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Original papers

Parasites of the digestive tract in cows managed in alternative (organic and biodynamic) as well as conventional farms in West Pomerania

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ABSTRACT. The aim of the study was to determine the species composition, prevalence and intensity of parasitic enteric infections in cows in relation to farm management system. Prevalence of gastrointestinal nematodes and *Eimeria* protozoans was determined from coproscopic examinations using Willis-Schlaf flotation. The species composition of coccidia was determined from morphological characters and the time of oocyst sporulation. Fluke liver eggs were detected by decantation. The average rates of parasitic infections were 67.42%, in the biodynamic farm, 62.14%, in the organic farms, and 63.26%, in the conventional cattle farm. Cows managed in the biodynamic farm suffered from infections by *Eimeria* protozoans and gastrointestinal nematodes, whereas *Eimeria*, gastrointestinal nematodes and *Moniezia* sp. were found in the organic farms. In cows of the conventional farm, we found *Eimeria*, gastrointestinal nematodes, *Moniezia* sp. and trematodes: *Fasciola hepatica* and *Paramphistomum* sp. The average intensity of *Eimeria* sp. infection in cows by farming system was as follows: 71 OPG (oocysts per gram of feces) in the biodynamic farm, 57 OPG in the organic farm and 71 OPG in the conventional farm. The mean intensity of gastrointestinal parasites was 290 EPG (eggs per gram feces) in the biodynamic farm, 455 EPG in the organic farm, and 228 EPG in the conventional farm. The average *Moniezia* infection intensity in cows was 125 EPG, in the organic farm, and 50 EPG (eggs per gram feces), in the conventional farm. It is noteworthy that the intensity of gastrointestinal nematode infection of cows in the biodynamic farm was very low (290 EPG) despite a high prevalence of infection (67.42%). A similar situation though was found in the cows managed in the conventional way.

Keywords: gastrointestinal parasites, cows, biodynamic farm, organic farm, conventional farm

Introduction

The problem of parasitic diseases affecting cattle herds persists. Massive endoparasite infections cause gastrointestinal disorders, which deteriorates both the productivity (lower body weights, reduced milk yields) and animal welfare, and – if untreated – may lead to emaciation, asthenia or even death of the animal [1–6]. Control measures against gastrointestinal parasites include administration of antiparasitics, pasture hygiene, rotational grazing and effective disinfection of cowshed and farm equipment. Possible deworming should be preceded by feces examinations for parasites (analysis of species composition, prevalence and intensity of infection). The action taken should be examined for effectiveness afterwards. Medications represent a quick and effective method of parasite control; however, some management system do not accept chemical treatments, hence an analysis of species composition, prevalence and intensity of endoparasitic infections is so important. Cows, however – no matter how well managed and cared for – are always susceptible to parasitic infections.

In recent years, alternative agriculture methods have grown in popularity in Europe and world-wide.

This may be a result of either numerous food security scandals we have faced over the recent decades (for example, the BSE threat, food contaminants such as dioxins, mycotoxins and pesticides, or the “salt scandal”) or just arises from a better health and ecological awareness of the consumers. More and more people believe that consumption of organically produced foods is the cheapest form of disease prevention and health maintenance. Organic farming is commonly associated with both healthy, high-quality produce and a high level of animal welfare (large cowsheds, access to paddocks and pastures, etc).

Currently, three forms of farming styles are distinguished in the agricultural space:

– organic farming – alternative farming system of sustainable agriculture based on traditional methods,

– “biodynamic” farming – alternative agriculture methods based on occult and dogmatic assumptions rather than on agricultural experiments, questionable in terms of alternative or sustainable agriculture development [7],

– conventional farming – industrial cattle management systems which accept the use of medications, e.g. deworming agents.

Organic farming is an agricultural management system which tends to achieve a balance between the animal and plant production, i.e. all the resources necessary for growing crops (organic fertilizers) and raising animals (feeds) are produced within the farm. No chemical fertilizers or pesticides are used, hence this method is often perceived as more environment friendly compared to industrial farming [8,9].

Biological dynamic farms use on-farm produced manure compounds. Various types of organic wastes are added to the manure before composting, including special farm-made biodynamic “preparations”, which are also used for crop protection. Ideally, cattle stocking density is one cow per one hectare of land. The choice when to plant, cultivate, and harvest the crops depends on the so-called “biodynamic calendar”, which takes into account the phases of the moon, solar activity, and the position of planets [7].

Conventional animal farms are focused on maximizing profit, which is attained through high yields of crop and animal production. High levels of productivity are achieved by using industrial technologies which require a relatively low level of labor input [10].

There are very few articles in the available literature dealing with parasitic fauna in the cattle managed on organic farms. An important element of cattle health care, regardless of the management system, is the monitoring of parasitic diseases [11]. The aim of the study was to determine the species composition, prevalence and intensity gastro-intestinal tract parasitic infection in cows in relation to the management system.

Materials and Methods

Coprological examinations were carried out in three alternative farms (two organic and one biodynamic) and a conventional farm, all located in West Pomerania, Poland, during grazing.

