Appearance of the large American liver fluke

*Fascioloides magna* (Bassi, 1875) (Trematoda: Fasciolata) in Hungary

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Abstract: *Fascioloides magna*, the large American liver fluke of cervids was found in the northwestern corner of Hungary for the first time. At necropsy, the liver of a red deer (*Cervus elaphus*) was found to contain 10 almost adult flukes. Faecal examination revealed *F. magna* eggs in 11 out of 15 droppings randomly collected in the natural habitat. The hunters assume that almost every red deer living in the area in question carries this fluke. The infected deer population lives freely in an area near the River Danube, where the parasite’s European intermediate host, the dwarf pond snail (*Lymnaea truncatula*) is very common along the branches of the river. The risk of spread of this parasite via snails and through trade in cervids is emphasized.

**Key words:** *Fascioloides magna*, red deer, first occurrence, Hungary, pathology, epizootiology

**INTRODUCTION**

The discovery of the large American liver fluke (*Fascioloides magna*) well illustrated the easy spread of endoparasites. This New World flatworm was first described by Bassi from an outbreak among cervids of the royal game reserve near Turin in 1875, well before its discovery in America (Malek 1980). Already the author of the first description concluded that this fluke must have been introduced into the game reserve by American wapitis; however, the general prevalence of the pathogen in North America was demonstrated only later. The potential definitive hosts of that liver fluke are cervids of the Northern hemisphere (elk, red deer, wapiti, white-tailed and black-tailed deer, fallow deer, roe-deer, Sika deer, sambar deer, reindeer, etc.), all of which may shed this fluke’s eggs capable of embryonation (Soulsby 1965). However, only the American deer species are natural carriers of this helminth; its ability to infect European cervids is known only from accidental or experimental cases following its introduction (Erhardová-Kotrlá and Blazek 1970, Erhardová-Kotrlá 1971). Accord-
ingly, while *F. magna* is widespread in North America, in the Old World it has only been reported from Italy, Germany, Austria, Slovenia and Czechoslovakia as a consequence of an introduction of uncertain date (Malek 1980, Pfeiffer 1982, Boch and Supperer 1983). As a consequence of the natural movement of big game, it was expected that this parasite would spread to other countries of Europe. Its unnoticed spread is facilitated by the fact that the large liver fluke is usually not too pathogenic in cervids, which prevents the early diagnosis of clinically inapparent infections. In contrast, hollow-horned ruminants, pigs, horses and some rodents are paratenic hosts of the helminth or, rather, they do not or only exceptionally shed eggs of the fluke, and the outcome of *F. magna* infection is in most cases fatal in these species. Sheep are especially susceptible to *F. magna* invasion and usually die already in the acute stage (Price 1953, Erhardová-Kotrlá and Blazek 1970, Foreyt and Todd 1976a).

All these facts underscore the importance of the recent finding that deer infected by *F. magna* occur also in Hungary. A remarkable feature of this finding is that the infected deer were found in the Szigetköz, an area in northwestern Hungary, whose changing structure and status of wildlife are nowadays a matter of great concern both to environmentalists and to the general public.

**CASE REPORT**

It was about 3 years ago that during the evisceration of red deer (*Cervus elaphus*) bagged in the Szigetköz area, between Dunaremete and Győr, hunters first noticed the presence of a large fluke in the liver of some animals. Organs were submitted to the laboratory of the Veterinary and Food Control Station of Győr-Sopron County, where *F. magna* infection was diagnosed by the laboratory specialists. The importance of this new fluke infestation prompted the veterinarians of the Central Veterinary Institute to initiate confirmative examinations in order to collect fluke specimens furnishing conclusive evidence, as well as to record to prevalence of infection.

