Dicrocoeliosis – the Present State of Knowledge with Respect to Wildlife Species

L. DUCHÁČEK, J. LAMKA

Department Pharmacology and Toxicology, Faculty of Pharmacy in Hradec Králové, Charles University in Prague, Czech Republic

Received April 16, 2003
Accepted September 22, 2003

Abstract

Ducháček L., J. Lamka*: Dicrocoeliosis – the Present State of Knowledge with Respect to Wildlife Species.* Acta Vet. Brno 2003, 72: 613-626.

The present paper summarizes contemporary knowledge concerning dicrocoeliosis (chronic disease of the liver caused by the lancet fluke *Dicrocoelium dendriticum*) as to its spraed, etiology, life cycle, epidemiology, pathogenesis, immunogenesis, clinical symptoms, diagnostics, therapy, prevention of dicrocoeliosis, and human infection. The major part of published data is connected with farm animal husbandry, dicrocoeliosis of wildlife species is examined to a limited extent only. Although dicrocoeliosis is intensively studied, numerous aspects of this trematodosis have to be verified. Control of dicrocoeliosis in domesticated and wildlife species is not fully effective at present.

Dicrocoelium dendriticum, lancet fluke

Dicrocoeliosis is a helmithosis caused by the lancet fluke *Dicrocoelium dendriticum* Rudolphi, 1819 (*D. dendriticum,* syn. *D. lanceolatum, Dicrocoelidae, Platyhelminthes*), parasitizing in the liver of ruminants as well as many other animals species including man. This parasitosis belongs to the six principal and economically most important pasture helminthoses of sheep and cattle–trichostrongylidosis, dictyocaulosis, protostrongylidosis, moniesiosis, fasciolosis, and dicrocoeliosis (Hiepe 1994). Parasitosis accompanies man and farm animals breeding from time immemorial. The eggs of *D. dendriticum* were found in the coprolites and paleofaeces of the prehistoric human population in Central Europe. Nevertheless, it is not certain whether the lancet fluke *D. dendriticum* was a real parasite, or whether the found eggs indicate pseudoparasitism after consummation of animal liver (Aspöck et al. 1999).

Spread of dicrocoeliosis

Dicrocoeliosis occurs in both pasture-bred and wildlife species throughout the world. The disease is common in those regions of Europe, Asia, North Africa and America, where the local conditions are favourable for certain species of earth snails and ants as intermediate hosts. Such regions in Europe are, e.g., mountain pastures of Alpine, Scandinavian and Mediterranean countries (Eckert and Hertzberg 1994); in Bohemia and Moravia (Czech Republic) dicrocoeliosis occurs in the regions with pasture breeding of ruminants, but its prevalence does not exceed 1% (Jurášek and Dubinský 1993). It occurs in central and southern Bohemia as well as southern Moravia (Kotrlá et al. 1984). Lietava (1984) evaluated the prevalence of dicrocoeliosis in the region of Central Slovakia, which amounted to 54.8%. Extensity of dicrocoeliosis in the northern part of central and eastern Slovakia ranged from 8% to 54% (Filo et al. 1986). In Hungary dicrocoeliosis ranks among the most frequently occurring parasitoses with the prevalence of 21% (Kassai and Bekesi 1993). In Germany in the region of Frankfurt/Oder Stuhrberg et al. (1975) report the

Address for correspondence:
MVDr. Lubomír Ducháček
Faculty of Pharmacy, Charles University in Prague
Heyrovského 1203, 500 05 Hradec Králové,
Czech Republic

Phone: +420 495 067 353
Fax: + 420 495 514 373
E-mail:duchacek@faf.cuni.cz
http://www.vfu.cz/acta-vet/actavet.htm

prevalence of 31.5% in sheep. In the same region Schuster et al. (1991) describe the intensity of ovine infection within a range of 394-1849 trematodes. The endoparasitic fauna in the region of Swabian Alb (Germany) was investigated by Rehbein et al. (1998) and they demonstrated infection with *D. dendriticum* in all animals examined. In Spain in the province of Leon, Manga-González et al. (1991) report the prevalence of 63.6% in sheep, Ferre et al. (1994) the prevalence of 26.7%, and González-Lanza et al. (1993) in the same province the prevalence of 37.6% in cattle. The immunity rate of infestation in Switzerland is reported by König and Gottstein (1997) as 44.7% in sheep and 31.4 % in cattle. Cringoli et al. (2002) found 53.1% of bovine and 67.5% of caprine farms positive in region of southern Apennines. Findings of flukes in goats were also described by Chartier and Reche (1992) in the southern part of the region of Poitou-Charentes in France. Gargili et al. (1999) found 23.5% prevalence in sheep and 2.6% prevalence in goats in Trakya (the European part of Turkey). The immunity rate of sheep and goats in Himachal Pradesh (India) was examined by Jithendran and Bhat (1996). Coprological studies in these migrating animals revealed 8.1% of positive sheep and 4.1% of infected goats. According to Kassai (1999), dicrocoeliosis does not occur in Australia at present. Jurášek and Dubinský (1993), however report its occurrence as the result of introduction. Causative agent of dicrocoeliosis known from southern Africa is *Dicrocoelium hospes*, Looss, 1907 (Eckert et al. 1992).