The biodynamic farm has held an organic agriculture certificate since, and since 2004 the farm has been applying the procedures of the so-called “biodynamic agriculture”. Animal management in such a style aims at longevity of the cows, with emphasis on health and long-term production of milk. The cowsheds are partly open, one of the walls removed, opening to a roofed feeding area and a partly roofless yard. The buildings contain a rest zone (free stalls) and a feeding zone (yard with bile feeders). The free stalls are littered with a mixture of manure, straw, sawdust and lime, fresh straw being replenished daily. Milking cows are fed hay plus concentrate (oats, wheat, lupine, maize) with feed additives (minerals, salt, yeast). Hay is fed ad libitum, concentrate twice a day after milking in an amount depending on lactation stage and milk yield. In the summer, cows graze on pastures. In all, 65 stool samples were collected in the biodynamic farm (34 samples from Brown Swiss and 31 from Holstein-Friesian cows).

The analyzed organic farms possess the certificate of organic agriculture. Both farms have free-stall barns, with pasture grazing applied in summer. Free-stalls littered with straw. The feeding is based on farm-produced feeds, green forage in summer and meadow-grass silage plus hay and concentrate in winters. All roughage and concentrate feeds are produced from own crops. We collected 29 stool samples from both organic farms, 14 samples from farm A and 15 from farm B.

The conventional farm manages HF cows, from which 49 feces samples were collected. The animals graze on pastures during the season, winter feeding comprises maize silage, haylage and concentrates. Veterinary care is applied occasionally, usually

Table 1. Mean gastrointestinal parasite infection prevalence (%) in cows by parasite and farm type

	Type of farm							
	Biodynamic			Organic			Conventional	Test
	BS	H-F	Mean	A	B	Mean	H-F	
Total	73.53	61.29	67.41	64.28	60.0	62.14	63.26	χ^2=1.14; P=0.57
Eimeria sp.	45.71	40.00	42.86	42.86	50.00	46.43	24.49	χ^2=4.63; P=0.10
Gastrointestinal nematodes	73.57	61.29	67.43	64.28	60.00	62.14	63.26	χ^2=0.38; P=0.83
Moniezia sp.	0	0	0	0	13.33	6.90	24.49	χ^2=19.32; P<0.001
Fasciola hepatica	0	0	0	0	0	0	8.16	χ^2=7.89; P=0.02
Paramphistomum sp.	0	0	0	0	0	0	12.24	χ^2=12.01; P=0.003

when diseases happened. Deworming is carried out on a regular basis.

The study was performed, i.e. the faecal samples were collected, in the grazing season during the second half of June. Animals from all three farms had been grazing for a month on permanent grasslands with similar flora. All farms included in the study were located in areas with similar soil and climate conditions to West Pomerania, in the north-eastern part of the voivodeship. While on pasture all animals had constant access to water in drinking troughs, in which the water was refilled once a day. The animals moved to livestock buildings for milking and night rest.

Feces samples were collected to polyethylene bags (about 20g) and, if necessary, stored up to two days in refrigerated conditions (4–6°C).

Prevalence and intensity of intestinal parasite infections were determined through coprological examinations, using the Willis-Schlaf and McMaster methods [12]. A decantation method according to Żarnowski and Josztowa, as described by Ziomko and Cencek [12], was used to detect trematode eggs. In order to identify the species of gastrointestinal nematodes, infective (L3) larvae were cultured. Identification of gastrointestinal helminths by eggs was performed according to Tienpont and Rochette [13]. Coccidia species composition was determined using the key by Pellerdy [14]. Additionally, the procedures involved oocyst culture carried out in a humidified incubator at 24–26°C. To prevent mold growth, a 2.5% aqueous solution of potassium dichromate ($K_2Cr_2O_7$) was used. Infection intensity was determined based on the number of oocysts/eggs in 1 gram of feces (OPG/EPG). Mean infection intensity was calculated as (number of oocysts or parasite eggs / n), where n is the number of infected animals.

The statistical analysis was performed using Statistica 13.3 PL. The χ2 testwas used to determine the influence of farm type on the extensity of parasitic invasions, while the non-parametric Kruskal-Wallis testwas used to calculate the significance of any differences in infection intensity between the compared farms.

Results

The average prevalence of gastrointestinal parasitic infections were 67.42%, in the biodynamic farm, 62.14%, in the organic farms, and 63.26%, in the conventional cattle farm (Fig. 1). In the cows managed in the biodynamic farm, we detected infections by *Eimeria* protozoans and gastro-intestinal nematodes, whereas *Eimeria*, gastro-intestinal nematodes and *Moniezia* sp. were found in both analyzed organic farms. In the cows from the conventional farm, we found *Eimeria*, gastro-intestinal nematodes, *Moniezia* sp. and trematodes: *Fasciola hepatica* and *Paramphistomum* sp. (Fig. 1, Table 1).

The average infection intensity of *Eimeria* sp. protozoans in cows by the applied farming system was as follows: 71 OPG (oocysts per gram of feces), in the biodynamic farm, 57 OPG, in the organic farms, and 71 OPG, in the conventional farm. The mean intensity of gastrointestinal parasites was 290 EPG (eggs per gram of feces), in the biodynamic farm, 455 EPG, in the organic farms, and 228 EPG, in the conventional farm. The average *Moniezia* infection intensity in cows was 125 EPG, in the organic farm, and 50 EPG, in the conventional farm (Fig. 2, Table 2).

