1991. 39. P. 149–160.

30. Roepstorff A., Jorsal S. E. Relationship of the prevalence of swine helminthes to management practices and anthelmintic treatment in Danish sow herds. Veterinary Parasitology. 1990. 36. P. 245–257.

31. Roepstorff A., Nansen P. Epidemiology and control of helminth infections in pigs under intensive and non-intensive production systems. Veterinary Parasitology. 1994. 54(1–3). P. 69– 85.

32. Roepstorff A., Nilsson O., Oksanen A., Gjerde B., Richter S. H., Őrtenberg E., Christenson D., Martinsson K. B., Bartlett P. C., Nansen P., Eriksen L., Helle O., Nikander S., Larsen K. Intentinal parasites In swine in the Nordic countries: prevalence and geografical distribution. Veterinary Parasitology. 1998. 76. P. 305–319.

33. Romaniuk K. Występowanie chorób inwazyjnych świń zależnie od technologii chowu. Wiadomości Parazytologiczne. 1979. 1. P. 7–9.

34. Schuster F. L., Ramirez-Avila L. Current World Status of *Balantidium coli*. Clinical Microbiology Reviews. 2008. 21(4). P. 626–638.

35. Solaymani-Mohammadi S., Jr W., Petri A. Zoonotic implications of the swine-transmitted protozoal infections. Veterinary Parasitology. 2006. 140. P. 189–203.

36. Thamsborg S. M., Roepstorff A., Larsen M. Integrated and biological control of parasites in organic and conventional production systems. Veterinary Parasitology. 1999. 84. P. 169–186.

37. Thienpont D., Rochette F., Vanparijs O. F. J. Diagnosing helminthiasis by coprological examination. Jannsen Research Foundation. Beerse. 1986. P. 1–187.

38. Wieczorek M., Balicka-Ramisz A., Pilarczyk B., Tomza A. Wpływ inwazji pasożytniczej na parametry hematologiczne krwi u świń. Acta Scientiarum Polonorum. 2006. 5(1). P. 129–136.

39. Zajac A. M., Conboy G. A. Veterinary Clinical Parasitology. New York. USA. 2006. P. 1–368.

40. Ziomko I. Problemy pasożytnicze w różnych grupach wiekowych świń i typach hodowli. Trzoda Chlewna. 1998. 5. P. 81–85.

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