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Tapeworm *Khawia sinensis*: Review of the introduction and subsequent decline of a pathogen of carp, *Cyprinus carpio*

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ABSTRACT

The Asian tapeworm *Khawia sinensis* Hsü, 1935 (Cestoda: Caryophyllidea) is a large-sized (body length up to 11.5 cm) monozoic (unsegmented) parasite of common carp (*Cyprinus carpio* L.) that may cause mortality of young fish (fry). Since the 1960s, this cestode successfully colonized a large part of Europe, including the British Isles, North America and Japan. However, a review of published records provides evidence that the tapeworm *K. sinensis*, invasive parasite of carp, has become less common during the last two decades. Decline of *K. sinensis* may have been related to the recent introduction of another invasive tapeworm, the caryophyllidean *Atractolytocestus huronensis* Anthony, 1958 to Europe. Other factors that may have caused that *K. sinensis* is much less common than previously are also briefly discussed. A comparison of *K. sinensis* from feral and cultured carp, published to date, with those recently found for the first time in wild populations of carp in Slovakia did not reveal any marked differences in their morphology or measurements.
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1. Introduction

A recent finding of the tapeworm *Khawia sinensis* Hsü, 1935 (Cestoda: Caryophyllidea) in wild populations of common carp (*Cyprinus carpio* L.) in eastern Slovakia (Oros and Hanzelová, 2009) raised the question as to the current distribution and veterinary importance of this cestode parasite. *K. sinensis* was considered to be a pathogen of carp in aquaculture and was intensively studied in the 1970s and 1980s (Bauer et al., 1973; Williams and Jones, 1994), but it currently seems to be neglected and its veterinary importance appears to be negligible.

Therefore, published records on the occurrence, biology, pathogenicity and treatment of this invasive parasite of carp are reviewed and the history of its colonization of Europe, Asia and North America are summarized herein. Factors that may have facilitated its successful spread to new continents are briefly discussed and the morphology of the tapeworms found recently in Slovakia is compared with those in cultured and feral carp from other geographical regions (Kulakovskaya and Krotas, 1961; Williams and Sutherland, 1981; Scholz, 1989; Chubb and Yeomans, 1995).

2. Materials and methods

The study is based on current investigation of *K. sinensis* parasitizing common carp in Slovakia and a review of literature data dealing with all aspects of *K. sinensis*. Altogether 107 literature sources published from 1961 up to the present were reviewed. The current sampling of fish was carried out in two reservoirs and two rivers: Ružín reservoir built on the Hornád River (48°44′N, 20°53′E, eastern Slovakia), reservoir Kamenec situated on the border with Hungary (49°19′N, 22°10′E, south-eastern Slovakia) and rivers Tisa (48°23′N, 22°07′E) and Latorica (48°28′N, 22°00′E), both south-eastern Slovakia. More than 700 cyprinid fishes belonging to 17 species were examined within the years 2002–2007. Twenty specimens of *K. sinensis* from Ružín reservoir and the Latorica River were

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used for morphological characterisation of this species in Slovakia.

Helminths were isolated from the intestines of freshly killed hosts, washed in saline, fixed with hot 4% formaldehyde solution, stained with acid Schuberg's carmine, differentiated in 70% acid ethanol, dehydrated through a graded ethanol series, clarified in clove oil and mounted as permanent preparations in Canada balsam. Mature specimens were identified on the basis of morphological species-specific markers (Protasova et al., 1990) and illustrated. Morphological characters were measured under a microscope equipped with image analysis software (Olympus Image-Pro programme). Histological sections (cross and longitudinal) were made by standard procedures (staining with hematoxylin and eosin). Specimens and histological sections are deposited at the Parasitological Institute SAS in Košice.

The following voucher specimens of records of Žitňan (1971, 1982), deposited in the East-Slovakian Museum, Košice, Slovakia (Coll. Nos. 731/1–62), were also re-examined and found to be accurately identified as *Caryophyllaeus fimbriceps* and not as misidentifications of *K. sinensis*:

(1) 14 worms, Danube River near Komárno, southwestern Slovakia, May 1970;
(2) 35 worms, ponds near Perín village, eastern Slovakia, May and June 1976;
(3) 13 worms, ponds near Brzotín village, eastern Slovakia, April 1976.