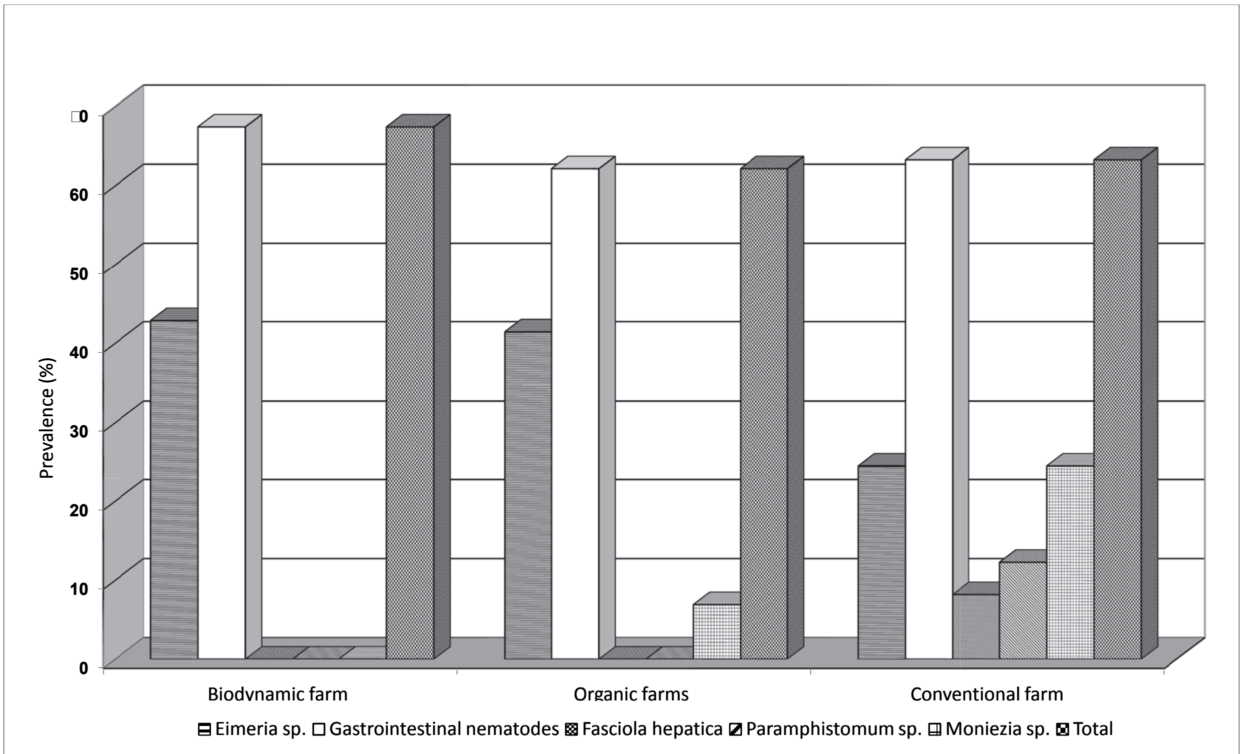

Fig. 1. Prevalence of gastrointestinal parasite infections in cows

Five species of coccidia were isolated from cow's feces in the biodynamic farm: *E. bovis*, *E. aubernensis*, *E. zürni*, *E. ellipsoidalis* and *E. cylindrica*. The dominant species was *E. auburnensis*, 23.52%. Four species of coccidia were found in the stool samples from organic farms: *E. bovis*, *E. aubernensis*, *E. zürni* and *E. ellipsoidalis*. The dominant species were *E. auburnensis*, 23.80% and *E. ellipsoidalis*, 29.11%. Five species of coccidia: *E. bovis*, *E. aubernensis*, *E. zürni*, *E. ellipsoidalis* and *E. cylindrica* were isolated in stool samples from the conventional farm. *E. auburnensis*, 12.24%, and *E. ellipsoidalis*, 10.20% were the dominant species (Table 3).

In all the analysed farms cows revealed infections by six species of gastrointestinal nematodes of the following genera: *Ostertagia* sp., *Trichostrongylus* sp., *Cooperia* sp., *Nematodirus* sp., *Haemonchus* and *Strongyloides* (Table 4). *Trichostrongylus* sp. predominated in the biodynamic farm, whereas *Ostertagia* was dominant in both prganic and conventional farms (Table 4).

Table 2. Intensity of gastrointestinal parasite infection (OPG/EPG) in cows by parasite and farm type

	Type of farm						
	Biodynamic			Organic			Conventional
	Brown Swiss	H-F	Mean	A	B	Mean	H-F
Eimeria sp.							
Mean	75	68	71.5^{a}	58	57	57.5^{a}	71^{a}
Range	50–150	50–150	50-150	50–100	50–100	50–100	50–150
Gastrointestinal nematodes							
Mean	280	300	290^{ab}	492	418	455^{a}	228^{b}
Range	50–900	50–800	50–900	50–1400	50–1200	50–1400	50–800
Moniezia sp.							
Mean	0	0	0	0	125	125	50
Range	0	0	0	0	50–200	50–200	50–100

[a,b] – the different lower case letters denote statistically significant differences at $p< 0.05$; OPG – number of oocysts per gram of feces; EPG – number of eggs per gram of feces

