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Redescription of *Echinostoma jurini* (SKVORTZOV, 1924) with a discussion of its identity and characteristics

(Trematoda: Echinostomatidae)

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Abstract

The life cycle of *Echinostoma jurini* (SKVORTZOV, 1924) is completed experimentally. All developmental stages are redescribed and its specific validity and identity are discussed. Synonyms of *E. jurini*, with parthenitae from viviparid snails and adults from mammals in Europe, are listed. Experimental life cycle studies showed that (1) the first intermediate host is a viviparid snail; (2) the second intermediate hosts are molluscs, frogs and freshwater turtles; (3) final hosts are mammals; (4) *E. jurini* occurs in Europe and possibly in Asia where viviparid snail hosts are distributed.

Key words: Echinostomatidae, *Echinostoma jurini*, redescription, life cycle, synonyms, hosts, distribution.

Zusammenfassung

Der Entwicklungszyklus von *Echinostoma jurini* (SKVORTZOV, 1924) wird experimentell untersucht. Alle Entwicklungsstadien werden erneut beschrieben. Status und Identität der Art werden diskutiert. Die Synonyme von *Echinostoma jurini,* sowohl der Larven aus vivipariden Schnecken als auch von Adulten aus Säugetieren in Europa, werden angeführt. Die experimentellen Untersuchungen des Entwicklungszyklus zeigen folgendes: (1) erster Zwischenwirt sind viviparide Schnecken; (2) zweiter Zwischenwirt sind Mollusken, Frösche und Wasserschildkröten; (3) Endwirte sind Säugetiere; (4) *E. jurini* kommt in Europa und wahrscheinlich in Asien vor, wo viviparide Schnecken verbreitet sind.

Introduction

Echinostoma jurini (SKVORTZOV, 1924) is one of five closely related 37-collar-spined species belonging to the *Echinostoma revolutum*-group (KANEV 1985, 1993). Four species, known after KANEV (1985) as *Echinostoma revolutum* (FROELICH, 1802), *E. echinatum* (ZEDER, 1803), *E. trivolvis* (CORT, 1914) and *E. caproni* RICHARD, 1964, have been discussed previously (KANEV 1985, 1993, ODENING 1986, SCHUSTER 1986, VOLTZ 1987, HUFFMAN & FRIED 1990, CHRISTENSEN & al. 1990, KRUSE & al. 1992). *Echinostoma jurini* was also discussed by KANEV (1993) but this paper presents additional information as part of a series on the redescription and reclassification of 37-collar-spined echinostomes.

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Materials and methods

Thirty seven-collar-spined cercariae were shed from naturally infected snails, *Viviparus contectus* (MILLET 1813) and *V. viviparus* L. collected in biotopes along the Danube River in Bulgaria. For some studies cercariae were obtained from viviparid snails collected in Czechia and Russia. Metacercariae from the renopericardial sac of laboratory-reared snails, *Physa acuta* DRAPARNAUD and *P. fontinalis* (L.), exposed to cercariae, were fed to laboratory-reared mammals and birds. Eggs cultured for miracidia were obtained by washing the faeces of experimentally infected golden hamsters. Various prosobranch and pulmonate freshwater snails, were exposed to miracidia. The same species of snails, mussels, frogs, and freshwater turtles were also exposed to cercariae. The species names of the animals exposed to miracidia and cercariae or fed with metacercariae are listed in the chapter "Main characteristics of *E. jurini*". Techniques for collection, fixation, staining, and examination of parasites were as described by KANEV (1984). At least 50 specimens were measured for each stage of the life cycle. All measurements are in micrometers unless otherwise indicated. Figures were made with the aid of a camera lucida unless otherwise indicated.

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Redescription of *Echinostoma jurini*

