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OESOPHAGOSTOMINAE (NEMATODA: CHABERTIIDAE) OF SUIDS FROM SOUTHERN POLAND*

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Abstract

Until recently, the genus *Oesophagostomum* was the only Oesophagostominae occurring commonly in both domestic and wild suids of Europe. A few years ago, an alien oesophagostomin nematode *Bourgelatia diducta* was recorded in the wild boar population from southern Poland, and Vietnamese potbellied pig was blamed for introduction of this Far Eastern parasite. Apart from wild boars kept in captivity for meat production purposes, Vietnamese potbellied pigs can be raised in extensive, organic, or especially agrotourism farms, which constitutes an infection hazard to domestic pigs. The aim of the research was to determine and compare species composition of Oesophagostominae in wild boars from the natural environment, and in domestic pigs from extensively managed farms, located in the area where *B. diducta* was previously noted for the first time. A postmortem examination of the large intestines of 25 wild boars and 20 domestic pigs, each from different smallholdings, was conducted in the autumn and winter season of 2010–2011. *Oesophagostomum dentatum* with coexisting *O. quadrispinulatum* were ascertained in swine, whereas the sole *Bourgelatia diducta* was recorded in wild boars. All the parasites occurred commonly in their hosts, with the prevalence of 80, 50 and 32% for *O. dentatum*, *O. quadrispinulatum* and *B. diducta*, respectively. Mean number of worms was many-fold higher in pigs, reaching 181 (range 1 to 2500) specimens in individual host, versus 3 (1–6) parasites in wild boars. A presumable influence of the alien nematode species on the European wild boar population as well as the potential for further spread of the parasite are elucidated.

Key words: wild boar, domestic pig, *Oesophagostomum* spp., *Bourgelatia diducta*

The European wild boar (*Sus scrofa scrofa*) and the domestic pig (*Sus scrofa* f. *domestica*) constitute the same animal species and are the hosts of shared parasites. In the world, two species of Oesophagostominae subfamily are prevailing and occur concurrently in pigs and wild boars, namely *Oesophagostomum dentatum* (Rudolphi,

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1803) and *O. quadrispinulatum* (Marcone, 1901) (Poelvoorde, 1978; Barutzki et al., 1991; Urquhart et al., 1996). Some other species are observed in suids of America (*O. brevicaudum* Schwartz et Alicata, 1930) and Asia (*O. watanabei* Yamaguti, 1961) (Stewart et al., 1996; Sato et al., 2008). Two additional named species, the American *O. georgianum* (Schwartz et Alicata, 1930) and the European *O. granatensis* (Herrera, 1958), are most probably morphovariants of *O. dentatum* (Poelvoorde, 1978; Cutillas et al., 1999).

Apart from oesophagostomins of *Oesophagostomum* genus, *Bourgelatia diducta* (Railliet, Henry et Bauche, 1919) is commonly observed in tropic and subtropic regions of Southeast Asia (India, Indochina, Java, Thailand) and Oceania (Papua New Guinea, Solomon Islands) (de Jesus and Waramontri, 1961; Soulsby, 1968; Talbot, 1972; Martin and Epstein, 1999). The species was also noticed in pigs of China (Fan-yao and Yi-chiang, 1965) and wild boars of Japan (Yamaguti, 1954; Sato et al., 2008), in the regions with such a climate.