In Europe the parasitosis occurs ubiquitarily in wildlife species (Kutzer 1997). It has been reported to occur in a population of moufflon in Spain (Lavin et al. 1998), Bulgaria (Nahlik et al. 1996), and there has been isolated findings in moufflon and fallow deer in Hungary (Andras 1995; Takacs 2000). Dicrocoeliosis has occasionally been found in chamois in Slovakia and in Japan (Ciberej et al. 1997; Nakamura et al. 1984), roe deer in Switzerland (Nesvadba 2000b), and in hare in Finland (Soveri and Valtonen 1983). In moufflon of the former Czechoslovakia Dyk and Chroust (1973) have reported the prevalence of dicrocoeliosis in two localities in the area of Blansko at the prevalences of 100% a 73.6%. Lochman et al. (1979) report it occurrence virtually in all regions with moufflons in this country and in several localities with red deer, fallow deer, roe deer, and white-tailed deer, too. It has also been found in hare and wild rabbit (Páv et al. 1981). Chroust (2001) has reported the prevalence of dicrocoeliosis in moufflons in a range of 0-89%, in chamois 0-11%, and in roe deer 0-12%.

Causative agent

The adult fluke is dorsoventrally flattened, of lanceolate shape, transparent, 5-15 mm long, and 1.5-3 mm wide. The parasite is localized in the biliary tract and the gall bladder, or in the outlet of the pancreas. The life cycle of lancet fluke lasts six and more months (Kassai 1999). Kirkwood and Peirce (1971) obtained from two slaughtered sheep, which had been kept without a possibility of reinfection for six years, 365 and 189 adults. The eggs of these flukes were still viable.

The eggs of *D. dendriticum* are oval-shaped, dark brown, and very small (36-45 × 20-30 μm). They have a lid and contain a mature miracidium. They are highly resistant to the action of low or high temperatures and drying, they can winter and survive on the pastures for at least 10-12 months (Odening 1969). Alunda and Rojo-Vázquez (1984) examined the effect of some abiotic factors on the survival of the eggs of *D. dendriticum* under laboratory conditions. The highest mortality of eggs was observed at a relative density of 75-80% and at a temperature higher than 18 °C. The authors concluded their paper with a persuasion that the principal cause of the mortality of the eggs could be the action of some microorganisms. Alunda and Rojo-Vázquez (1983) carried out also studies of the survival and infectivity of the eggs of *D. dendriticum* in ground conditions. They assumed that mortality of the eggs was independent of their age, but that there was a marked effect of the season of the year. Studies of infectivity of the eggs of *D. dendriticum* by means of experimental infection of suitable intermediate hosts showed that there was no decrease in the infectivity of eggs in the course of the experiment (15 months).

Spectrum of definitive hosts

The definitive hosts are various species of mammals, in particular the sheep, goat, cattle, moufflon, red deer, fallow deer, white-tailed deer, roe deer, buffalo, camel, hare, rabbit, as well as the horse, pig, dog, rodents, and man (Kassai 1999; Eckert et al. 1992; Lochman et al. 1979; Jíra 1998). Isolated findings have been reported in the donkey (Demir et al. 1995), yak (Ansari et al. 1989), chamois (Ciberej et al. 1997; Nakamura et al. 1984), and the cat (Nesvadba 2000a). *D. dendriticum* can exceptionally also parasitize in birds (Macko and Štefančíková 1996).