3. Results

3.1. History of invasion

K. sinensis Hsü, 1935 was described from common carp (*C. carpio*) from the vicinity of Peking, China (Hsü, 1935) and its original distribution area probably included China and the Russian Far East (see Dubinina, 1971). The tapeworm was disseminated to several states of the former Soviet Union with the introduction of carp, its hybrids and herbivorous fish, especially grass carp, *Ctenopharyngodon idella* (Valenciennes, 1844). In 1954–1955, the tapeworm appeared in fishponds in Lithuania, where it was most likely introduced by translocation of hybrids of carp from Latvia and Byelorussia (Kulakovskaya and Krotas, 1961; Table 1). A very fast expansion of *K. sinensis* throughout Europe took place mainly in the 1960s and early 1970s when this tapeworm appeared step by step in as many as eight European countries, as well as in Japan and Kazakhstan (Table 1).

K. sinensis was recorded for the first time in Central Europe, namely in the western part of the former Czechoslovakia, in 1965 (now the Czech Republic, Přibyslavský et al., 1965). Further translocation of this parasite was associated with the transfer of stocking carp throughout continental Europe (see Table 1) and the United Kingdom, where it was found in 1986 (Chubb and Yeomans, 1995). In 1975, *K. sinensis* appeared in North America (Oregon, USA, Williams and Sutherland, 1981) and Japan (Nakajima and Egusa, 1978). Due to its fast colonization and pathogenicity of carp fry, *K. sinensis* caused worldwide concern as a potential pathogen (Körting, 1975).

Table 1
First record of *Khawia sinensis* in individual countries.

Year	Country/locality	Reference
1935	China	Hsü (1935)
1954–1955	Byelorussia	Kulakovskaya and Krotas (1961)
1954–1955	Latvia	Kulakovskaya and Krotas (1961)
1954–1955	Lithuania	Kulakovskaya and Krotas (1961)
1961	Ukraine	Kulakovskaya and Krotas (1961)
1963	Russia	Musselius et al. (1963)
1965	Czech Republic	Přibyslavský et al. (1965)
1966	Romania	Rădulescu and Georgescu (1966)
1966	Kazakhstan	Akhmetova (1966)
1973	Germany	Kulow (1973)
1974	Poland	Pańczyk and Żelazny (1974)
1975	Hungary	Molnár and Buza (1975)
1975	Japan	Nakajima and Egusa (1978)
1975	USA	Williams and Sutherland (1981)
1977	Bosnia and Herzegovina	Kiškároly (1977)
1980	Bulgaria	Kakacheva-Avramova et al. (1980)
1986	Great Britain	Yeomans et al. (1997)
2004	Slovakia	Oros and Hanzelová (2009)

By 1986, *K. sinensis* had a wide distribution (Fig. 1). Its presence has been reported in the following countries: Bosnia and Herzegovina, Bulgaria, Byelorussia, China, Czech Republic, Germany, Great Britain, Hungary, Japan, Kazakhstan, Latvia, Lithuania, Poland, Romania, Russia, Slovakia, Ukraine and USA (Table 1). The parasite was particularly well established and common in Russia and Central Europe (Přibyslavský et al., 1965; Kulow, 1973; Pańczyk and Żelazny, 1974; Molnár and Buza, 1975; Protasova et al., 1990).

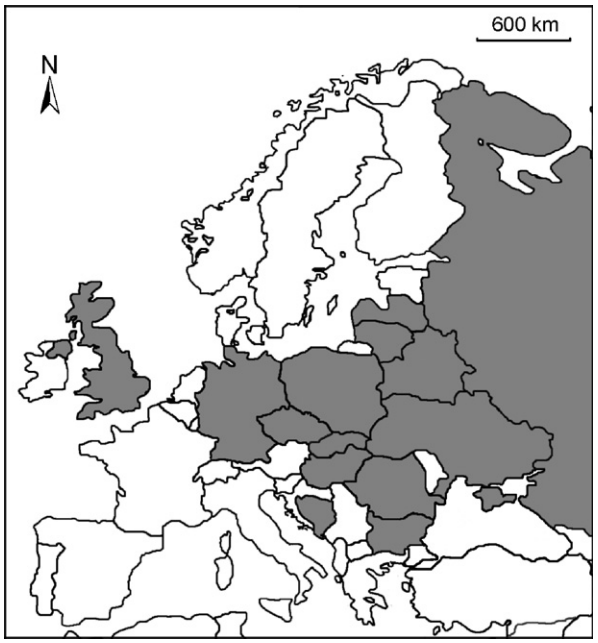

Fig. 1. Distribution of *Khawia sinensis* in Europe. States with records of the tapeworm are shaded.

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