At the Institute's request, in late March of the subsequent year, a hind was bagged on the basis of a separate bagging licence outside the hunting season. The liver of that animal was submitted to the institute. The thickened, whitish Glisson's capsule of the partially lacerated liver, which had originally weighed approx. 4 kg, was covered by outgrowths measuring 1-2 cm and consisting of tough fibres, primarily on the portal surface facing the rumen. White connective tissue fibres could be seen on the entire surface of the organ; these fibres connected the flattened hepatic lobes of otherwise normal shape, or continued in the fibre network of the omentum or the parietal peritoneum. The liver was tense and compact to the touch, and softer foci the size of a nut were seen indistinctly protruding over its surface on all sides. On the cut surface of the pale brown liver parenchyma a non-confluent, blackish-brownish discolouration was seen, which resembled a nutmeg pattern of ragged distribution, but was much rougher and less distinct than that. Here and there, pigmentation was accompanied by connective tissue proliferation; however, neither pigmentation nor connective
tissue proliferation proceeded along either the blood vessels or the bile ducts. The nut-sized foci seen in the liver proved to be connective tissue cysts of 3-5 mm wall thickness. The wall of the cyst became inseparably attached to the parenchyma, and its lumen was filled with a reddish-brown to blackish-brown, slightly granular substance of indistinct structure and resembling a blood clot in consistency. Each of these cysts was at least 3-4 cm in diameter; they often formed coalescing lacunae and were grouped primarily around the hepatic portal. Because of the coalescence, the exact number of the cysts could not be determined. While the majority of the cysts contained only the necrotic debris described above, from some of them flukes of large size could be squeezed out. The lumen of the cysts communicated with the larger bile ducts. A total of 10 flukes could be collected from the liver. The flukes occurred exclusively within the cysts, and at least 6 specimens were seen in the cyst lumen in pairs. The absence of the gallbladder prevented us from examining its content.

All of the large flukes removed from the liver belonged to the species *F. magna*. The liver contained no other flukes or other parasite species. Some measurements of the flukes removed from the liver are shown in Table 1. Only one of the flukes, the biggest specimen, had a shape typical of adult *F. magna*, i.e. having a rounded tail end and a blunt cephalic end. The other specimens were more slender and had more tapered ends, thus resembled the fluke *Fasciola gigantica* in shape but were thicker than that. None of the animals contained mature eggs, and such eggs could neither be demonstrated from the tissue debris present in the cysts seen in the liver. The helminths' multibranched intestines were filled with a reddish-brown substance similar to the tissue debris present in the liver cysts. The intestinal branches around the oral sucker displayed the fine ramification typical of the species, which could be used for distinguishing the species from members of the genus *Fasciola*. Although the sexual organs, including the vitellaria, were at a stage preceding full development even in the biggest fluke specimen, in histological sections of the helminths it could be demonstrated that vitellaria developed only on the ventral side of the caecal branches, as opposed to *Fasciola hepatica* and *Fasciola gigantica* in which they develop both ventrally and dorsally. The opercular suture was clearly distinguishable on the colourless, oval-shaped, 178-180 μm long eggs collected from the uterus of the biggest fluke specimen; however, the egg-shell thickening characteristic of mature eggs was not yet discernible. Thin-walled eggs tended to undergo deformation; many of them had a tapering, deformed operculum.

Prompted by the fact that we found such a severe infection in a single hind bagged at random, we wished to determine the prevalence of *F. magna* infection in deer living in the Szigetköz region. Therefore, we asked game wardens to collect deer droppings for parasitological examination. In mid-April 1994, 15 such samples were collected in the region of Dunaremete and Lipót. The samples were processed by routine parasitological examination methods used at the Central Veterinary Institute. Using a 5-gram amount of sample, we performed coprological examination using Benedek's egg enrichment by sedimentation and a combined zinc sulphate floatation procedure (Majoros 1986, Nemeséri and Holló 1972). As all the samples were derived from deer
droppings that had been lying on the ground for several days, they contained numerous free-living protozoans, rotifers and nematodes; however, the eggs and larvae of parasitic nematodes could not be detected in them. Eleven out of the 15 faecal samples contained *F. magna* eggs, all of them in a quantity less than 50 eggs/gram. The mature, 120-160 μm long, dark yellow eggs found in the faeces resembled the eggs of the common liver fluke (*F. hepatica*) in shape but were of darker colour than the latter. The opercular suture could be seen on the eggs only exceptionally. The wall of the eggs was thicker than that of *F. hepatica* eggs. A circumscribed thickening of the egg-shell could be seen at both ends. The yolk material of the egg filled the lumen of the egg-shell in the form of rough spherical granules 15-20 μm in diameter, making the eggs similar to those of the rumen fluke (*Paramphistomum*). Two of the samples also contained *Paramphistomum* eggs.