Life cycle

Two intermediate hosts are necessary for the development of the parasite (a triheteroxenous development). The first one is a terrestrial snail, which swallows eggs containing the miracidium in the fecal substrate. In experimental infection, 17.5-75% of snails were infected in this way (González-Lanza et al. 1997). More than 99 snail species were demonstrated to be intermediate hosts of *D. dendriticum* (Otranto and Traversa 2002). The asexual development, in the course of which the miracidium is transformed via sporocysts of the 1st and 2nd order into cercaria, takes 3-4 months (Kassai 1999). This period, however, fluctuates considerably in dependence on temperature (Eckert et al. 1992). When cercaria are completely mature they migrate from the hepato-pancreas to the pulmonary cavities with help of their tails, enzymatic products and stalets inside their oral suckers (Otranto and Traversa 2002). Cercaria are excreted by snails in mucous balls. They can be up to 2 mm in diameter and they contain up to 400 cercaria (Kotrlá et al. 1984). Otranto and Traversa (2002) document excretion of at least 5000 cercaria. Infected snails can winter and survive for a period of 2-3 years (Eckert et al. 1992). But according to Schuster (1992), the infection of snails with fluke interferes with their capability of reproduction and average life cycle. Schuster (1993) has also found that the majority of the snails *Helicella obvia* are infected in the autumn in the second year of their lives. The percentage of snails which contain daughter sporocysts is highest in spring. Expulsion of cercarial balls can be induced only in May and June. The viability of cercaria in this mucous aggregate lasts only for a few days (Eckert et al. 1992).

The second intermediate host is ant (*Formica* spp.) which swallows cercaria. They encyst in the body cavities of ants and within 1-2 months they develop into metacercaria. There can be even about 100 of them in one ant (Vrzgula and Jagoš 1986; Jurášek and Dubinský 1993). Schuster (1991) examined the factors influencing the intensity of the occurrence of metacercaria of *D. dendriticum*. He found a dependence of the intensity of infection on the length of ants, but not on the species of ants, or the period of their collection. Cercaria act on the nervous system (suboesophageal ganglion) of the intermediate host and make ants to remain on plant tops due to a cataleptic spasm, if the temperature is lower than 15 °C. The infected ants can thus be swallowed more easily by grazing definitive hosts (Kassai 1999). Behavioural aspects in ants as supplementary intermediate hosts of *D. dendriticum* were evaluated by Spindler et al. (1986). These authors investigated which parts of plants are attractive for infected ants and found that flowers were evidently preferred to other parts of plants. When examining ants during day hours, they found that with increasing temperature ants leave plants (they appear mainly at lower temperatures in the morning and in the evening), nevertheless in the period when temperature was highest, a certain percentage of ants still remained clinging to plants. They also examined the distances between the anthill and the sites with clinging ants and found that the majority of infected ants were found in the vicinity of the anthill (3.65 m from the anthill), but some of them were found even within 14 m from the anthill.

Infection of the definitive host of parasitosis commences when ants containing metacercaria are swallowed. Badie (1978) noticed that an increased number of clinging ants occurred in the period of rainfall, whereas the minimum was at high temperatures of the culminating summer. When the infected ant is swallowed by the host, young dicrocoelia migrate via *ductus choledochus* into the biliary ducts, but there is no parenchymatous migration in the liver (Kassai 1999). Metacercaria excyst from the ants due to the action of duodenal enzymes (Otranto and Traversa 2002). Alzieu and Ducos de Lahitte (1991), Hillyer and Hopla (1982), and Lochman et al. (1979) also report possible migration via the portal blood system. The prepatent period lasts 7-9 weeks, the whole life cycle then approximately 6 months (Kassai 1999). As the miracidium produces numerous sporocysts of the first and second generation, which subsequently give rise to cercaria (10-40 from one sporocysts), one egg can theoretically produce up to 400 000 of adults (Kotrlá et al. 1984).

Epidemiology

The important factors limiting presence of dicrocoeliosis (Otranto and Traversa 2002) are mainly:

1. The environmental and ecological factors;
2. The presence and aetiology of intermediate hosts;
3. The presence of definitive hosts.