In Poland, the infection of suids with *Oesophagostomum* sp. is well documented in studies by many authors. However, by means of coproscopic examinations usually carried out, the species of nodular worms could not be distinguished on the basis of eggs appearance. Postmortem, the presence of *O. dentatum* has been proven by Tarczyński (1956, 1961) in domestic pigs and wild boars, and by Gadomska (1981) in boars. As regards *O. quadrispinulatum*, it was noted for the first time in 2006, in pigs from the southern region of Poland (Nosal et al., 2007), which was probably the result of breeding material import. In wild boar of the area, *O. quadrispinulatum* was absent (Nosal, 2010), though its coexistence with *O. dentatum* has been observed in wild populations of neighbouring countries, e.g. in Germany (Barutzki et al., 1991). It was mentioned elsewhere (Nosal, 2010) that apart from *Metastrongylus asymmetricus* – a lungworm typical of Asiatic wild boars – the other alien nematode species, *Bourgelatia diducta* appeared unexpectedly in European wild boar inhabiting the area presented herein. As a source of infection with Far Eastern parasites, Vietnamese potbellied pig (*Sus scrofa vittatus*) was blamed (Nosal, 2010), following its escape into the wildlife from one of the farms in the area examined. Vietnamese potbellied pigs are sometimes raised in Poland in extensive and organic farms, and especially in agrotourism farms, thus posing an infection threat to domestic pig herds. In addition, wild boars are raised in enclosures situated in agricultural environments. The current research was aimed to reveal the present species structure of Oesophagostominae community settled in large intestine of suids from this part of Europe, and to compare wild boar populations to domestic pig herds for the similarity of oesophagostomins.

Material and methods

The study was conducted from November 2010 to February 2011, and all the examined animals originated from the area situated in the proximity of Kraków, Małopolska province. This region of southern Poland is characterized by mostly

traditional or organic farm management, and arable lands border woodlands or even primeval forests.

The guts of animals derived from 25 hunted wild boars (for which the data on the site of origin, age and sex were collected), as well as from 20 fattening pigs (6–7 months of age) – each of different small farm origin – slaughtered at a local abattoir. The large intestines were uncoiled, divided into three sections: I – caecum and the first 20% of the total length of colon; II – next 20–60% part of large intestine; III – the last 60–100% of its length, and from each section 30% of its contents was processed according to Rospestorff and Nansen (1998). Gathered Oesophagostominae specimens were differentiated (either all the worms, or 250 from the more intensively affected individuals), following the descriptions given by Haupt (1966) and Poelvoorde (1978), or on the basis of Lichtenfels (1980), Yamaguti (1954), and Fan-yao and Yi-chiang (1965), as regards *Bourgelatia diducta*. Measurements and photographs were made using Motic Images Plus 2.0 program, under 100 and 400× magnification. Quantitative Parasitology 3.0 (Rózsa et al., 2000) was used to reveal associations between helminth infections and wild boar site of origin (arable land vs. primeval forest), age group (juveniles under 1 year vs. adults) or sex.

Results

Eight of the 25 examined wild boars were infected (prevalence of 32%) with sole *Bourgelatia diducta* species identified (Fig. 1, Table 1); the mean intensity of infection equalled 3 parasites, ranging from 1 to 6 specimens in an individual host. The animals proved to be infected irrespective of their age, sex and habitat. Altogether, 21 nematodes were gathered, including 6 males and 15 females (sex ratio 1:2.5). Only one egg could be seen in the vagina of a female worm, resembling very much those produced by *Oesophagostomum* spp. (Table 1). All worms, apart from one male collected from section II of the large intestine, lived in caecum.

Table 1. Morphometric data of the examined Oesophagostominae species

Feature	Mean ± SD (range) of measured features (μm)		
	Bourgelatia diducta n = 10*	*Oespohagostomum dentatum* n = 10	*Oesophagostomum quadrispinulatum* n = 10
Distance from vulva to anus in females	471.67 ± 35.98 (407.1÷ 504.9)	360.74 ± 34.56 (313.1 ÷ 400.4)	469.96 ± 30.64 (429.1 ÷ 515.2)
Length of tail in females	424.51 ± 55.83 (327.2 ÷ 511.7)	315.72 ± 29.39 (285.2 ÷ 359.7)	481.76 ± 49.78 (395.5 ÷ 503.0)
Eggs in vagina:			
– length	65.5	76.33 ± 2.57 (73.4 ÷ 78.2)	63.65 ± 3.18 (60.9 ÷ 68.0)
– width	33.5	44.83 ± 4.02 (41.5 ÷ 49.3)	33.42 ± 3.90 (31.4 ÷ 39.0)
Length of spicules in males	1197.36 ± 101.06 (1077.7 ÷ 1321.2)	1029.42 ± 56.20 (982.2 ÷ 1105.9)	840.58 ± 13.39 (822.2 ÷ 858.4)

* In the case of *B. diducta* males, all the 6 collected specimens were measured.