Table 1

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* The oral end of older flukes undergoes relative shortening during growth; therefore, the distance between the cephalic and the abdominal sucker does not increase in direct relation to body length. According to American authors, adult flukes may reach 100 mm in length and 37 mm in width (Malek 1980). The maximum size of European specimens is 70 x 40 mm (Kotrlá and Kotrlý 1980). The shape and size of the fluke probably depend also on the host species.

DISCUSSION

The examinations performed and the observations made so far suggest that *F. magna* infection of deer living in the Szigetköz area is an infection of not very old standing: it cannot have appeared more than a few years ago. In view of the data available on the spread of this fluke in Europe, the parasite must have been introduced into the Szigetköz region by deer moving across the border between Slovakia and Hungary. Besides the fact that such flukes had not been found in Hungary until that
time, this assumption is supported also by the fact that a fairly large number of Slovakian deer were driven to the Hungarian side during the construction of the power canal of the Bös hydroelectric power plant. According to the game wardens, these animals differ from those belonging to the Szigetköz deer population in their colour and form of antlers. As in Czechoslovakia F. magna infection has been known to occur at least since 1960 in several species of deer living in areas close to the Hungarian border (Kotrlá et al. 1984, Kotrly and Kotrlá 1980), the fluke is most likely to have migrated into Hungary from the North, most probably directly via the deer arriving from there. Theoretically, the fluke may have been brought to Hungarian territory not only by deer but also by the intermediate host snails carried away by flood, although in these snails it cannot survive for more than a few months.

Here we mention that although in connection with a parasitological survey using questionnaires Kassai and Békési (1993) reported the occurrence of F. magna in Hajdú-Bihar county, that case has not been investigated; thus, it is not known whether that observation was based on the examination of organs from an animal bagged in that region or on that of a liver derived from another area. As, according to data of the Veterinary Institute of Debrecen, the flukes found in that case were not submitted to the laboratory and nor were the circumstances of the observation documented, we could not ascertain whether this fluke actually occurred in that area.

On the other hand, hunters have repeatedly seen flukes in Szigetköz deer for about three years; however, they have regarded them as common liver fluke and, thus, have not attached great importance to them. This is not surprising if we consider that in Eurasian deer F. magna usually grows to a smaller size than in American deer, and it may differ from the latter also in shape. According to Kotrlá and Kotrly (1980) this phenomenon, occurring in a non-indigenous host and in a new habitat, may sometimes render accurate species identification more difficult. By now the fluke seems to have grown to such high numbers that, according to the game wardens, the decisive majority of bagged deer carry it. The high prevalence of F. magna infection is indicated also by the high ratio of egg-containing droppings. The presence of roughly even-aged flukes found in the liver of the deer examined by us indicates that until its bagging the given animal had been infected by flukes on a single occasion only. Considering this, the intensity of its infection seems to be very high, as even the parasite’s natural host, the white-tailed deer (Odocoileus virginianus) living in its original habitat usually harbours not more than five flukes (Foreyt et al. 1977). The pairing tendency observed also by us, i.e. the occurrence of flukes in pairs in a cavity formed around them, was demonstrated also in white-tailed deer (Foreyt et al. 1977). From the point of view of adaptation, the advantage of pairing may be the facilitation of mutual fertilization.