Dicrocoeliosis occurs in large lowland or mountain pasture areas, which provide suitable conditions for the survival and development of the individual species of terrestrial snails and ants (Eckert and Hertzberg 1994). Intermediate hosts do not require damp surroundings and they can therefore occur in pastureland diffusely. The disease occurs mainly in drier regions with limestone subsoil (Jurášek and Dubinský 1993). Stuhrberg et al. (1975), however, draws attention to the fact that in Germany dicrocoeliosis is not only limited to mountainous limestone regions, but it also occurs in lowlands with a small amount of limestone in the brown-soil area of Frankfurt/Oder. On the other hand, potential intermediate hosts are known to occur in mountain pastures in the altitudes of 1800-2600 m in various countries (e. g., in Austria, Switzerland, and Spain) (Gebauer and Hohorst 1968; Meier 1987; Manga 1992). Mountain pastures are contaminated with the eggs of fluke mainly from infected domestic ruminants, but wild ruminants, rabbits, and hares can also contribute to the spread of infection (Boray 1985). Chroust (2001) in this connection also draws attention to the importance of the wild boar. It is the wildlife species infected with flukes that disseminates the germs also in the pastures shared with farm animals, thus becoming a significant factor in the maintenance of the localities of the disease and overall spread of dicrocoeliosis (Jurášek and Dubinský 1993). The eggs of *D. dendriticum* are capable of surviving in dry pastures for more than one year (Kassai 1999). Fluke eggs may over-winter and remain infective for up to 20 months on pastures (Otranto and Traversa 2002). The highest degree of excretion of eggs was observed by Manga-González et al. (1991) in sheep in the catchment basin of the river Porma in Spain in the winter period, similarly as González-Lanza et al. (1993) in the cattle in the same region in the autumn-winter period. Wintering of the developmental stages is possible in snails and ants (Kassai 1999). Studies carried out in lowland pastures in the northern part of Germany (Schuster and Neumann 1988) demonstrated that the degree of infection of snails after the spring peak was decreased in summer and increased again in autumn. The mentioned authors have demonstrated that ants containing infectious metacercaria are available for grazing animals particularly in spring at temperatures below 20 °C. That is why most infections of final hosts occur in the period April /May, but low infections are possible during the whole pasture period (Wolf 1976). González-Lanza et al. (1993) remark that the epidemiology of dicrocoeliosis does not depend only on behavioural factors of parasites and the etiology of the hosts, but also on local environmental and ecological factors.

Pathogenesis, immunogenesis, and clinical symptoms

In the first days of infection, when young flukes penetrate into the sites of definitive localization, angioectasis of central veins and portobiliary vessels take place. After the termination of the acute stage, chronic inflammation of the biliary ducts with marked proliferation of the connective tissue develops (Alzieu and Ducos de Lahitte 1991). The lumen of the biliary ducts is extended, their walls are thickened, and the mucosa is proliferated (Kutzer 1997). The walls of the biliary ducts show a picture of glandular hyperplasia, and desquamation of the mucosa is superficial (Rahko 1972). Irrespective of mechanical irritation due to the migration of flukes, pathological changes are attributed to the toxic effect of metabolic products released by parasites (Hillyer and Hopla 1982). Camara et al. (1995) investigated infiltration with inflammatory cells induced by the occurrence of flukes in the bovine liver. They found that an increase in the average number of monocytes and eosinophils corresponds with an increase in the number of flukes. On the other hand, such relationship was not observed in lymphocytes. Theodoridis et al. (1999) examined hematological values in sheep infected by *D. dendriticum*. With the exception of increased serum albumin in heavily infected animals (4800-8180 parasites), they did not find statistically significant deviations. Similar conclusions were drawn by Páv and Zajíček (1976) in clinical examinations of the blood of naturally infected moufflons. Small and moderate fluke infections take place subclinically. Serious long-lasting infection (over 5000 trematodes in sheep) causes total induration and cicatrization of the liver with chronic cholangitidis, extension of the biliary ducts, and fibrosis (Kassai 1999). Camara et al. (1996) evaluated the role of the number of parasites in the development of changes induced by flukes in the bovine liver tissue. According to their conclusions, the changes in the surface biliary ducts and lesions of liver cirrhosis were increased with the intensity of infection from 0 to 300 of *D. dendriticum*. With the intensity of infection of 301-600 flukes, they observed a decrease in their further development. Wolf et al. (1984) evaluated the regenerative capability of the ovine liver after the treatment of dicrocoeliosis. In the course of days 20-108 after treatment, they did not record unambiguous indices of hepatic regeneration. Sanchez-Campos et al. (1996) have demonstrated that experimental dicrocoeliosis produced an impairment of the capability of the hamster liver to metabolize drugs and xenobiotics. They also studied the effect of experimental dicrocoeliosis on the biliary function of the hamster liver (Sanchez-Campos et al. 1998). Their data suggest that enhancement in choleresis (excretion of bile by the liver cells) had a canalicular origin. In the study of biochemical changes caused by experimentally induced dicrocoeliosis in hamsters, they concluded that dicrocoeliosis resulted in oxidative hepatic damage (Sanchez-Campos 1999; Sanchez-Campos 2000). In humans, Jíra (1998) unequivocally distinguishes the stage of migration through the hepatic parenchyma and subsequent sedimentation in the biliary tract, in the same way as it is known in larger flukes.