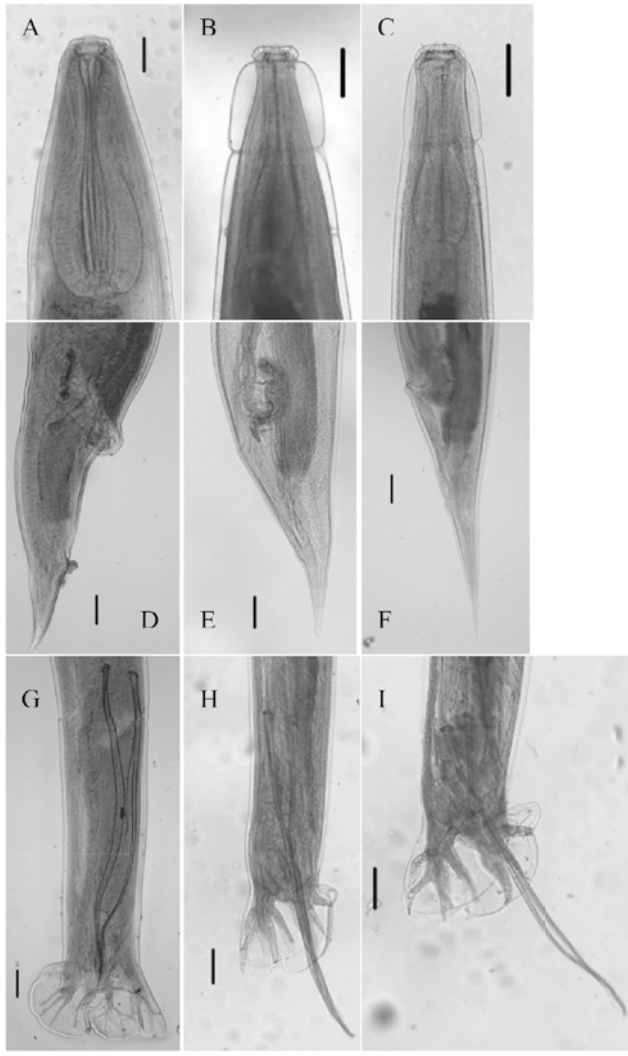

Fig. 1. Morphological features characteristic of *Bourgelatia diducta* (A, D, G), *Oesophagostomum dentatum* (B, E, H) and *Oesophagostomum quadrispinulatum* (C, F, I) (scale bar = 100 μm). (A, B, C) Lateral view of the anterior end of body and oesophageal region. (D, E, F) Lateral view of the posterior end of a female adult showing the position of vulva and anus. (G, H, I) Lateral view of the posterior end of a male adult showing spiculae, and copulatory bursa with distinctive arrangement of rays, branches and twigs.

Out of the 20 fattening pigs investigated, 18 harboured *Oesophagostomum* spp. (prevalence of 90%), and the mean intensity of infection reached 181 (1–2500) worms. Among infected swine, concurrent infection of *O. dentatum* and *O. quadrispinulatum* was observed in 7 animals, whereas pure *O. dentatum* or *O. quadrispinulatum* infection in 9 or 2 pigs, respectively. Within 893 nodular worms differentiated (Fig. 1, Table 1), predominating *O. dentatum* constituted 78.2%. This species

occupied mainly section II (48.7% of specimens identified) or section III of the large intestine (39.4%), whereas *O. quadrispinulatum* was found primarily in sections I (66.2% of worms) and II (31.3%). The male to female ratio was 1:1.2 for *O. quadrispinulatum*, and 1:1.7 for *O. dentatum*.