F. magna infection of the deer population living in the Szigetköz region has dual importance. On the one hand, it poses the risk of further spread of infection in the game population. Eggs may overwinter in the outworld (Erhardová 1965) and may be carried away by water to distant places. The Lymnaea species acting as intermediate hosts are very common in that faunal region. This is especially true for Lymnaea truncatula, which is the most suitable intermediate host for the development of F.
magna in Europe (Erhardová-Kotrlá 1968). In America, several water-snail species belonging to the Lymnaea s. str. subgenus have been demonstrated to act as potential intermediate hosts for the large liver fluke of deer (Griffiths 1955, 1959, 1973, Malek 1980). The European representatives of this group of species are indigenous also in Hungary, and they are especially common in the Szigetköz and along the River Danube (Pintér and Szigethy 1979). Therefore, it can by no means be excluded that, besides Lymnaea truncatula, occasionally also other Lymnaea spp. occurring in Hungary may serve as a subject for the helminth’s parthenogenetic development. Depending on the ambient temperature, the developmental stages of F. magna can persist in these snails for some months or even for a half year. In frost-free places the metacercariae of F. magna may overwinter and may remain viable for as long as a year (Griffiths and Christensen 1972, 1974). After even a single successful infection, infected deer will shed fluke eggs from the fluke-containing cysts through the biliary ducts practically throughout the remainder of their life (Foreyt et al. 1977). Although the fertility of eggs produced by old flukes decreases (Erhardová-Kotrlá 1968), due to the helminths’ high egg-producing capacity the deer, even those infected on a single occasion, can always shed viable eggs. From all this a slow spread of F. magna infection in the Danube valley can be anticipated. Because of its proximity, the big game population of the Hanság area is also at risk; in addition, through artificial transfers of big game the fluke may be carried to other regions of Hungary as well.

Both roe-deer and deer are definitive hosts of the large American liver fluke; shedding viable fluke eggs, they may spread the infection throughout their entire range of occurrence (Kotrly and Kotrlá 1980). The wild boar (Sus scrofa) and naturally also the domestic pig act as paratenic hosts of the fluke. Although these species not shed fluke eggs (Foreyt et al. 1975), F. magna causes severe liver lesions. In Hungary, the fallow deer (Dama dama) originally considered an exotic species, is also at risk of F. magna infection, as it is highly susceptible to that fluke (Erhardová-Kotrlá and Blazek 1970, Pfeiffer 1982). The rich animal population of game preserves and deer forests, comprising a multitude of antlered species, provides an ideal medium for the proliferation of infection (Kotrly and Kotrlá 1977). All things considered, large American liver fluke infestation is usually not fatal to game living in the forest; however, this fact also means that the conditions necessary for parasite persistence are available in that environment.

The other reason why the large American liver fluke is important, is its role in infecting domestic animals. The fluke, developing within a closed cyst, produces chronic liver lesions in cattle (Price 1953). In this host the maturation process and egg laying may occur even 20 weeks after inoculation (Foreyt 1988), but the eggs can leave the liver only in case of very severe infections because of the closed cyst. Therefore, cattle do not regularly shed F. magna eggs but sustain more damage through that infection than cervids. (In the fourth edition of their basic parasitological book, Boch and Supperer (1992) stated that the patent period of this fluke in cattle might last as long as five years; however, we could not find any original papers or published data about this phenomenon.) Sheep and goats invariably succumb to F. magna infection.
at an early stage; thus, chronic lesions and mature flukes usually do not develop in these species (Stromberg et al. 1985a). Although potential egg shedding by sheep was described as an exceptional case (Campbell and Todd 1955), because of its rare occurrence this has, fortunately, no epizootiologic importance. Domestic swine react to *F. magna* infection in a manner similar to the wild boar. Although domestic animals rarely stay in areas visited by game, because of the mostly symptomless helminth-carrier status of game animals the infection may extend to large areas and, hence, it may occasionally pose a risk to domestic animals. As, apart from exceptional cases, no domestic animal species sheds eggs of the large American liver fluke in its faeces, by diagnostic faecal examination the infection of domestic animals cannot be demonstrated *in vivo* (Soulsby 1965).