With advancing age of animals, fluke infection is increased, often up to several hundred (Jurášek and Dubinský 1993). Dyk and Chroust (1973) observed the lowest findings in one-to four-year moufflons, in five-year-olds the findings were rapidly increased, the highest being in six-year olds. Nahlik et al. (1996) in the study of a moufflon population found that the intensity of dicrocoeliosis infection was higher in the middle-aged group

(4-7 years) and much higher in moufflon ewes of this group. The age of infected animals might influence the egg output rate, although further investigations are necessary (Manga-González et al. 1991). Sex has also been correlated to the sensitivity of definitive hosts to the lancet fluke. The higher rate of in females can be accounted for the fact that dairy heifers and cows graze for several seasons, acquiring infection, while steers and oxen may spend a considerable period of their live in extra natural conditions (Ducommun and Pfister 1991). In the definitive host, the parasites can persist up to 6 years and immunity does not play a role in the regulation and decrease of parasitic population (Kirkwood and Peirce 1971). González-Lanza et al. (2000) concluded that there was no direct relationship between the antibody level and intensity of infection. Although the antibody levels do not correlate with immunological protection of definitive hosts, their detection is important for immunodiagnosis (Otranto and Traversa 2002).

Clinical symptoms are not specific. The disease often takes place inapparently, in particular in older animals. In strong infections (several thousand individuals in sheep), the symptoms are often inexpressive in the form of anaemia, icterus, oedemas, body wasting, and decrease in the production of animals (Jurášek and Dubinský 1993). Most infections of cloven-hoofed game in hunting grounds also take place without any visible symptoms (Rakušan et al. 1998).

Diagnostics

Intravital diagnostics is carried out with the use of coprological examination methods of concentration of the eggs by means of sedimentation, or flotation. Flotation solutions of high specific density are employed. Rehbein et al. (1999) compared some techniques of counting of the eggs of *D. dendriticum* in faeces. The unambiguously best result was achieved with the use of a HgI_2/KI flotation solution (specific weight 1.44), whereas with the use of $ZnSO_4$ (specific weight 1.3 and 1.45) and K_2CO_3 (specific weight 1.45) flotation solutions markedly worse results were obtained. Sotiraki et al. (1999) examined the effect of stress on the intensity of egg excretion in sheep. They found that stressed animals excreted more eggs. Campo et al. (1999) reported that excretion of the eggs of *D. dendriticum* was higher in the samples of faeces withdrawn in the afternoon than in the samples withdrawn from the same animals in the morning. The number of eggs in one gram of faeces (EPG) correlates in naturally infected ewes with the intensity of infection (Rojo-Vázquez et al., 1981). This correlation was found also in experimentally infected lambs (Campo et al. 1999). Braun et al. (1995) compared findings of fluke eggs in liver, faeces, and bile. They found important differences among them, and the highest sensitivity was documented for bile. Rehbein et al. (2002) tested relationship of faecal egg, gall bladder egg, gall bladder fluke counts and number of *D. dendriticum* in naturally infected lambs and ewes. No correlation was found. Negative coprological finding is not always evidence of parasitological negativity (Campo et al. 1999). In experimentally infected lambs egg excretion started 49-79 days post infection.

Postmortem diagnostics is carried out on the basis of postmortem findings and in slaughterhouse inspection. Thickening and extension of the biliary ducts as well as hepatic induration are the most significant macroscopically observable changes in the liver in dicrocoeliosis. In the thickened biliary ducts there are numerous flukes of various sizes, which are sometimes located also in the gall bladder. When examining the bile sediment from the liver evaluated as suitable for consumption, Klimas et al. (1994) have found that not all cases of dicrocoeliosis can be recognised in the slaughterhouse inspection of meat and that the safety of the inspection is decreased with increasing prevalence of the disease. By comparing coprological results and necropsy of ovine and caprine liver the coprological method proved to detect the presence of dicrocoeliosis out in one out of three infected animals (Jithendran and Bhat 1996).

Differential diagnostics must differentiate lancet flukes from juvenile stages of a similar size located in the haemorrhagically changed hepatic parenchyma, which is important particularly when acute fasciolosis is suspected (Kassai 1999).