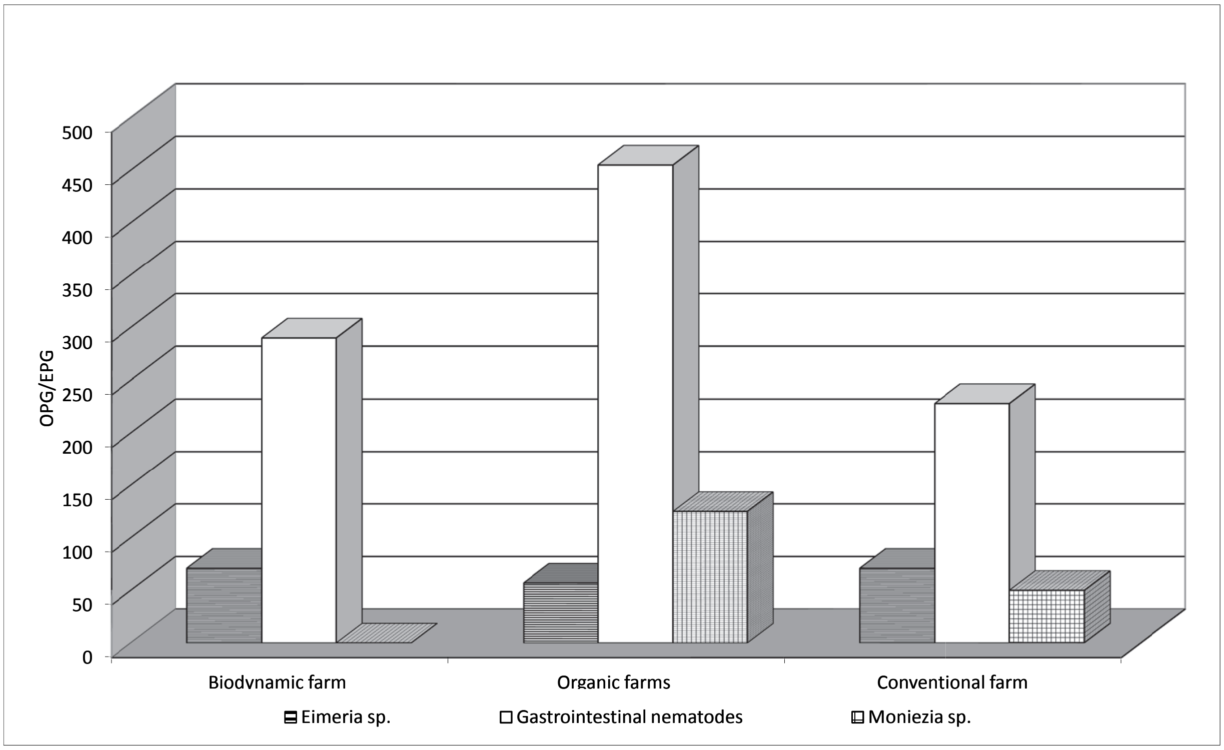

Fig. 2. Intensity of gastrointestinal parasite infections in cows

Farm type was found to have a significant influence on the extensity of invasion for *Moniezia* spp. ($\chi 2=19.32$; $P<0.001$), *Fasciola hepatica* ($\chi 2=7.89$; $P=0.02$) and *Paramphistomum* spp. ($\chi 2=12.01$; $P=0.003$). The mean extensity of gastrointestinal nematode infection was found to be significantly higher in organic farms than traditional farms.

Discussion

According to literature of the subject, parasites are the most common cause of economic losses in organic cattle farms [15]. The reason for this is that the use of antiparasitic agents to control infections in cattle is forbidden on organic farms. In consequence, both prevalence and intensity of parasitic infections are higher in organic farms compared to conventional, industrial farms. The results of our studies, however, dio not fit in this relationship. The mean rates of affected cows in all the studied farms were on a similar level, despite the fact that combating parasitic control measures applied in the conventional farm involved antiparasitic medications. In the organic farms, however, parasitic invasions control consists in destroying eggs or oocysts in the external environment through appropriate management of grazing and pastures. Such actions aim at limiting the extensiveness and intensity of cattle infestation with gastrointestinal parasites. In conventional farms, it seems advisable in the future to combine

Table 3. Mean *Eimeria* sp. infection prevalence (%) in cows by species and farm type

	Type of farm				
	Biodynamic		Organic		Conventional
	Brown Swiss	H-F	A	B	H-F
E. bovis	8.82	9.68	7.14	6.66	2.04
E. auburnensis	23.52	25.81	14.28	33.33	12.24
E. zürnii	5.88	6.45	7.14	6.66	2.04
E. ellipsoidalis	17.64	9.68	35.71	6.66	10.20
E. cylindrica	2.94	3.22	0	0	8.16

Table 4. Mean gastrointestinal nematode infection prevalence (%) in cows by species and farm type

	Type of farm				
	Biodynamic		Organic		Conventional
	Brown Swiss	H-F	A	B	H-F
Cooperia sp.	11.76	16.12	21.43	20.00	12.24
Nematodirus sp.	20.59	19.35	21.43	26.67	18.36
Strongyloides	11.76	12.90	14.29	13.33	12.24
Haemonchus	5.88	9.68	7.10	6.67	8.16
Trichostrongylus sp.	29.40	35.48	28.57	33.33	6.12
Ostertagia	35.29	25.80	35.71	40.00	24.48

anti-parasitic chemicals with other treatment methods that reduce both the scale and intensity of parasite infections, since prolonged and easy use of antiparasitic agents may in the future increase the drug resistance of parasites. This effect is most often the result of a long-term and frequent use of drugs with the same active substance and their overdose [16,17].