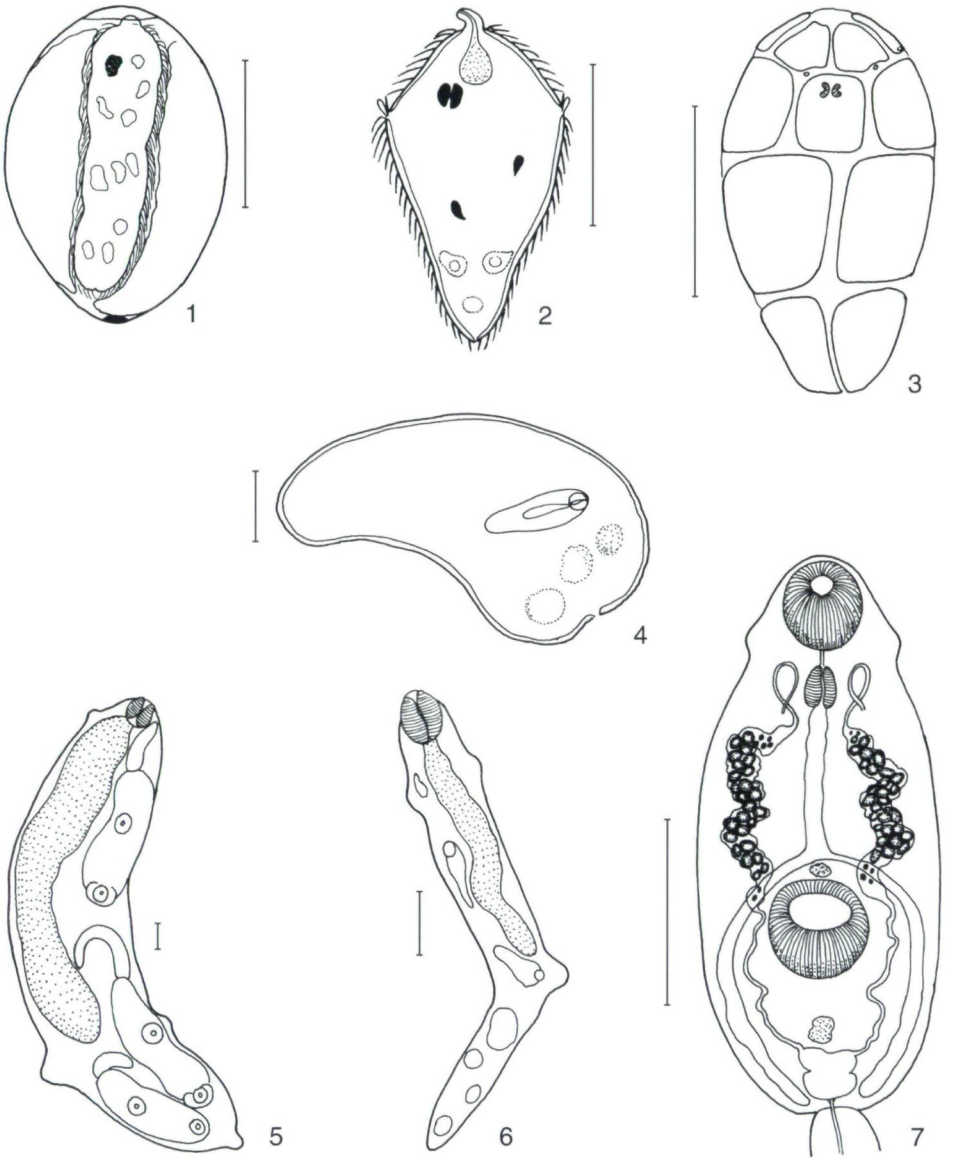
The life cycle and general morphology

Eggs (Fig. 1):

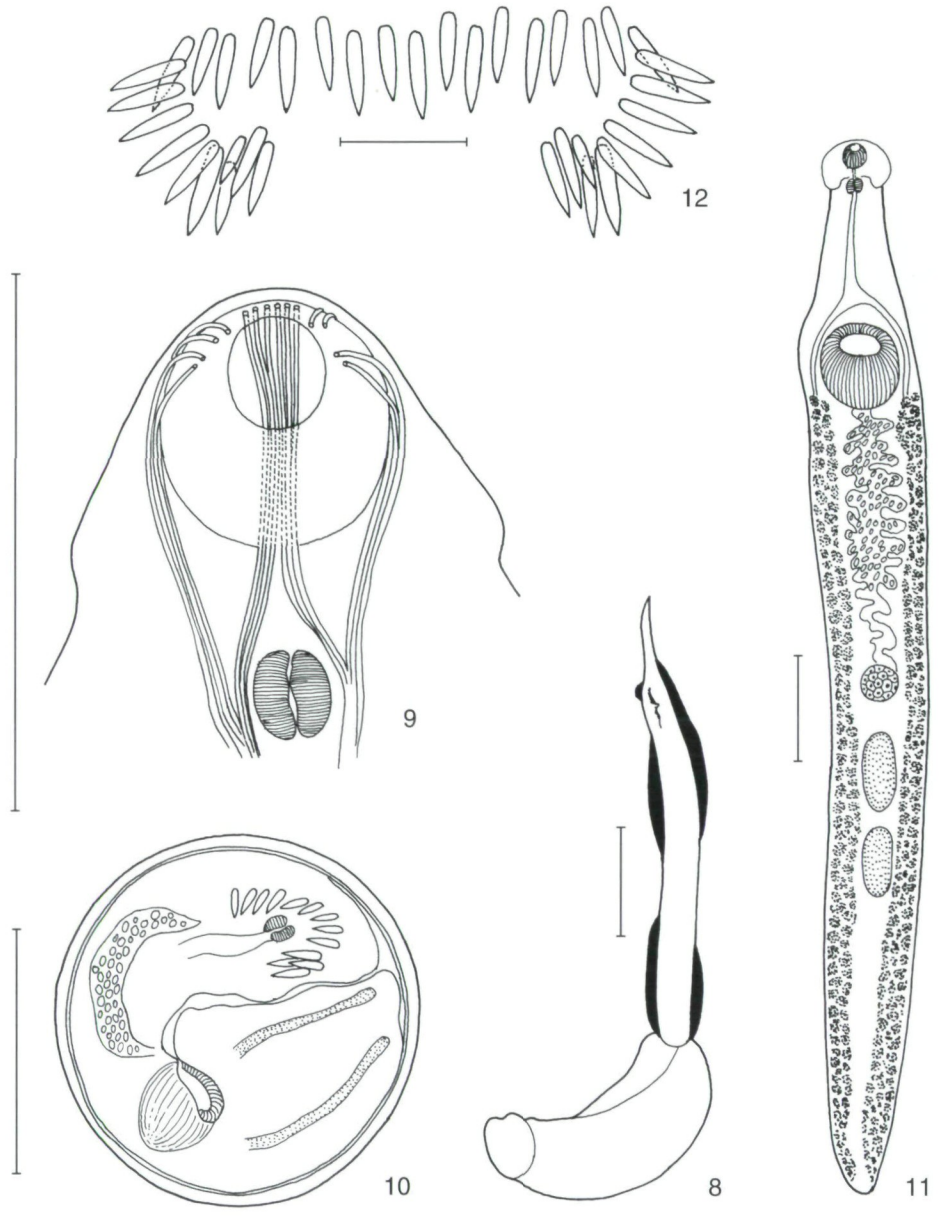
Eggs first appeared in the faeces 13 days after infection of hamsters. They were unembryonated, yellow-brown, with a thickening at the anopercular end and measured 96 - 132 long by 72 - 88 wide. Eggs maintained in distilled water in a Petri dish at 28° C, yielded fully developed miracidia within 9 days.