The diagnostic value of serologic tests for the detection of dicrocoeliosis in sheep and goats was estimated by Jithendran et al. (1996). Counter-current immunoelectrophoresis was evaluated as most sensitive. This specific and rapid test of epidemiological examination of sheep and goats makes it possible to diagnose dicrocoeliosis already in the prepatent period. The antibodies are detectable with help of ELISA test, too (Haralabidis 1987; Fioretti 1980). A high anti-*D. dendriticum* antibodies titre was detected 4-8 weeks before the appearance of eggs in faeces (Ambrosi et al. 1980). The IgG was detected by ELISA 19 and 23 days earlier than eggs in faeces, too (González-Lanza et al. 2000). ELISA detecting is important for epidemiological studies and early diagnosis of dicrocoeliosis leading to treatment and decreasing of economic losses (Otranto and Traversa 2002).

A useful tool for epidemiological studies of dicrocoeliosis can be the detection of metacercaria of *D. dendriticum* in ants (Heussler et al. 1998).

Treatment

Treatment is indicated only in severe infections. Due to the localization of flukes in the thinner biliary ducts, a number of antitrematodic agents in recommended doses do not exert sufficient efficacy on *D. dendriticum* and they must be administered repeatedly and in higher doses. Some benzimidazoles and probenzimidazoles are especially recommended, then there are pyrazinoisoquinoline derivatives (praziquantel) or halogenated salicylanilides (closantel) or some other agents (diamfenetide). An overall survey of generalized experience with pharmacotherapy of dicrocoeliosis in sheep is shown in Table 1. More detailed

Table 1
Drugs investigated against lancet fluke (*Dicrocoelium dendriticum*) in sheep (oral administration)

Drug	Daily dose (mg/kg body weight)	Therapeutic effect (%)	Reference
Albendazole	1 x 7,5–10	34–96	Theodorides and Freeman (1982), Čorba et al. (1988)
	1 x 15–20	90–100	Schuster and Hiepe (1993), Lazic et at. (1994)
	2 x 7,5 (1–2 week interval)	83–100	Cordero del Campillo et al. (1982) Lazic et al. (1994)
	2 10 (1 week interval)	90–95	Tharaldsen and Wethe (1980) Cordero del Campillo et al. (1982)
Fenbendazole	1 x 150	90	Düwel et al. (1975)
	5 x 15–25	87–99	Düwel et al. (1975), Čorba et al. (1981)
	10 x 5–10	68–97	Čorba et al. (1981)
Fenbendazole + triclabendazole	1 x 5–10	89–100	Čorba et al. (1988)
Thiabendazole	1 x 50–200	66–99	Macchioni et al. (1978)
Mebendazole	1 x 40–80	74–100	Ambrosi and Grelloni (1991)
Cambendazole	1 x 25	95	Čorba et al. (1978)
Luxabendazole	1 x 7,5–12,5	47–84	Kassai et al. (1988), Schusster and Hiepe (1993)
Netobimin	1 x 20	89–99	Schuster and Hiepe (1993)
Thiofanate	1 x 50	74–100	Onar (1990), Dorchies et al. (1988)
Thiofanate + broptianid	1 x 50 + 1 x 5–6	100	Tinar et al. (1988)
Praziquantel	1 x 30–50	52–98	Güralp et al. (1977), Wolff et al. (1984)
Diamfenetide	1 x 240–300	70–98	Daněk et al. (1987), Calamel et. al (1979)

information is given below in the text in the items concerning the individual active principles. The route of administration is oral (if not stated otherwise).

When studying the efficacy of albendazole in sheep, Lazic et al. (1994) found that a single oral dose of 15 mg/kg, or two doses of 7.5 mg/kg in a fifteen-day interval showed 100% efficacy against *D. dendriticum*. Schuster and Hiepe (1993) described more than 90% efficacy in a dose of 15 and 20 mg/kg. Tharaldsen and Wethe (1980) treated sheep with two doses of 10-12 mg/kg in a one-week interval, which decreased the number of eggs in faeces by approximately 90%. Himonas and Liakos (1980) described the efficacy of albendazole in a dose of 20 and 15 mg/kg against *D. dendriticum* in sheep (98.2 a 99.6%). Theodorides and Freeman (1982) demonstrated that albendazole in a dose of 7.5 mg/kg reduced the number of lancet flukes in sheep by 34. 1%, whereas a dose of 20 mg/kg reduced the number of flukes by 98.6%. Cordero del Campillo et al. (1982) demonstrated that a single dose of 7.5 mg/kg decreased the parasitic burden by 85.9%, two doses of 7.5 mg/kg after seven days showed a decrease between 82.4 and 85.5%, whereas two doses of 7.5 mg/kg after 14 days decreased the parasitic burden by 91.7%, that a single dose of 10 mg/kg of albendazole decreased the parasitic burden by 92.2%, and finally that two doses of 10 mg/kg in seven-day intervals showed a degree of reduction of parasites of 94.5%. Verification of the efficacy of albendazole was also carried out by Schuster et al. (1989). They found that the intensity of infection was reduced by 72.2 and 87.5% when administering 7.5 mg/kg and 10 mg/kg, respectively, and in another experiment they estimated the degrees of efficacy at 92.9 and 94.9% with the use of 15.0 and 20.0 mg/kg, respectively. Kassai and Fok (1985) achieved 83.4% efficacy on administering albendazole in a dose of 7.5 mg/kg, 83.0-86.3% efficacy in a dose of 10 mg/kg, and 86.3-100.0% efficacy in a dose of 15 mg/kg. Čorba et al. (1988) estimated the efficacy of a single-dose administration of 10 mg/kg at 95.9%. A relatively new alternative of treatment is intraruminal bolus. Boluses have been shown to decrease the excretion of the eggs of *D. dendriticum* in sheep by o 88.5% (Čorba et al. 1991), or by 91.8% (Čorba et al. 1994). The safety of ovine products and danger of parasite resistance to anthelminthics has to be taken into consideration in case of use of systems based on long-term releasing of drug (Otranto and Traversa 2002).