A common opinion is that pasture is the source of gastrointestinal nematode infections in grazing cattle. Therefore, it seems necessary to apply proper grazing and pasture management rules in this respect. While on pasture, young grazing animals should be separated from adult ones (possibly host organisms spreading eggs or cysts), and manure, which is the main source of parasite invasive forms, should be removed. Such measures and operations have been proved effective in reducing both prevalence and intensity of parasitic infections of bovine gastrointestinal tracts in organic farms, which is evident from this study as well. These operations, however, require more labor and this is probably the reason why conventional cattle farm managers still use anti-parasitic medications.

The extensiveness of cattle infection with gastrointestinal nematodes observed in this studies on the biodynamic farm was similar to the results published by Pilarczyk et al. [18] in cows imported from Germany to Poland (70%), and higher than in cows imported from the Czech Republic (48.36%) and France (42.86%). In Belgium, extensiveness of cattle infestation with gastrointestinal nematodes was found 75% [19], in Serbia 64.17% [20], while in Germany 42.2% [21].

It is noteworthy that the intensity of gastrointestinal nematode infections of cows in the biodynamic farm was very low (290 eggs in 1 g of feces) despite the high prevalence of infection (67.42%). A similar situation occurred in cows kept on the conventional farm. Compared to the latter farm, cows from the organic farms had almost twice the intensity of infection. This result is comparable to the values reported by Pilarczyk et al. [18] in cows imported from Germany (550 EPG) and in cows in south-western Spain [22], and less than one fifth of that found in cows imported from the Czech Republic (2300 EPG). Jäger et al. [23], on the other hand, who analyzed beef cattle managed in a foothills area in Germany, observed a five-fold lower level of gastrointestinal nematode egg excretion (50–100 EPG). Studzińska et al. [24] indicate that during the rearing period, calves from small farms are more likely to be exposed to protozoa of the genus *Eimeria* spp. (26%). The number of oocysts in 1 gram of faeces (OPG), reflecting the intensity of infection with *Eimeria* spp., ranged from 50 to 414 000.

In our studies, the same gastrointestinal nematodes were found in cows in the biodynamic, organic and conventional farms, and the difference was only in the prevalence of infection. Pilarczyk et al. [18], in cows imported from the Czech Republic, found gastrointestinal nematodes of the following genera: *Ostertagia* (37.3%), *Trichostrongylus* (27.1%), *Cooperia* (15.3%), *Nematodirus* (11.9%), *Oesophagostomum* (25.4%). Also in cows imported from France, they found the following nematodes: *Oesophagostomum* (25.0%), *Nematodirus* (33.3%), *Cooperia* (25.0%), *Ostertagia* (41.7%), *Trichostrongylus* (25%). However, in cows imported from Germany, the authors report gastrointestinal nematodes of the genera: *Ostertagia* (63.2%), *Cooperia* (15.8%), *Oesophagostomum* (26.3) and *Nematodirus* (10.5%). The examined animals were affected by a mixed invasion of gastrointestinal nematodes.

Coccidiosis is a chronic, parasitic disease caused by protozoa of the genus *Eimeria* sp., which infect the intestinal epithelium. *Eimeria bovis*, *E. zürni*, *E. ellipsoidalis* and *E. aubernensis* are the most aggressive pathogens [25,26]. In Poland, cases of clinical coccidiosis in adult animals occur sporadically. In our studies, cows in the biodynamic, organic and conventional farms were infected by the following species: *E. zürni*, *E. bovis*, *E. aubernensis* and *E. ellipsoidalis*; these are species that in our geoclimatic conditions at high intensity of infection they are responsible for the occurrence of clinical coccidiosis [27].

It is noteworthy that the intensity of *Eimeria* infection in the biodynamic fand organic farms was very low despite a high prevalence. *Eimeria* protozoan infections of cows on these farms do not represent a real problem, which is also a case in the conventional farm, where infestation prevalence and intensity are low. Similar results as those in the conventional farm were determined by Pilarczyk et al. [28] in cows imported from France (28.57%), with a much higher level in cows imported from Germany (51.85%); in cows imported from the Czech Republic, on the other hand, *Eimeria* prevalence was lower, 12.30%. Five coccidia species were isolated by these authors from feces of animals imported from the Czech Republic: (*E. bovis*, *E. aubernensis*, *E. ellipsoidalis*, *E. subspherica* and *E. zürni*), four from France (*E. bovis*, *E. aubernensis*, *E. ellipsoidalis* and *E. zürni*), and seven in cows from Germany (*E. bovis*, *E. aubernensis*, *E. ellipsoidalis*, *E. canadensis*, *E. cylindrica*, *E. alabamensis* and *E. zürni*). The analysed animals were infected by a mixture of mostly 2 or 3 species of coccidia. Tomczuk et al. [29] report a low prevalence of *Eimeria* spp. on very small farms with up to five animals, and that the incidence of this invasion increases with the size of the herd; they also identify a prevalence of 52% among calves and younger cattle. Very high prevalence of coccidia cattle infection (93%) was measured by Klockiewicz et al. [27] in twelve voivodships of southern Poland. Also in Germany, a high prevalence of cattle coccidial infections was demonstrated by Samson-Himmelstjerna et al. [30]. In north-western Germany, the authors reported cases of clinical coccidiosis in calves.