Despite the fact that liver flukes themselves are not strictly host specific (Foreyt and Todd 1976b), in the United States *F. magna* infection of deer is both epizootiologically and ecologically distinct from *Fasciola hepatica* infection of domestic animals, perhaps due to the fact that deer are indigenous on the American continent while domestic animals were introduced to it. Nevertheless, mixed fluke infections do occur in both host groups, but especially in cattle (Foreyt and Todd 1972). Since mixed infection may occur also in the European ungulate species which are of "chaotic" origin, *in vivo* diagnosis by coprological examination cannot always offer essential proof of the existence or absence of infection. The yellow fluke eggs shed by cervids cannot be differentiated with absolute certainty on a morphological basis and, as has been mentioned above, from domestic animals only the eggs of flukes belonging to the genus *Fasciola* can be demonstrated.

In view of these facts, the prevalence of *F. magna* can be monitored only by the regular examination of the liver and droppings of antlered game. Initially this does not appear to be a simple task, as the pathogen is insufficiently known in Hungary and because hunting as an activity is not aimed at surveying the health status of animals. It is difficult to make realistic predictions as to the future fate of *F. magna* infection in Hungary; however, two premises can, and have to, be outlined. If the scope of free movement of the big game population, including the Szigetkőz deer, will be restricted and individual stocks will become isolated from each other, a local increase of the fluke population can be reckoned with, as the risk of infection of snails will be higher within a given area. In that case *F. magna* infection is likely to manifest itself in a clinically apparent form in big game. If, however, changes disturbing the living-space (e.g. in the Szigetkőz area) lead to a more intensive movement and transmigration of trophyed game, the inapparent form of infection may disperse throughout a large area. In that case there will be no local increase in the number of fluke eggs present in the droppings; hence, the risk of infection of snails will be lower, but the expanded scope of game movement will expose domestic animals to a risk of infection. *F. magna* infection of the big game population entails unforeseeable consequences as to the condition of trophies. In Hungary this has outstanding importance, as our antlered big game (red deer, fallow deer, roe-deer) have long been known as animals carrying trophies which belong to the world's best as far as quality is concerned. Although *F.*
F. magna will certainly not cause a pathological condition of fatal outcome in Hungarian deer either, by impairing the animals' natural resistance it may lead to a loss of condition and a consequent deterioration of the trophy in value.

Under the present conditions no effective measures can be taken to control the spread of the large American liver fluke. Theoretically, drug therapy could be used; however, for entirely free-moving game this approach is unfeasible. In other countries the following two different treatment approaches are recommended for the control of fluke infestation in cervids.

The approach considered to be more effective requires immobilization of the animals with an immobilizing bullet and intraruminal drenching of a suitable anthelmintic, followed by a 30-day quarantine period (!) until complete excretion of helminth eggs. Although such administration of an anthelmintic is rather expensive and involves a risk to the animals, it gives almost 100% efficacy if triclabendazole, a compound known to have excellent activity against F. magna (Pybus et al. 1991), is used. Despite its efficacy, this method is an unlikely candidate for use in areas other than game preserves with a game population kept in an enclosed area, as a very high proportion of deer living in a given area would have to be captured for a successful control of infection. This would involve enormous costs, rendering this approach of fluke control uneconomical.

Free-ranging trophied game showing only spontaneous territoriality can only be medicated with anthelmintics mixed in bait or feed. This method will be effective only if there is no abundance of feed in the given area, or if the animals regularly visit the feeders for some other reason, thus taking up the required dose of drug with high reliability. The efficiency of medication with anthelmintic-containing bait is far lower than that of individual treatment; hence, the 63% reduction achieved by such medication in F. magna infection of white-tailed deer can be considered a fairly good result (Qureshi et al. 1994). This form of medication requires the use of an anthelmintic of very low toxicity, as the feed intake of individual game specimens living in herds is not equal because of the hierarchy existing within the herd. With such medication it is an important requirement that animals occupying a higher rank in the hierarchy should not take up toxic amounts of drug even with the higher amount of feed consumed; at the same time, animals having lower ranks in the hierarchy should also have access to an effective dose of drug with the feed left over by the others. This principle can only be met in a satisfactory manner by administering an anthelmintic at a low dose for a long time. Apart from the technical difficulties, prolonged medication also poses the problem of drug residues accumulating in the meat.