Miracidia (Figs. 2, 3):

Hatching started on day 9, but usually miracidia hatched in greatest numbers on day 11. Exposure to light stimulated hatching which usually occurred after noon. Newly hatched miracidia swam rapidly and changed direction periodically. They were positively phototactic and lived for 6-8 h. Fixed in hot 2 % silver nitrate, miracidia measured 76 - 118 long by 58 - 82 wide. Retractile apical papilla 12 by 6 when protruded, with two pairs of ciliae. Body with four rows of ciliated epidermal plates: first (anterior) row with 6 tri-



Figures 1 - 7. *Echinostoma jurini.* (1) Egg, containing fully developed miracidium, showing operculum and posterior thickening of the shell. (2) Miracidium, dorsal view, with apical papilla, gut, eyespots, flame cells, cilia lateral processes and cilia. (3) Miracidium stained with silver nitrate, lateral view showing epidermal plates. (4) Sporocyst containing one redia and three germ balls. (5) Redia found in snail 60 days after exposure, containing three cercariae and a long gut reaching near the ambulatory buds. (6) Redia, found in snails 20 days after exposure, containing two rediae, several germ balls and a long gut. (7) Cercaria, ventral view, showing collar, oral sucker, prepharynx, pharynx, oesophagus, caeca, acetabulum, excretory bladder, main excretory ducts, and genital primordia. Camera lucida drawings. Projected scales 100 micrometers for Figs. 5, 6, 7; 50 micrometers for Figs. 1, 2, 3; and 25 micrometers for Fig. 4.



Figures 8-12. *Echinostoma jurini.* (8) Cercaria, lateral view, showing six of the seven fin folds on the tail. (9) Freehand drawing of cercaria stained with nile blue sulfate, showing two lateral groups of 4 duct outlets of the paraesophageal gland cells and 6 median outlets of the penetration gland cells on the ventral surface of the dorsal lip. (10) Metacercaria with visible parts of the collar spines, excretory granules, acetabulum and intestinal caeca. (11) Adult worm, ventral view, general morphology. (12) Collar spines in the adult worm, ventral view. Camera lucida drawings. Projected scales 100 micrometers for all figures, except for Fig. 11: 1 mm, and Fig. 12: 200 micrometers.

angular plates: 2 ventral, 2 dorsal, and 2 lateral (1 on each side), about 18 long and 14 wide at base; second row with 6 square plates: 3 dorsal and 3 ventral, about 18 long and 16 wide; third row with 4 square plates: 2 lateral, 1 dorsal, and 1 ventral, about 25 long and 20 wide; and fourth row with 2 subtriangular plates: 1 ventral and 1 dorsal, about 28 long and 25 wide at anterior end. Cilia 15 long. 2 lateral processes, 3.5 long, each situated posteriorly to lateral anterior epidermal plate, with short cilia immediately anterior to each process. Primitive gut about 20 long, filled with refractile granules with opening at tip of apical papilla. Penetration gland cells not visible before or after vital staining with neutral red. Eyespots 2 pairs of dark brown pigmented bodies, consisting of oval disks measuring about 5 in diameter and pair of rods situated posterior or posterolateral to oval disks. Flame cells present, the left one ventral and posterior, and right dorsal and anterior. Two excretory ducts opened between third and fourth row of epidermal plates, duct connecting right flame cell opening dorsolaterally, other ventrolaterally. Several germ cells in middle and posterior parts of body. In laboratory experiments miracidia produced larval infections only in prosobranch snails, *Viviparus viviparus* and *V. contectus*. Other prosobranch and pulmonate snails exposed to miracidia did not develop infections.

Sporocyst (Fig. 4):

Sporocysts developed in the ventricular cavity of the snail heart where they arrived about 48 h p.i. Newly produced sporocysts measured 96 - 150 long by 58 - 88 wide. They developed into contractile elongated sacs attached by broader end to heart muscle and with narrow end free in heart cavity; they contained germ balls and one or two rediae. Sporocysts, 14 days old, 540 - 910 long by 250 - 310 wide; largest 980 long by 360 wide, found 18 days after exposure. Birth pore of sporocysts difficult to see in most specimens, but rediae emerged from opening near attached base of sporocyst. After the 4th week, sporocysts were smaller and more opaque, and production of rediae declined until none was observed after 8 weeks. Empty sporocysts persisted in the snail heart and remained active through 10th week post exposure when they averaged 150 long and 80 wide at broader end. Old sporocysts were dark-grey, small and empty.

Redia (Figs. 5, 6):

Active first generation (mother-) rediae released 15 or more days after exposure; motile, colorless, with locomotor organs and conspicuous collar when fixed with hot silver nitrate; about 560 - 880 long by 85 - 120 wide, pharynx 30 - 55 wide, gut reached almost to locomotor organs, distance from anterior end to locomotor organs 300 - 460, distance from anterior end to collar 60 - 90. Mother rediae usually remained in heart cavity, although some migrated to haemolymph space surrounding viscera and albumen gland; they matured 20 - 25 days after exposure, producing daughter rediae. Rediae of second and subsequent generations contained fully developed cercariae, obtained from snails 66 days after exposure measured 980 - 2860 long by 230 - 600 wide, pharynx 50 - 80 in diameter, collar 100 - 180 from anterior end; birth pore dorsal, immediately posterior to collar; gut length variable, but usually reached nearer to ambulatory buds than gut of rediae of *E. revolutum*, *E. echinatum*, *E. trivolvis* and *E. caproni*. Mature rediae differed in size, length of gut and larval contents. Second generation rediae were usually more

than 1 mm long, sometimes nearly 3 mm. Second and third generation rediae contained up to 30 cercariae, in addition to number of germ balls. In some rediae, along with cercariae, there were also 1 - 2, rarely 3 - 4, rediae of next generation. Daughter rediae were concentrated in sinuses along heart, hepatopancreas and ovo-testis. Old rediae were shriveled, with dark-grey bodies and orange guts.