Trematodes *Fasciola hepatica* and *Paramphistomum* sp. were found only on the conventional farm. No *Moniezia* sp. tapeworms, which were present in the conventional farm, were found in the alternative farms. Pilarczyk et al. [18] did not find *Fasciola hepatica* eggs in cows imported to Poland, whereas previous studies by these authors [31] revealed its presence in 32.1% of pregnant heifers imported from the Netherlands to Poland. Also Stancampiano et al. [32] did not report *F. hepatica* in cows imported from France to Italy. In Germany, prevalence of *Fasciola hepatica* infected cows was significantly reduced over years, from 80% in 1969 to 0.005% in 1992, due to an appropriate preventive program [33]. In 2004, the prevalence of trematode infestation ranged from 0.6% to 1.43% [34,35]. Berning and Daugschies [35] observed differences in the prevalence of *F. hepatica* between individual districts resulting from *Fasciola hepatica* control programs deployed in some regions. Also in Poland, liver fluke infections in cows occur in a varying degree, depending on the period and region of survey. In a study conducted in 2001, Pilarczyk et al. [36] found no invasions of *Fasciola hepatica* in a random representation of West Pomeranian cattle farms. In contrast, prevalence of fluke infection with this parasite in the north-eastern Poland may reach 11% [37]. In Poland, *Paramphistomum* sp. occurs sporadically, with a case found in cows in a conventional farm. Pilarczyk et al. [18] report the presence of *Paramphistomum* sp. in cows imported from the Czech Republic (6.67%). Tomczuk et al. [38] report that invasions by *Fasciola hepatica*, *Paramphistomum* spp. and *Moniezia* spp. were only observed in herds kept on pasture. This is due to the need for an intermediate host in the development cycle. They also report a higher infectivity by nematodes of the Trichostrongylidae and the genus *Nematodirus* among beef cattle than dairy cattle.

This trematode was also reported by Stancampiano et al. [32] in cows imported from France to Italy. The prevalence of infection noted by these authors was relatively high, reaching 27.6%.

Alternative agriculture involves a risk of an increased level of parasite infections. On the one hand, manure is an excellent fertilizer, a source of essential nutrients for plants, on the other, however, it may be a source of parasitic infections. Organic farms operators, in order to control parasitic invasions, use various types of feed supplements in the form of medicinal herbs which contain active substances. Plants with antiparasitic properties include: garlic (*Allium sativum*), winter squash (*Cucurbita moschata*), wormwood (*Artemisia absinthium*), black walnut (*Juglans nigra*), common pumpkin (*Cucurbita pepo*), common mugwort (*Artemisia vulgaris*), fennel (*Foeniculum vulgare*), and thyme (*Thymus vulgaris*) [39–41]. Appropriate pasture management is also necessary.

In conclusions, the research confirmed that the issue of gastrointestinal parasites in cattle is still valid. The prevalence of infection with gastro-intestinal parasites in the cattle on organic and conventional farms was very high, which was accompanied by a low intensity of infection. This indicates the need to conduct screening for the presence of gastrointestinal parasites in alternative and conventional cattle herds with the use of inexpensive yet effective diagnostic methods. This will help reduce the incidence of parasitic invasions among animals and ultimately contribute to an increase in productivity. Complete eradication of gastrointestinal parasites in organic farming is infeasible; however, pasture management needs improvement if we are to reduce the level of parasitic invasion. Also in conventional farms, it is necessary to introduce new preventive programs in breeding and management of cattle herds, which will limit the use of antiparasitic medications in favor of alternative methods.

References

[1] Bennema S.C., Vercruvsse J., Morgan E., Stafford K., Hoglund J., Demeler J., Von Samson-Himmelstierna G., Charlier J. 2010. Epidemiology and risk factors for exposure to gastrointestinal nematodes in dairy herds in northwestern Europe. *Veterinary Parasitology* 173: 247-254. https://doi.org/10.1016/j. vetpar.2010.07.002

[2] Charlier J., Hoglund J., Von Samson-Himmelstierna G., Dorny P., Vercruvsse J. 2009. Gastrointestinal nematode infections in adult dairy cattle: impact on production, diagnosis and control. *Veterinary Parasitology* 164: 70-79. https://doi.org/10.1016/j .vetpar.2009.04.012

[3] Peńa-Espinoza M., Thamsborg S.M., Denwood M.J., Drag M., Hansen T.V., Jensen V.F., Enemark H.L. 2016. Efficacy of ivermectin against gastrointestinal nematodes of cattle in Denmark evaluated by different methods for analysis of faecal egg count reduction. *International Journal for Parasitology: Drugs and Drug Resistance* 6: 241-250. https://doi.org/10. 1016/j.ijpddr.2016.10.004

[4] Maqbool I., Wani Z.A., Shahardar R.A., Allaie I.M., Shah M.M. 2016. Integrated parasite management with special reference to gastro-intestinal nematodes. *Journal of Parasitic Diseases* 41: 1-8. https://doi.org/10.1007/s12639-016-0765-6