Discussion

In the present study, Oesophagostominae of domestic swine were confirmed to be typical of the host and region (Tarczyński, 1956; Nosal, 2010). Nematodes of *Oesophagostomum* genus are called "nodular worms" since their infective L3 larvae tend to become encapsulated – by excessive reactive inflammation – deep in the intestinal mucosa of the sensitized host. After moulting to fourth stage, the larvae may remain arrested within the nodules for several months until emerging and developing to adults in the lumen. Clinical signs of oesophagostomosis are usually associated with host reactions to the larval stages in the gut wall, thus the acute disease occurs during the prepatent period (Urquhart et al., 1996). Nodule formation may cause catarrhal enteritis, spoils sausage casings, and interferes with feed efficiency and maximum growth of young swine. Pregnant sows show inappetence, become very thin, and after farrowing milk production is reduced, which affects litter performance and influences the growth and meat quality of fatteners (Romaniuk et al., 1981; Stewart and Hale, 1988; Urquhart et al., 1996; Theodoropoulos et al., 2004; Knecht et al., 2012).

From the two common species of nodular worms, *Oesophagostomum quadrispinulatum* is generally found more proximally, especially prevailing in the caecum of large intestine, and causes more severe damage and larger nodules in caecal and colonic mucosa than *O. dentatum* (Christensen et al., 1997). It is uncertain whether this could be attributed to a higher degree of host tissue reaction against *O. quadrispinulatum* (Christensen et al., 1997). Its prepatent period is longer and varies between 18 and 42 days, compared to *O. dentatum* with the interval of 18–28 days (Várady et al., 1996). *O. quadrispinulatum* is also more difficult to remove, which may be related to the pharmacokinetic properties of anthelmintics along the large intestine, or denotes natural tolerance of this species to the drugs (Várady et al., 1996). When presenting Oesophagostominae community, Christensen et al. (1997) reported about the negative influence of *O. quadrispinulatum* on *O. dentatum* establishment, location and distribution in the gut, and fecundity, but at the same time emphasized that a variety of interactions may exist between the two closely located helminths.

In contrast to *Oesophagostomum* spp., the biology of *Bourgelatia diducta*, alien to Europe, as well as its pathogenicity, remain unrecognized (Soulsby, 1968; Yadav and Tandon, 1993), and merely Hanzhong and Yiqiang (1987) report that the early stages of the nematode follows the development of other oesophagostomins, with third stage infective larvae reaching maturity after 39–42 days of prepatent period. Thus, it is not known what actually might happen when the close-related parasite enters the gut already inhabited, and whether incoming infective larvae can establish,

causing the pre-existing worm species to be displaced or expelled. Further, it is not certain whether or not *Bourgelatia diducta* can influence the healthiness of European wild boar more than nodular worms of *Oesophagostomum* spp. already do. It is interesting that in the previous work (Nosal, 2010) *B. diducta* was observed together with *Oesophagostomum dentatum* in wild boars originating from arable lands of the region characterized. These species coexist in the native range of *Bourgelatia*, which was noted in some available publications (Talbot, 1972). Therefore, it cannot be said that the present investigation provides evidence that one Oesophagostominae species begins to displace the other within their community. Nevertheless, *Bourgelatia* occupies a privileged anterior location in the large intestine of infected hosts, similarly to *O. quadrispinulatum*, and it is important to recall that – as defined by Pence et al. (1988) – the nematode occurred already commonly in the studied population as the sole Oesophagostominae species.

Sus scrofa is considered to be an invader (ISSG Database). For ecologically invasive species, the presence of their own parasites sometimes seems to be essential in competition with native, closely related fauna. Since *Bourgelatia* comes to prevail within the oesophagostomins of wild boar population, it speaks also in favour of the nematode as a new alien invasive species. Fernandez-de-Mera et al. (2003) caution that wild boar translocations constitute an important source of foreign disease introduction, and it might be substantial to mention here that, e.g. in ruminants, the more pathogenic species of *Oesophagostomum* occur in the subtropics and tropics (Urquhart et al., 1996).