Cercaria (Figs. 7 - 9):

Cercariae first escaped from snails 60 days after exposure, but typically after 65 - 66 days. Emergence was most pronounced during the morning. Cercariae were negatively phototactic, swimming through the water while curving the body ventrally. After swimming for 3 to 6 h, they sank to the bottom and died a few hours later. In half-strength saline they lived more than 12 h. Measurements based on specimens fixed in 2 % silver nitrate were: body 327 - 445 long, 159 - 254 wide. Collar distinct, 108 - 124 wide, with 37 spines 8 - 12 long, arranged as in adult. Body covered with minute spines in diagonal rows; longest spines immediately posterior to collar, average 4 long, becoming sparse at posterior end. Oral sucker subterminal, 38 - 58 long by 38 - 60 wide. Prepharynx 14 - 25 long; pharynx 20 - 28 long by 14 - 20 wide. Oesophagus 50 - 100 long, consisting of 7 poorly visible cells. Bifurcation anterior to acetabulum. Caeca reaching posterior end of body. Acetabulum protrusive, 60 - 90 long by 64 - 92 wide, posterior to midbody. Cystogenous cells throughout body, numerous, oval to spherical, 18 - 25 long, few near oral sucker and pharynx, containing ovoid granules 2.5 long by 1 wide. Penetration gland cells along the oesophagus with 6 inconspicuous gland ducts opening on dorsal lip of oral sucker. Paraoesophageal gland cells opened with 8 - 10 outlets arranged bilaterally in two groups of 4 - 5 outlets each on anterior ventrolateral surface of oral sucker. Gland cells located around the oesophagus did not stain with vital stains such as neutral red and nile blue sulphate. Genital primordia of two masses of cells, one at anterior margin of acetabulum, other between acetabulum and excretory vesicle, connected by string of cells passing dorsally to acetabulum. Flame cells inconspicuous, most probably 36, excretory bladder bipartite at posterior end of body; main collecting tubes distended between acetabular and pharyngeal levels, each containing numerous (40 - 100) excretory granules up to 12 in diameter in central portion and 8 at ends; caudal excretory tube extending one-fifth of tail length before bifurcating. Tail 381 - 473 long by 31 - 48 wide, with finger-like narrowing at tip. Seven fin folds: 2 dorsal, 2 ventral, 2 small ventrolateral and 1 very small ventral just anterior to narrow tip.

Metacercaria (Fig. 10):

Metacercarial cysts spherical or subspherical, 140 - 160 in diameter. Cyst wall consisting of outer, transparent layer, about 12 thick, and inner, opaque layer, about 3 thick. Collar spines, excretory granules, oesophagus and caeca visible through cyst wall. Encysted metacercariae were in the pericardial sac and posterior kidney region of various freshwater snails, and mussels, in kidney and eye cavity of frogs and freshwater turtles. Periodically, metacercariae were found in the mantle and soft tissues of the snails already harbouring rediae and cercariae of the same species; in some cases metacercariae were found within the rediae. Within about 24 h, the metacercariae became infective.

Adult (Figs. 11 - 12):

In laboratory adult worms were recovered from the posterior part of the small intestine, i.e., jejunum and ileum of golden hamsters, rats, and mice. Attempts were made to obtain adult worms from birds. Only once, in a single young pigeon (7 days old when fed encysted metacercariae) two preovigerous worms were recovered. Egg production began about 13 days after infection of hamsters. Extensive egg production started several days later. Measurements based on 20 to 25 days old worms, obtained from hamsters were: body 6,600 - 14,000 long by 580 - 1,340 wide, attaining maximum width at about one-third body length from anterior end. Body spines posterior to collar, covering anterior sixth of body dorsally, all but posterior sixth laterally and almost all ventrally. Collar well developed, 250 - 470 wide with 37 conspicuous spines up to 100 long; spine arrangement: 5 corner spines on each side, 3 oral and 2 aboral; 6 lateral on each side in single row; 15 dorsal, 3 oral and 3 aboral on each side; and 3 dorsomedian spines, 2 oral and 1 aboral, resulting in an odd number of collar spines. Latero-aboral largest among corner spines, up to 100 in length, ventro-oral usually smallest, about 45 in length. The spines of aboral row were slightly larger (50 - 75) than those of aboral row (40 - 60). Oral sucker subterminal, 170 - 260 long by 150 - 250 wide. Prepharynx up to 230 long, pharynx 90 - 150 long by 110 - 156 wide. Oesophagus about 450 long, bifurcating anterior to acetabulum; caeca extending almost to posterior end of body. Acetabulum in anterior fifth of body, 450 - 650 long by 470 - 660 wide. Genital pore median, immediately preacetabular, followed by genital atrium. Testes tandem, beginning at mid-hind body, smooth, oval or slightly irregular in outline; anterior testis 230 - 500 long by 250 - 520 wide; posterior testis 270 - 580 long by 210 - 520 wide. Small ovoid cirrus sac extending postero-dorsally from genital atrium to middle of acetabulum, containing coiled internal seminal vesicle, pars prostatica and unspined cirrus. Ovary spherical, at or anterior to midbody, 200 - 450 in diameter. Oviduct with small dilated ovicapt near ovary. Canalicular seminal receptacle absent, uterine seminal receptacle containing numerous spermatozoa. Laurer's canal opening medially on dorsal surface posterior to ovary, joining oviduct distally to ovicapt. Small vitelline reservoir present. Mehlis' gland diffuse. Uterus intercaecal, postacetabular, preovarian, with 8 - 16 coils, containing numerous eggs, opening into genital atrium through metraterm. Vitelline follicles lateral, dorsal and ventral to caeca, extending from near level of posterior margin of acetabulum to short distance from posterior end of body, rarely confluent posterior to testes. Excretory bladder Y-shaped, with stem opening at posterior extremity.