[5] Bandyopadhyay S., Mandal S., Datta K.K., Devi P., De S., Bera A.K., Bhattacharya D. 2010. Economic analysis of risk of gastrointestinal parasitic infection in cattle in North Eastern States. *Tropical Animal Health and Production* 42: 1481. https://doi.org/10.1007/s11250-010-9582-6

[6] Perri A.F., Mejia M.E., Licoff N., Lazaro L., Miglierina M., Ornstein A., Becu-Villalobos D., Lacau-Mengido I.M. 2011. Gastrointestinal parasites presence during the peripartum decreases total milk production in grazing dairy Holstein cows. *Veterinary Parasitology* 178: 311-318. https://doi.org/10.1016/j.vetpar.2010.12.045

[7] Kirchmann H. 1994. Biological dynamic farming – an occult form of alternative agriculture? *Journal of Agricultural and Environmental Ethics* 7: 173-187. https://doi.org/10.1007/BF02349036

[8] Stolze M., Lampkin N. 2009. Policy for organic farming: Rationale and concepts. *Food Policy* 34: 237-244. doi:10.1016/j.foodpol.2009.03.005

[9] Lairon D. 2010. Nutritional quality and safety of organic food. A review. *Agronomy for Sustainable Development* 30: 33-41. http://dx.doi.org/10.1051/agro/2009019

[10] Kuś J. 2002. Systemy gospodarowania w rolnictwie. Materiały IERiGŻ, Warszawa (in Polish).

[11] Höglund J., Svensson C., Hessle A. 2001. A field survey on the status of internal parasites in calves on organic dairy farms in southwestern Sweden. *Veterinary Parasitology* 99: 113-128. https://doi.org/10.1016/s0304-4017(01)00452-6

[12] Ziomko I., Cencek T. 1995. Zarys laboratoryjnej diagnostyki parazytologicznej zwierząt gospodarskich [Parasitic invasions in farm animals, selected diagnostic methods]. Drukarnia Piotra Wlodkowica, Warsaw, Poland: 8-24 (in Polish).

[13] Tienpont D., Rochette F. 1986. Diagnosting helminthiasis by coprological examination. Janssen Research Foundation, Beerse, Belgium.

[14] Pellerdy L.P. 1974. Coccidia and Coccidiosis. Akademiai Kiodo, Budapest

[15] Thamsborg S.M., Roepstorff A., Larsen M. 1994. Integrated and biological control of parasites in organic and conventional production systems. *Veterinary Parasitology* 84: 169-186. https://doi.org/10.1016/s0304-4017(99)00035-7

[16] Vercruysse J., Jackson F., Besier B., Pomroy B. 2009. Novel solutions for the sustainable control of nematodes in ruminants (PARASOL). *Veterinary Parasitology* 164: 1-2. https://doi.org/10.1016/j.vetpar.2009.04.025

[17] Geurden T., Chartier Ch., Franke J., Frangipane di Regalbono A., Traversa D., Himmelstjerna-Samson G., Demeler J., Bindu H. 2015. Anthelmintic resistance to ivermectin and moxidectin in gastrointestinal nematodes of cattle in Europe. *International Journal for Parasitology: Drugs and Drug Resistance* 5: 163-171. https://doi.org/10.1016/j.ijpddr.2015.08.001

[18] Pilarczyk B., Pilarczyk R., Tomza-Marciniak A., Kavetska K., Rząd I., Binerowska B., Tylkowska A. 2011. Nachweise von gastrointestinalen Nematoden und von *Paramphistomum cervi* bei nach Polen