Pathogenicity of any parasitosis is conditioned by the infection level. Pence et al. (1988) state that *Oesophagostomum* species, with their direct life cycle, may require a certain host population density in order to maintain worm transmission potentials, thus reduced wild boar population could explain even the apparent loss of nematodes which occur at low prevalences. The lack of *Oesophagostomum* was reported in autochthonous wild boars from Spain (Fernandez-de-Mera et al., 2003), or the isolated wild boar population close to the northern border of its habitat area (Järvis et al., 2007). However, the population of wild boars inhabiting Poland rapidly increases nowadays (Kamieniarz and Panek, 2008). They live also in breeding conditions, where a higher level of *Oesophagostomum* infection is observed as compared with animals from the wildlife (Gadomska, 1981; Popiołek et al., 2010). In swine production, following stock density, nodular worms of *Oesophagostomum* spp. are the most common parasites, and in relation to wild boars from nature, optimal abundance is many-fold higher there (Tarczyński, 1961; Fudalewicz-Niemczyk and Nowosad, 1988; Knecht et al., 2011). An adequate increase in the level of infection with new, foreign nematode species in farm-reared game animals, or swine production, could be therefore very harmful.

If completely different Oesophagostominae fauna of wild and domestic suids, despite the same area occupied, testify to the impossibility of direct parasite transmission between wild populations and domestic pigs, still oesophagostomins may be distributed to swine herds by a wide variety of biological mechanisms (flies, cockroaches, earthworms, rats) (Jacobs et al., 1971), which pose some threat of *Bourgelatia* transmission to domestic animals. In organic, and especially agrotourism farms

holding various species of animals, the risk of the alien parasite introduction may therefore be high.

Whether or not *Bourgelatia* is significant, and occurs in the wildlife or household conditions of other European countries, it should be considered henceforth. Accordingly, postmortem oesophagostomin species identification should be essential in any parasitological research or monitoring programme conducted on suid populations or herds in the area.

References

Barutzki D., Schoierer R., Gothe R. (1991). Helmintheninfektionen von Wildschweinen bei Gatterhaltung in Süddeutschland: Befallsstärke und Ausscheidungsintensität. Tierarztl. Prax., 19: 644–648.

Christensen C.M., Nansen P., Barnes E.H. (1997). The effect of concurrent or sequential *Oesophagostomum dentatum* and *O. quadrispinulatum* infections on the worm burdens of the two species in pigs. Parasitology, 114: 273–278.

Cutillas C., Guevara-Martínez D., Oliveros R., Arias P., Guevara D.C. (1999). Characterization of porcine and ovine *Oesophagostomum* spp. by isoenzymatic patterns and restriction-fragment-length polymorphisms (RFLPs). Acta Trop., 73: 59–71.

De Jesus Z., Waramontri J. (1961). Parasites of domesticated animals in Thailand: worm parasites of the pig. J. Natl. Res. Council. Thailand, 2: 11–25.

Fan-yao K., Yi-chiang C. (1965). Some parasitic nematodes from Kuanghsi. Acta Vet. Zootech. Sin., 8: 29–34.

Fernandez-de-Mera I.G., Gortazar Ch., Vicente J., Höfle U., Fierro Y. (2003). Wild boar helminths: risk in animal translocations. Vet. Parasitol., 115: 335–341.

Fudalewicz-Niemczyk W., Nowosad B. (1988). Intestinal helminthiasis in pigs in different types of farms in southern Poland. Zesz. Nauk. AR Kraków, Zootechnika, 26: 63–71.

Gadomska K. (1981). The qualitative and quantitative structure of the helminthocoenosis of wild boar (*Sus scrofa* L.) living in natural (Kampinos National Park) and breeding conditions. Acta Parasitol. Pol., 28: 151–170.

Hanzhong Ch., Yiqiang Z. (1987). Studies on *Bourgelatia diducta* 1. Studies on the early life-cycle of *Bourgelatia diducta* and its life-cycle type. Acta Vet. Zootech. Sin., 18: 141–145.