Identification notice

Identification could be completed only if the following questions were answered correctly:

(1) How many species of *Echinostoma* RUDOLPHI, 1809, with 37-collar-spines are distributed in Europe? Three species have been documented by KANEV (1985, 1993), namely *Echinostoma revolutum*, *E. echinatum*, and *E. jurini*. These species differ as shown in Table I.

Table I. Differences between *E. revolutum*, *E. echinatum* and *E. jurini*. Data obtained experimentally by the authors.

Features	*E. echinatum*	*E. revolutum*	*E. jurini*
Adults			
hosts	birds and mammals, including man	only birds	only mammals
protein fractions	21	20	not studied
cirrus	Different in shape and surface		
Cercariae			
first intermediate hosts	lymnaeid & planorbid snails	lymnaeid snails	viviparid snails
development in days	within 30	within 30	over 60
penetration gland cell openings in the ventral surface of the dorsal lip of oral sucker	6	4	6
paraesophageal gland cell outlets: common number	60 - 64	16 - 20	8 - 10
on oral sucker	14 - 16	12 - 14	8 - 10
on the body	36 - 42	4 - 6	0
stained with glyoxalic acid	no reaction	fluorescent green	not studied
argentopohilic structures	Different in number and position		
Eggs			
length in µm	under 100	under 100	over 100
development in days at 28°C	within 11	within 9	within 10

(2) How many species of *Echinostoma* with 37-collar-spines use viviparid snails as first intermediate hosts and mammals as final hosts in Europe? Table I shows that only one species, described here as *E. jurini*, uses viviparid snails as the first intermediate host. *E. jurini* and *E. echinatum* use mammals as final hosts but their larval stages show morphological and biological differences as shown in Table I.

(3) How many echinostomatid cercariae use viviparid snails as first intermediate hosts in Europe? The literature shows that at least four echinostomatid species use *Viviparus viviparus* and *V. contectus* as first intermediate hosts in Europe. These species belong to:

Neoacanthoparyphium YAMAGUTI, 1958, has 51-collar-spined cercariae. Viviparid snails were first found to be infected with these cercariae by SWAMMERDAM (1737/8) working on material from the Netherlands. He published descriptions and illustrations but did not give specific or generic names. FILIPPI (1854) first offered a name, *Cercaria echinatoides*, for these larvae examined from Italy. LA VALETTE (1855) found the same cercariae in Germany and offered the name *Cercaria echinifera* for them. Since then adults and larvae of *Neoacanthoparyphium* have been found in different regions in Europe and have been described under the names: *Cercaria echinata* SIEBOLD, 1837; *C. spinifera* LA VALETTE, 1855; *C. Distomi militari* BENEDEN, 1858; *C. mobilis longa* SKVORTZOV, 1924; *C. Echinopariphium petrowi* NEVOSTRUEVA, 1954; *C. Neoacanthoparyphium echinatoides* (FILIPPI, 1854) ODENING (1962); *Distoma militare* BENEDEN, 1858; *Echinostoma echiniferum* (LA VALETTE, 1855) SPREHN (1932); *Echinoparyphium petrowi* NEVOSTRUEVA, 1954; *Neoacanthoparyphium petrowi* (NEVOSTRUEVA, 1954) YAMAGUTI (1958); *Echinoparyphium echinatoides* (FILIPPI, 1854) KUPRIANOVA-SCHAKHMATOVA (1960); *Neoacanthoparyphium echinatoides* (FILIPPI, 1854) ODENING (1962); and *Echinoparyphium colchicum* DZAVELIDZE, 1957. The validity and identity of these names have been discussed by NEVOSTRUEVA (1954), ODENING (1962) and KANEV (1984). Table II gives the main differences between *Neoacanthoparyphium* and other echinostome cercariae in viviparid snails.

Echinoparyphium sp. DIETZ, 1909, was represented by 45-collar-spined cercariae with an unknown life cycle. Our data suggest that these cercariae have been found in viviparid snails in France, Germany, and Italy by DAVAINE (1858), v. LINSTOW (1873), PERRIER (1897), ERCOLANI (1881), NEUMANN (1892), and RAILLIET (1895). However, these authors failed to establish a new name for these cercariae, considering them identical with *C. spinifera* LA VALETTE, 1855, or *C. echinata* SIEBOLD, 1837. We have completed the life cycle of these cercariae experimentally (Kanev, in prep.).

Echinochasmus DIETZ, 1909, was represented by cercariae which do not show collar spines when studied by light microscopy, but in the metacercaria and adult, collar spines were well developed and clearly visible. As far as we know, the life history and identity of these cercariae have not been studied. Our unpublished results show that they differ from all other cercariae from viviparid snails as shown in Table II.

Echinostoma RUDOLPHI, 1809, was represented by 37-collar-spined cercariae described in this paper. The data available suggest that these cercariae were first found by MUELLER (1773) and BERMANN (1774). Also, adult worms that developed from these cercariae may have been examined and described as *Distoma echinatum* by RUDOLPHI (1809, 1819) and DIESING (1850, 1858). However, there is not enough clear evidence to

support this suggestion. Below, only names that are well documented are listed and discussed.