importierten Kühen aus Deutschland, Frankreich und Tschechien. *Tierärztliche Umschau* 66: 387- 390 (in German).
[19] Agneessen S.J., Claerebout E., Dorny P., Borgsteede F.H., Vercruysse J. 2000. Nematode parasitism in adult dairy cows in Belgium. *Veterinary Parasitology* 90: 83-92. https://doi.org/10.1016/s0304-4017(00)00232-6
[20] Kulišić Z., Aleksić N., Dordević N., Gajić B., Tambur Z., Stevanović J., Stanimirović Z. 2012. Prevalence of gastrointestinal helminths in calves in Western Serbia. *Acta Veterinaria* 62: 665-673. doi:10.2298/AVB1304429K
[21] Kemper N., Henze C. 2009. Effects of pastures' re-wetting on endoparasites in cattle in northern Germany. *Veterinary Parasitology* 161: 302-306. https://doi.org/10.1016/j.vetpar.2009.01.025
[22] Nogareda C., Mezo M., Uriarte J., Lloveras J., Cordero del Campillo M. 2006. Dynamics of infestation of cattle and pasture by gastrointestinal nematodes in an Atlantic temperate environment. *Journal* of *Veterinary Medicine* 53: 439-444. https://doi.org/10.1111/j.1439-0450.2006.00979.x
[23] Jäger M., Gauly M., Bauer C., Failing K., Erhardt G., Zahner H. 2005. Endoparasites in calves of beef cattle herds: Management systems dependent and genetic influences. *Veterinary Parasitology* 131: 173-191. https://doi.org/10.1016/j.vetpar.2005.05.014
[24] Studzińska M., Bogucki J., Demkowska-Kutrzepa M., Roczeń-Karczmarz M., Szczepaniak K., Junkuszew A., Tomczuk K. 2018. Pasożyty jelitowe u cieląt z małych i średnich gospodarstw w południowo-wschodniej Polsce [Gastrointestinal parasites in calves in small and middle-sized farms of South-East Poland] *Medycyna Weterynaryjna* 74: 520-525 (in Polish).
[25] Peralta J., Bertolino A., Guglielmone G. 1994. Curva de prevalencia de coccidiosis (OPG) en terneros de crianza artificial. *Veterinaria Argentina* 9: 322-326 (in Spanish).
[26] Svensson C., Trenti F. 1994. Overwintering of oocysts of *Eimeria alabamensis* on Swedish pastures. In: Proceedings 18th World Buiatrics Congress: 26th Congress of the Italian Association of Buiatrics, Bologna, Italy: 1395-1398.
[27] Klockiewicz M., Jaba J., Tomczuk K., Janecka E., Sadzikowski A.B., Rypula K., Studzinska M., Malecki-TePicht J. 2007. The epidemiology of calf coccidiosis (*Eimeria* spp.) in Poland. *Parasitology Research* 101:121-128. doi: 10.1007/s00436-007-0619-3
[28] Pilarczyk B., Pilarczyk R., Binerowska B., Hendzel D., Tomza-Marciniak A., Kavetska K. 2011. Prevalence of *Eimeria* Protozoa in cows imported to Poland from the Czech Republic, France, Germany. A preliminary study. *Bulletin of the Veterinary Institute in Pulawy* 55: 203-206.
[29] Tomczuk K., Grzybek M., Szczepaniak K., Studzińska M., Demkowska-Kutrzepa M., Roczeń-Karczmarz M., Klockiewicz M. 2015. Analysis of intrinsic and extrinsic factors influencing the dynamics of bovine *Eimeria* spp. from central-eastern Poland. *Veterinary Parasitology* 214: 22-28. https://doi.org/10.1016/j.vetpar.2015.09.027
[30] Samson-Himmelstjerna G., Epe C., Wirtherle N., Von Der Heyden V., Welz C., Radeloff I., Beening J., Carr D., Hellmann K., Schnieder T., Krieger K. 2006. Clinical and epidemiological characteristics of *Eimeria* infections in first-year grazing cattle. *Veterinary Parasitology* 136: 215-221. https://doi.org/10.1016/j.vetpar.2005.11.022
[31] Pilarczyk B., Balicka-Ramisz A., Kozak W., Ramisz A. 2009. Occurrence of endoparasites in heifers imported to Poland from the Netherlands. *Archiv fur Tierzucht* 52: 265-271.
[32] Stancampiano L., Corradini D., Bulgarelli M., Micagni G., Battelii G. 2007. Parasites of the digestive tract in beef cattle imported from France to Italy. *Parasitologia* 49: 101-106.
[33] Runge C. 1992. Leberegelbefall bei Schlachtrindern in Nordfriesland (Liver fluke infections in beef cattle in Northern Friesland). In: Deutsche Veterinärmedizinische Gesellschaft, Tagung der Fachgruppe "Parasitologie und parasitäre Krankheiten", Husum: 47-48 (in German).
[34] Epe C., Coati N., Schnieder T. 2004. [Results of parasitological examinations of faecal samples from horses, ruminants, pigs, dogs, cats, hedgehogs and rabbits between 1998 and 2002]. *Deutsche Tierarztliche Wochenschrift* 6: 243-247 (in German).
[35] Berning H., Daugschies A. 2005. Occurrence and significance of bovin fascioliasis in the north of Lower Saxony on basis of slaughter findings. *Der Praktische Tierarzt* 66: 50-55.
[36] Pilarczyk B., Ramisz A., Jastrzębski G. 2002. Pasożyty wewnętrzne bydła w wybranych gospodarstwach Pomorza Zachodniego. *Wiadomości Parazytologiczne* 48: 383-390 (in Polish with summary in English).
[37] Michalski M., Romaniuk K. 2000. Liver fluke (*Fasciola hepatica* L.) in dairy cows in North-East Poland. *Medycyna Weterynaryjna* 56:182-184.
[38] Tomczuk K., Szczepaniak K., Demkowska-Kutrzepa M., Roczeń-Karczmarz M., Junkuszew A., Gruszecki T., Drozd L., Karpiński M., Studzińska M. 2018. Występowanie pasożytów wewnętrznych bydła w zróżnicowanych systemach hodowli w Polsce południowo-wschodniej [Occurrence of internal parasites in cattle in various management systems in South-East Poland]. *Medycyna Weterynaryjna* 74: 501-506 (in Polish).
[39] Benksy D., Gamble A. 1993. Herbs that expel parasites. In: *Chinese Herbal Medicine: Material Medica.* Eastland Press Inc. Seattle, Washington: 441-

444.
[40] Pena M.T., Fontenot M.E., Miller J.E., Gillespie A., Larsen M. 2002. Evaluation of the efficacy of *Duddingtonia flagrans* in reducing infective larvae of *Haemonchus contortus* in feces of sheep. *Veterinary Parasitology* 103: 259-265.
[41] Waller P.J., Bernes G., Thamsborg S.M., Sukura A., Richter S.H., Ingebrigt-Sen K., Höglund J. 2001. Plants as de-worming agents of livestock in the Nordic countries: historical perspective, popular beliefs and prospects for the future. *Acta Veterinaria Scandinavica* 42: 31-44.

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