Haupt W. (1966). Ein Beitrag zur Morphologie der Knötchenwürmer des Hausschweines, ihrer Eier sowie der dritten invasionstüchtigen Larvenstadien. Arch. Exp. Veterinarmed., 20: 701–711.

Jacobs D.E., Dunn A.M., Walker J. (1971). Mechanisms for the dispersal of parasitic nematode larvae: rats as potential paratenic hosts for *Oesophagostomum* (Strongyloidea). J. Helminthol., 45: 139–144.

Järvis T., Kapel Ch., Moks E., Talvik H., Mägi E. (2007). Helminths of wild boar in the isolated population close to the northern border of its habitat area. Vet. Parasitol., 150: 366–369.

Kamieniarz R., Panek M. (2008). Game animals in Poland at the turn of the 20th and 21st century. Czempiń, Stacja Badawcza – OHZ PZŁ.

Knecht D., Jankowska A., Zaleśny G. (2012). The impact of gastrointestinal parasites infection on slaughter efficiency in pigs. Vet. Parasitol., 184: 291–297.

Knecht D., Popiołek M., Zaleśny G. (2011). Does meatiness of pigs depend on the level of gastro-intestinal parasites infection? Prev. Vet. Med., 99: 234–239.

Lichtenfels J.R. (1980). No. 7. Keys to genera of the superfamily Strongyloidea. In: R.C.A. Anderson, G. Chabaud, S. Willmott (Eds), CIH keys to the nematode parasites of vertebrates. Commonwealth Agricultural Bureaux, Farnham Royal, UK.

Martin T., Epstein V. (1999). The animal health status of the Solomon Islands. Noumea, New Caledonia, Secretariat of the Pacific Community.

Nosal P. (2010). Factors determining the occurrence of nematodes (Nematoda) in suids and the ways of controlling thereof. The University of Agriculture Publishers, Cracow, Dissertations no. 340.

Nosal P., Nowosad B., Petryszak A. (2007). *Oesophagostomum quadrispinulatum* (Marcone, 1901) Alicata, 1935 – a new for Poland parasite of swine. Wiad. Parazytol., 53: 239–243.
Pence D.B., Warren R.J., Ford Ch.R. (1988). Visceral helminth communities of an insular population of feral swine. J. Wildl. Dis., 24: 105–112.
Poelvoorde J. (1978). Oesophagostomosis in sows. Zbl. Vet. Med. B, 25: 835–640.
Popiołek M., Knecht D., Szczęsna-Staśkiewicz J., Czerwińska-Rożałow A. (2010). Helminths of the wild boar (*Sus scrofa* L.) in natural and breeding conditions. Bull. Vet. Inst. Pulawy, 54: 161–166.
Roepstorff A., Nansen P. (1998). Epidemiology, diagnosis and control of helminth parasites of swine. Rome, Italy, FAO.
Romaniuk K., Olejnik T., Ulanowski M. (1981). The influence of *Oesophagostomum dentatum* invasion on fertilization of sows and body weight gains of piglets. Med. Weter., 37: 12–14.
Rózsa L., Reiczigel J., Majoros G. (2000). Quantifying parasites in samples of hosts. J. Parasitol., 86: 228–232.
Sato H., Suzuki K., Yokoyama M. (2008). Visceral helminths of wild boars (*Sus scrofa leucomystax*) in Japan, with special reference to a new species of the genus *Morgascaridia* Inglis, 1958 (Nematoda: Schneidernematidae). J. Helminthol., 82: 159–168.
Soulsby E.J.L. (1968). Helminths, arthropods and protozoa of domesticated animals. London, UK, Baillière, Tindall & Cassell, Sixth edition, 824 pp.
Stewart T.B., Fox M.C., Wiles S.E. (1996). Doramectin efficacy against gastrointestinal nematodes in pigs. Vet. Parasitol., 66: 101–108.
Stewart T.B., Hale O.M. (1988). Losses to internal parasites in swine production. J. Anim. Sci., 66: 1548–1554.
Talbot N.T. (1972). Incidence and distribution of helminth and arthropod parasites of indigenous owned pigs in Papua New Guinea. Trop. Anim. Health Prod., 4: 182–190.
Tarczyński S. (1956). Parasitic worms of swine and wild boars in Poland. Acta Parasitol. Pol., 4: 663–779.
Tarczyński S. (1961). Biocoenological studies on the invasion with *Oesophagostomum dentatum* Rudolphi 1803 in domestic swine and wild boars. Acta Parasitol. Pol., 9: 447–461.
Theodoropoulos G., Deligeorgis S., Fegeros K., Papavasiliou D., Rogdakis E. (2004). Influence of natural parasitism on meat quality criteria and carcass weight of pigs kept under outdoor farming conditions. Agric. Med., 134: 68–76.
Urquhart G.M., Armour J., Duncan J.L., Dunn A.M., Jennings F.W. (1996). Veterinary parasitology. Oxford, UK, Blackwell Science Ltd. Second edition, 307 pp.
Várady M., Petersen M.B., Bjørn H., Nansen P. (1996). The efficacy of ivermectin against nodular worms of pigs: the response to treatment using three different dose levels against *Oesophagostomum dentatum* and *Oesophagostmomum quadrispinulatum*. Int. J. Parasitol., 26: 369–374.
Yadav A.K., Tandon V. (1993). SEM structure of *Bourgelatia diducta* (Nematoda, Chabertiidae). Acta Parasitol., 38: 128–130.
Yamaguti S. (1954). Studies on the helminth fauna of Japan. Part 51. Mammalian nematodes, V. Acta Med. Okayama, 9: 105–121.