(4) How many names were given to cercariae of the genus *Echinostoma* found in viviparid snails in Europe? At least seven names have been used: *Cercaria echinata* of LINSTOW (1873), described from snails in Germany; *C. spinifera* of ERCOLANI (1881) of NEUMANN (1892), and of RAILLIET (1895) described from snails in Italy and France; *C. jurini* SKVORTZOV, 1924, described from snails collected along the Volga River in Russia and from snails from Bulgaria (this paper); *Cercaria bolschewensis* KOTOVA, 1939, described from snails collected along the Klyazma River in Russia; of CHERNOGORENKO-BIDULINA (1958, 1964, 1966), described from snails collected along the Dniester River in Ukraine; of GINETSINSKAYA & DOBROVOLSKI (1964) from snails collected along the Volga river in Russia, of STADNYCHENKO (1972) from snails collected in Ukraine, and of NASINCOVA (1991) from snails from Czechoslovakia; *Cercaria Echinostoma revolutum* of ISKOVA (1985) based on reports from viviparid snails collected along the Dnieper and Dniester rivers in Ukraine; *C. trivolvis* of CHERNOGORENKO-BIDULINA (1963), and of STADNYCHENKO (1972) described from snails collected in Ukraine; and *Cercaria Echinostoma armigerum* of KISELIENE (1983) described from snails collected in Lithuania.

(5) Are these cercariae described completely and adequately? Those cercariae listed above in point (4) are described incompletely and inadequately. Due to technical limitation, cercariae examined 60 - 70 years ago were described less completely than those studied in the last decade. Three examples will be given as illustrations: (a) Body spines were not reported by LINSTOW (1873), ERCOLANI (1881), SKVORTZOV (1924), and GINETSINSKAYA & DOBROVOLSKI (1964) for cercariae named *C. echinata*, *C. spinifera*, *C. bolschewensis*, and *C. jurini*, but KOTOVA (1939) and NASINCOVA (1991) described body spines for *C. bolschewensis*. Comparative studies on body spination of cercariae of *E. revolutum*, *E. echinatum*, *E. trivolvis*, *E. caproni*, and *E. jurini* (KANEV 1985, 1993, this paper), found that all 37-spined cercariae of *Echinostoma* have body spines and cannot be distinguished on this basis. (b) No fin folds were described by LINSTOW (1873), ERCOLANI (1881), SKVORTZOV (1924), and GINETSINSKAYA & DOBROVOLSKI (1964) for cercariae named *C. echinata*, *C. spinifera*, *C. jurini* and *C. bolschewensis*. Later descriptions reported fin folds for cercariae named *C. bolschewensis* but gave different numbers and arrangements as follow: two long fin folds (KOTOVA 1939), four fin folds (CHERNOGORENKO-BIDULINA 1964), and seven fin folds (NASINCOVA 1991). Comparative experimental studies with cercariae of *E. revolutum*, *E. echinatum*, *E. trivolvis*, *E. caproni*, and *E. jurini* (KANEV 1985, 1993, KANEV & al. 1990) showed that all 37-spined cercariae of *Echinostoma* possess fin folds equal in number and arrangement and cannot be a distinguishing character. (c) No glands and outlets were described by LINSTOW (1873), RAILLIET (1895), SKVORTZOV (1924) and KOTOVA (1939) for cercariae named *C. echinata*, *C. spinifera*, *C. jurini*, and *C. bolschewensis*. GINETSINSKAYA & DOBROVOLSKI (1964) and NASINCOVA (1991) described glands and outlets for cercariae named *C. bolschewensis*. We have found gland cell outlets in cercariae obtained from viviparid snails collected in Bulgaria, Czechoslovakia, and Russia, visible only after vital staining with neutral red, nile blue sulphate and other recent techniques. This explains why outlets and openings were not described in earlier studies.

Table II. Differences between four echinostomatid genera using viviparid snails in Europe as first intermediate host. Data obtained experimentally by the authors.

Features	*Neoacanthoparyphium*	*Echinostoma*	*Echinochasmus*	*Echinoparyphium*
host	birds and mammals	mammals	birds	birds
location	duodenum, jejunum	ileum, caecum rectum	jejunum	duodenum, jejunum
body size	1 - 2 mm	6 - 30 mm	1 - 3 mm	3 - 6 mm
collar spines	51	37	22	45
corner spines	larger than lateral	like lateral	like lateral	larger than lateral
vitellaria	posterior to acetabulum	at level of the acetabulum	at level of the acetabulum	posterior to acetabulum
eggs	1 - 2	hundreds	2 - 5	20 - 100
Rediae				
pharynx	small	midsize	small	large
gut	very long	long	very long	very short
karyotype	2 n = 20	2 n = 22	2 n = 16	2 n = 20
Cercariae				
body size	very large	midsize	very small	midsize
collar spines	51	37	not visible	45
oesophagus	numerous refractile granules	7 granules	not visible	7 - 8 granules
paraoesophageal glandcells outlets	0	6 - 8	0	0
flame cells	about 100	under 50	unknown	about 50
tail tip	conical	finger-like	conical	conical
fin folds	2	7	0	0
cystogenous	ovoidal rods	ovoidal rods	splinter-like	ovoidal rods
cells contents	2 - 3 x 1	2 - 3 x 1	2 - 3 x 1	2 - 3 x 1
argentophilic structures	Different in number and position in numerous important groups			
Metacercariae				
host	snails, frogs turtles	snails, frogs turtles	fish	snails, frogs turtles
size	about 200	about 150	about 100	about 150
ovary & testes	developed	not developed	not developed	not developed
development	21 days	7 weeks	14 days	7 days