In sheep infected with *D. dendriticum*, the efficacy of fenbendazole with the use of a single oral of 150 mg/kg was about 90%, and with the use of five oral doses of 25 mg/kg the efficacy was about 98%. According to Düwel et al. (1975), the number of administrations of the drug is of greater importance than the total amount of the drug administered. Čorba et al. (1981) found that a ten-day administration of 5 mg/kg of fenbendazole showed 68.2% efficacy, whereas an administration of 10 mg/kg for a period of 10 days showed only 96.8% efficacy. A five-day administration of 15, 20, and 25 mg/kg produced 86.7%, 95.4%, and 98.9% efficacy, respectively. Čorba et al. (1988) also estimated the efficacy of a combined preparation of fenbendazole and triclabenbazole in a single dose of 5, 7.5, and 10 mg/kg at 89.9, 89.2, and 100%, respectively.

The treatment of sheep with a single oral dose luxabendazole of 10.0-12.5 mg/kg removed 63.2-83.8% of flukes (Kassai et al. 1988). Also Schuster and Hiepe (1993) reported that in a dose 7.5 and 10 mg/kg decreased the average number of flukes by only 47 and 59%, respectively.

The efficacy of thiabendazole doses 50, 100, and 200 mg/kg administered in sheep was estimated at 66.0, 80.7, and 98. 8% (Macchioni et al. 1978).

Ambrosi a Grelloni (1991) described that administrations mebendazole of 40 and 80 mg/kg in sheep were effective within a range of 74-85.4% and 93-99.4%, respectively.

Čorba et al. (1978) demonstrated 95.1% efficacy of a single administration of 25 mg/kg of cambendazole in sheep.

A dose of 20 mg/kg of orally administered netobimin drug induced 98.9% reduction of parasitic burden in sheep (Sanz et al. 1987), a dose of 15 mg/kg then 91.9% reduction (Rojo-Vázquez et al. 1989). According to Shuster and Hiepe (1993), a dose of 20 mg/kg resulted in 89% efficacy, and according to Čorba et al. (1993) then in 97.9% efficacy.

When estimating the anthelminthic efficacy of thiophanate in sheep with a dose of 50 mg/kg, 74.4% efficacy against *D. dendriticum* was found (Onar 1990). Dorchies et al. (1988) described 99.5%, 99.8%, and 100% efficacy of thiophanate administration at a dose of 50, 100, and 200 mg/kg, respectively, in sheep. The efficacy of 50 mg/kg of thiophanate in combination with brotianide (halogenated salicylanilide) at a dose of 5-6 mg/kg was estimated by Tinar et al. (1988) at 99.8%.

The study of Güralp et al. (1977) demonstrated that the therapeutic effect of praziquantel at a dose of 30, 40, and 50 mg/kg in naturally infected sheep was 52.3, 76.2, and 92.2%, respectively. Similarly as Wolf et al. (1984), they found that single-dose treatment with praziquantel at a dose of 50 mg/kg resulted in 89-98% reduction of parasitic burden.

The efficacy of closantel on *D. dendriticum* is questionable. Čanković et al. (1986) described 54.3% efficacy with a dose of 5 mg/kg (*i.m.*) in sheep, whereas Tinar et al. (1998) found that an oral dose of 7.5 mg/kg of fenbendazole + 10 mg/kg of closantel was not effective on *D. dendriticum*, and a subcutaneous dose of 0.2 mg/kg of ivermectin + 2 mg/kg of clorsulon was not effective either.