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Oesophagostominae (Nematoda: Chabertiidae) u świniowatych z Polski południowej

STRESZCZENIE

Do niedawna rodzaj *Oesophagostomum* stanowił jedyne nicienie z Oesophagostominae pasożytujące powszechnie zarówno u domowych, jak i dzikich europejskich świniowatych. Kilka lat temu w popu-

lacji dzików z południowej Polski stwierdzono obcego nicienia *Bourgelatia diducta* należącego do tej podrodziny, a za wprowadzenie pasożyta pochodzącego z Dalekiego Wschodu zostały obwinione wietnamskie świnie zwisłobrzuche. Oprócz dzików chowanych w celu produkcji mięsa, w ekstensywnym lub ekologicznym chowie oraz w gospodarstwach agroturystycznych utrzymywane mogą być też świnie wietnamskie, co stanowi zagrożenie zarażeniem świń domowych. Celem przeprowadzonych badań było określenie i porównanie składu gatunkowego Oesophagostominae u dzików z przyrody oraz świń domowych z małych gospodarstw rolnych zlokalizowanych na terenie, gdzie poprzednio po raz pierwszy odnotowano występowanie *B. diducta*.

W okresie jesienno-zimowym 2010–2011 przebadano sekcyjnie 25 dzików i 20 świń domowych pochodzących z różnych gospodarstw. W jelicie grubym świń został stwierdzony *Oesophagostomum dentatum* ze współistniejącym *O. quadrispinulatum*, podczas gdy u dzików odnotowano jedynie zarażenie *Bourgelatia diducta*. Wszystkie pasożyty występowały powszechnie u swych żywicieli, z ekstensywnością zarażenia odpowiednio na poziomie 80, 50 i 32% dla *O. dentatum*, *O. quadrispinulatum* i *B. diducta*. Średnia intensywność zarażenia była wielokrotnie wyższa u świń, osiągając 181 (od 1 do 2500) pasożytów u pojedynczych żywicieli, w porównaniu do 3 (1–6) pasożytów spotykanych u dzików. W pracy przedstawiono możliwy wpływ obcego nicienia na populacje dzika europejskiego oraz potencjalne możliwości dalszego rozprzestrzeniania się pasożyta.