(6) Are these cercariae identical or do they belong to different species? The data showed that, in Europe, viviparid snails are first intermediate hosts of cercariae of one species of *Echinostoma* with 37-collar spines. However, these cercariae were described incompletely and given seven different names listed in (4). This practice of using different names has persisted. KISELIENE (1983), NASINCOVA (1991), and we (this paper) used three different names for cercariae and their adults obtained experimentally from Lithuania, Czechoslovakia and Bulgaria and described as *E. armigerum*, *E. bolschewense* and *E. jurini*. Comparative studies on material from Bulgaria and Czechoslovakia showed no significant differences and we consider *E. bolschewense* of NASINCOVA (1991) and *E. jurini* described in this paper identical. *Echinostoma armigerum*, described by KISELIENE (1983), is considered by NASINCOVA (1991) identical with her species examined in Central Europe and our results support this. The problem is which of these three names is correct and has priority? This could be settled by correctly answering the following questions.

(7) Which is the oldest and the original name given to this cercaria and its adult? The first documented data, in respect of the original names, were published by SKVORTZOV (1924, 1934). In 1924 he briefly described *Cercaria jurini* from viviparid snails collected near Jurina village in Russia. In the same biotopes, he found *Arvicola terrestris* naturally infected with 37-collar-spined adults described in 1934 as *Echinoparyphium sisjakowi* sp.n. So far, no connection has been made between *C. jurini* and *E. sisjakowi* because the latter has been considered a member of *Echinoparyphium*. YAMAGUTI (1958) found that *E. sisjakowi* corresponded to *Echinostoma* and therefore transferred it to *Echinostoma sisjakowi* (SKVORTZOV, 1934). Our results support this. The data presented above showed that it was SKVORTZOV (1924, 1934), who first offered original names for the larval and adult worms. These names have priority and should be used for these species.

(8) Is *C. jurini* a valid name? The original description of *C. jurini* is short but informative enough to show that *C. jurini* is a valid name given to the larval stages of the genus *Echinostoma* that developed into adults found in the mammals from the same biotope and named *Echinoparyphium sisjakowi* by SKVORTZOV (1934). In the same paper SKVORTZOV (1924) described *Cercaria mobilis longa* (= *Neoacanthoparyphium echinatoides*, (FILIPPI, 1854), ODENING, 1962) and *C. echinata* (= *Echinoparyphium aconiatum* DIETZ, 1909) and showed that he knew these echinostome cercariae and differentiated between them and *C. jurini*. KOTOVA (1939) declined to use the name *C. jurini* and offered a new name, *C. bolschewensis*, for echinostome larvae in viviparid snails, which she considered similar yet different from *C. jurini* in the presence of body spines and two fin folds which had not been described for *C. jurini* by SKVORTZOV (1924). For reasons discussed above we consider these differences a result of incompletely described structures, and *C. bolschewensis* is considered identical with *C. jurini*.

Practically, all 37-spined adults of *Echinostoma* in mammals in Europe might be identical with *E. jurini*. So far these worms have been described with at least 12 names: *Distoma echinatum* ZEDER, 1803; *Distoma herisse* RAILLIET, 1895; *Echinostoma revolutum* (FROELICH, 1802) DIETZ, 1909; *E. armigerum* BARKER & IRVINE, 1915; *E. coalitum* BARKER & BEAVER, 1915; *E. lindoense* SANDGROUND & BONNE, 1940; *E. orlovi* ROMASHOV, 1966; *E. miyagawai* ISHII, 1932; *E. paraulum* DIETZ, 1909; *E. sisjakowi*

(SKVORTZOV, 1934) YAMAGUTI, 1958; *E. bolschewense* (KOTOVA, 1939) NASINCOVA, 1991; and *Echinoparyphium sisjakowi* SKVORTZOV, 1934. However, as discussed in previous papers (KANEV 1985, 1993), closely related species of *Echinostoma* with 37-collar spines cannot be identified on the basis of their adult morphology unless their larval stages are known. To us, only adults for which a direct link with naturally or experimentally infected viviparid snails has been documented could be considered identical with *E. jurini*. These included: *Echinoparyphium sisjakowi* SKVORTZOV, 1934, and *Echinostoma sisjakowi* (SKVORTZOV, 1934) YAMAGUTI, 1958, described from the same biotopes from which *C. jurini* was originally described. These echinostomes possessed large eggs and other structures which completely corresponded with adults described here. *Distoma echinatum* obtained experimentally by LINSTOW (1873) from cercariae and metacercariae from viviparid snails from Germany; *Distoma echinatum* and *Distoma herisse* obtained experimentally by ERCOLANI (1881), NEUMANN (1892) and RAILLIET (1895) from viviparid snails in Italy and France; *Echinostoma revolutum* of ISKOVA (1985) based on viviparid snails from Ukraine; *Echinostoma armigerum* obtained experimentally in material from Lithuania; *Echinostoma bolschewense* of NASINCOVA (1991) obtained experimentally in material from Czechoslovakia; and *Echinostoma orlovi* ROMASHOV, 1966, obtained from mammals from the same biotopes in Russia where 37-spined cercariae named *C. bolschewensis* were described. Also, these adults have large eggs which correspond to our results for *E. jurini*. Additional adults are suspected to be identical with *E. jurini*, but so far no proof can be given. Among these suspected synonyms are specimens found in naturally infected mammals from the same regions in Russia, Ukraine, Bulgaria, and Czechoslovakia where naturally infected viviparid snails were found, including *Echinostoma revolutum* of SHARPILO (1961, 1975), TENORA (1963), PROKOPIC & GENOV (1974), and GENOV (1981); *Echinostoma coalitum* of TENORA (1956) and of ERCHARDOVA (1958); and *Echinostoma miyagawai* of GENOV (1984).