Oxyklozanide at a dose of 15 mg/kg was practically ineffective against dicrocoeliosis (Tinar et al. 1988).

Čorba et al. (1978) administered a single dose of 200 mg/kg of diamfenetide *per os* to sheep and they estimated its 91.7% efficacy. A single dose of 240 mg/kg produced 98% efficacy of dicrocoeliosis treatment in sheep (Calamel et al. 1979). In the experiments of Daněk et al. (1987), the achieved intensity of effect with a dose of 240-300 mg/kg ranged from 70.1 to 97.2%.

Prevention

In order to prevent dicrocoeliosis and to limit economic damage, it is recommended to carry out deworming in the winter or early spring period. It considerably limits the dissemination of eggs of *D. dendriticum* in the period of their largest production. It is also important to carry out treatment towards the end of the principal period of infection, which culminates at the turn of April and May (Wolf 1976). Otranto and Traversa (2002) recommend to arrange the treatment two or tree times a year (at the beginning of spring, before housing of animals in late autumn). The control of dicrocoeliosis can be based in limited range on husbandry practices (avoid grazing early in the morning or late in the evening). In order to suppress reinfection of the environment with eggs, treatment would have to be regularly repeated at six-week intervals (the prepatent period is 7-9 weeks). Due to long-term survival of the developmental stages of lancet fluke (their survival is possible in snails and ants), treatment would have to last for a number of years. Because of economic reasons, treatment is practicable only within the framework of an integrated programme, which would be directed against economically more important species of roundworms (Eckert et al. 1992). The effect of lancet flukes on their definitive hosts, nevertheless, should not be underrated. Its unfavourable consequences are connected not only with the financial losses due to the confiscation of the liver in slaughtered farm animals, but also with a negative influence on their efficiency and impairment of the development of young animals (Nesvadba 2000b). Control of snail and ant populations cannot be implemented mainly for ecological reasons. Only in limited areas it is possible to decrease the infection of grazing animals by enclosing the anthills with the branches of trees and bushes in a circle with a distance of 1 m from the base of the anthill (infected ants are then most frequently found 30-50 cm from the base of the anthill) (Eckert and Hertzberg 1994). Effective in infected areas can be breeding of birds (turkeys, ducks, geese, chickens–about 50 birds per ha) due to the control of populations of intermediate hosts (Otranto and Traversa 2002). Vaccination of sheep against dicrocoeliosis was successful in three-month-old lambs. The efficacy of the vaccine was 98% (Prokopič and Kudrna 1989). The vaccination strategies are not developed at present (Otranto and Traversa 2002).

Infection in humans

Dicrocoeliosis is a zoonosis. With regard to the mode of infection, people are infected only sporadically. Such a rare case of autochthonous infection was described in former Czechoslovakia in an eleven-year-old boy (Ondriska et al. 1989). Humans can be infected accidentally by swallowing an ant on the vegetation or on various fruits. Children are therefore affected more frequently. Clinical manifestation is usually slight due to accidental infection and on the rule a small amount of parasites. The symptoms include digestive problems, flatulence, vomiting, diarrhoea often combined with constipation, and gall colic. Real infections should be differentiated from false infections, which occur after eating animal tissues infected with flukes. In such case the eggs pass through the digestive tract unchanged as the so-called transit eggs (Jíra 1998).

Dikroceliόza – současný stav poznání se zaměřením na volně žijící druhy zvířat

Dikroceliόza je v současnosti považována za celosvětově významnou, ale zároveň v běžných chovatelských podmínkách podceňovanou helmintózou domácích a volně žijících přežvýkavců, ale i jiných druhů zvířat a člověka. Práce shromažďuje soudobé poznatky o rozšíření, původcích, hostitelích, vývojovém cyklu, epidemiologii, patogenezi, klinických příznacích, diagnostice, léčbě a prevenci parazitózy se zřetelem zejména na volně žijící druhy zvířat. Ačkoli je dikroceliόze celosvětově věnována poměrně značná pozornost, stále existují mnohé velmi podstatné aspekty této trematodózy k dalšímu ověření. Teprve potom bude možné dikroceliόzu v chovech zvířat plně efektivně kontrolovat.

Acknowledgements

This review was supported by the Grant Agency of Charles University in Prague (Grant No. 96/2002/C/FaF) and Ministry of Education, Youth and Sports (Project No. 313/98:111600002).

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