Theoretically, domestic animals can be treated with different fasciolicides without any difficulty also in the case of F. magna infection. However, it must be kept in view that for destruction of the flukes living in a thick connective tissue capsule the common fasciolicides must be used at multiples of their normal dose. That dose is often close to the toxic level even in the case of individual treatment, not to speak of the potential adverse consequences of group medication used for free-ranging deer. Triclabendazole was used for treating F. magna infection in white-tailed deer at a dose
of 11 mg/kg body mass/day, on two consecutive days (Qureshi et al. 1994). In cattle, that dose is sufficient for a single treatment. In wapiti, which has a body size comparable to that of the European deer, the single, positively effective dose of triclabendazole has been set at 50-60 mg/kg body mass (Pybus et al. 1991). Taking into consideration the body mass ratios, this dose is not much lower than the 200 mg/kg body mass level reported to be toxic for sheep. Oxyclozanide and hexachlorophene have been tried out in white-tailed deer (Odocoileus virginianus) with good results (Foreyt and Todd 1973, Foreyt and Todd 1976c). Rofloxanide in most cases killed only the young flukes, while nitroxynil prevented egg production only during the time of medication. Dioxanide, diamphenetidc and hexachloroethane proved to be ineffective. Albendazole, which is often used for treating different helminthoses in Hungary, was also found to be effective against the large American liver fluke both in white-tailed deer and in cattle (Foreyt and Drave 1978, Ronald et al. 1979). For satisfactory efficacy, this anthelmintic must be used at a dose of approx. 25-45 mg/kg body mass, i.e. at a dose much higher than that used for nematode control. The efficacy of closantel and clorsulon against this parasite has only been investigated in the domestic cattle and sheep. Closantel was completely effective against 8-week-old flukes at a dose of 20 mg/kg of body mass per os (Stromberg et al. 1984, Stromberg et al. 1985b). At the same time, clorsulon was effective at a dosages of 7 and 21 mg/kg of body mass in 65 and 100 %, respectively. However, it was less effective against 16-week-old flukes (Foreyt 1988).

Initial eradication of the fluke could theoretically be accomplished by bagging of the entire game population in question. However, such an approach would be unfeasible not only on ethical and economic grounds, but also because the actual boundaries of infection are unknown and as that solution would not eliminate the risk of repeated introduction. Therefore, it seems to be highly probable that we will have to “coexist” with another exotic parasite, with all of its animal health implications, and to watch its gradual acclimatization in this new habitat. At any rate, from now on it will be advisable to perform faecal examination of cervids to be introduced to a new area or into a game preserve, even if we know that not even this in vivo testing method is absolutely reliable because of the incidental nature of egg shedding and the possible occurrence of young flukes not producing eggs.

Majoros, G. és Sztojkov, V: A Fascioloides magna (Bassi, 1875) (Trematoda: Fasciolata) métely megjelenése Magyarországon

A szerzők a nagy amerikai májmétely (Fascioloides magna) első magyarországi előfordulásáról számolnak be. A Szigetközben (Északnyugat-Magyarország) elejtett gímszarvastehén (Cervus elaphus) kórbonctani vizsgálata során a máj 10 esetben teljesen kifejlett mételyt tartalmazott. A természetes élőhelyről gyűjtött 15 bélsár- (hullaték-) mintha közül 11 tartalmazott E. magna petéket. A vadászok feltételezése szerint a szigetközi gímszarvaskos mindegyike hordozza ezt a métetyt. A fertőzött szarvaspopuláció a Duna közelében él, ahol a métely köztigazdádójaként szereplő törpe iszapesiga (Lymnaea truncatula) nagy számban fordul elő. A szerzők a parazita magyarországi terjedésének veszélyeit és módjait tárgyalják.
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