Main characteristics of *E. jurini*

Synonyms: *Cercaria jurini* SKVORTZOV, 1924, *Cercaria echinata* SIEBOLD, 1837 of LINSTOW (1873), *Cercaria spinifera* LA VALETTE, 1855 of ERCOLANI (1881) and of RAILLIET (1895), *Cercaria trivolvis* CORT, 1914 of CHERNOGORENKO-BIDULINA (1963) and of STADNYCHENKO (1972), *Cercaria bolschewensis* KOTOVA, 1939 and of CHERNOGORENKO-BIDULINA (1958, 1964, 1966), of GINETSINSKAYA & DOBROVOLSKI (1964) and of NASINCOVA (1991), *Distoma echinatum* ZEDER, 1803 of LINSTOW (1873) and of ERCOLANI (1881), *Echinoparyphium sisjakowi* SKVORTZOV, 1934 and of SHARPILO (1961), *Echinostoma sisjakowi* (SKVORTZOV, 1934) YAMAGUTI (1958), *Echinostoma armigerum* BARKER & IRVINE, 1915, of KISELIENE (1983), *Echinostoma revolutum* (FROELICH, 1802) of SHARPILO (1973) and of ISKOVA (1985), *Echinostoma orlovi* ROMASHOV, 1966, and *Echinostoma bolschewense* (KOTOVA, 1939) and of NASINCOVA (1991), *Distoma herisse* of NEUMANN (1895) and of RAILLIET (1895). Suspected synonyms are adults of *Echinostoma coalitum* BARKER & BEAVER, 1915, of ERHARDOVA (1958) and of TENORA (1956), *Echinostoma miyagawai* ISHII, 1932, of GENOV (1984) and *Echinostoma revolutum* (FROELICH, 1802) of SHARPILO (1961), of TENORA (1963), of GENOV (1981), and of PROKOPIC & GENOV (1974).

Morphology:

The morphology of *E. jurini* adults and larvae has been described by several authors (SKVORTZOV 1924, 1934, KOTOVA 1939, GINETSINSKAYA & DOBROVOLSKI 1964, KISELIENE 1983, NASINCOVA 1991, this paper), but the obtained results have been published under different names listed above in its synonymy. Some morphological structures such as body spines, fin fold number and arrangements, and others characters have been described incompletely in many of the previous papers.

Life cycle:

The complete life cycle of *E. jurini* has been elucidated experimentally three times, but the obtained data have been described under different names of *E. armigerum*, *E. bolschewense*, and *E. jurini*. These studies were carried out by KISELIENE (1983) in Lithuania, by NASINCOVA (1991) in Czechoslovakia, and in Bulgaria by us.

First intermediate host:

Echinostoma jurini miracidia infected prosobranch snails of the genus *Viviparus* (*V. contectus* MILLET and *V. viviparus* L.). All laboratory attempts to infect experimentally other prosobranch and pulmonate snails i.e. *Lymnaea stagnalis* L., *L. tomentosa*, *L. truncatula* O.F. MÜLLER, *L. palustris* O.F. MÜLLER, *L. peregra* O.F. MÜLLER, *L. auricularia* L., *Planorbarius corneus* L., *Planorbis planorbis* L., *Biomphalaria glabrata*, *B. alexandrina* EHRENBERG, *Physa acuta* DRAPARNAUD, *Bithynia tentaculata* L., and *B. leachi* SHEPPARD have failed.

Second intermediate host:

Echinostoma jurini cercariae easily penetrated and encysted in various freshwater pulmonate and prosobranch snails, mussels, frogs and turtles. So far the following animals were successfully infected: *Viviparus viviparus*, *V. contectus*, *Lymnaea stagnalis*, *L. tomentosa* PFEIFFER, *L. truncatula*, *L. palustris*, *L. peregra*, *L. auricularia*, *Planorbarius corneus*, *Planorbis planorbis*, *Biomphalaria glabrata* SAY, *B. alexandrina*, *Physa acuta*, *P. fontinalis* (L.), *Bithynia tentaculata*, *B. leachi*, *Unio crassus* PHILIPPSON and *Dreissena polymorpha* PALLAS, *Rana temporaria* L., *R. ridibunda* PALLAS, and *Emys orbicularis* L.

Final host:

Echinostoma jurini metacercariae developed easily in mammals: golden hamsters (*Mesocricetus auratus* WATERHOUSE), rats (*Rattus rattus* L.), and mice (*Mus musculus* L.). All attempts (except four preovigerous worms obtained from one young pigeon) to infect birds failed: ducks (*Anas platyrhynchos* L.), geese (*Anser anser* L.), chickens (*Gallus gallus* L.), pigeons (*Columba livia* GMELIN), turkeys (*Meleagris gallopavo* L.), partridges (*Alectoris graecca* MEISNER), and guinea-fowl (*Numida meleagris* L.).

Geographical distribution:

To date *E. jurini* has been reported from biotopes located along the largest rivers in Europe including the Danube River in Bulgaria, the Volga River in Russia, the Dnieper and Dniester River in Ukraine, the Po River in Italy, the Elba, Oder and Sprea in Germany, and the Niamunas River in Lithuania. It is suggested that *E. jurini* occurs in Asia where its viviparid snail host is distributed.

Parasite collection:

Adults of *E. jurini* obtained experimentally during these studies are deposited in the Naturhistorisches Museum Wien, Austria, slide Nr. 3284, in the Naturhistorisches Museum Berlin, Germany, slide Nr. 2715 and in the Harold W. Manter Laboratory of Parasitology, (HWML), Lincoln, Nebraska, USA, slide Nr. 34800.

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