***Oochoristica koubeki* n. sp. (Cestoda, Anoplocephalidae) from African *Chamaeleo senegalensis* (Chamaeleonidae) and emendation of the genus *Oochoristica* Lühe, 1898**

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Summary

During a survey of species diversity and ecology of selected West African vertebrates in the Niokolo Koba National Park, Senegal, two *Chamaeleo senegalensis* Daudin, 1802 (Chamaeleonidae) were collected and examined for parasites. A new species, *Oochoristica koubeki* n. sp., anoplocephalidian cestode of the genus *Oochoristica* Lühe, 1898 is described from the intestine of this host. The new species is related to *O. theileri* Fuhrmann, 1924; *O. theileri* Fuhrmann, 1924 f. *major* Baer, 1933; *O. celebensis* Yamaguti, 1954 and *O. rostellata* Zschokke, 1905 var. *agamicolle* Dollfus, 1957. All the forenamed species share characteristic strobila with proglottids wider than long. *Oochoristica koubeki* n. sp. differs from these species in different proportions of scolex, cirrus sac, ovary and vitellarium, further differences are in number of testes and presence of reinforced genital atrium. Only *O. theileri* shares two last mentioned features, however it differs in shape of testes (rounded) and in distribution of testes (two clusters). The new species differs from all other species in extremely high number of egg's capsules, different host species and zoogeographic distribution. Emendation of genus diagnosis *sensu* Beveridge (1994) is provided.

Keywords: *Oochoristica*; tapeworm; chameleon; Africa; Senegal

Introduction

Chamaeleo senegalensis Daudin, 1802 (Chamaeleonidae) is a common West African savanna chameleon with distribution from Senegal to Cameroon. They are found in moist savannah habitats. They have day activity and can be found on the ground crossing roads, or in bushes and small trees (Leaché *et al.*, 2006). Like other reptiles, chameleons host a variety of metazoan parasites. Often reptiles parasites are tapeworms from genus *Oochoristica* Lühe, 1898 (Linstowiinae). Eight cestode species of this genus infect-

ing the intestine of chameleons have been reported from African chameleons till now. These species are mentioned in Table 1. In this paper a new African anoplocephalid tapeworm *Oochoristica koubeki* sp. n. from *C. senegalensis* is described and compared with similar species.

Material and methods

The two specimens of *Chamaeleo senegalensis* were examined in 2007. They were collected under the authority of Senegal's National Parks General Management. Both specimens were collected at Simenti (13°01'33.4"N; 13°17'40.4"W; elevation 59 m) in the Niokolo Koba National Park, Tambacounda district, East Senegal, Africa. Whole animals with opened ventral side were fixed in 96 % ethanol. The gastrointestinal tract of each chameleon was removed and examined for helminths. In total, 3 fragments with scolices, and 19 fragments without scolices were obtained from the intestine of a single chameleon. Cestodes were fixed in 96 % ethanol, stained in iron acetocarmine according to the method of Georgiev *et al.* (1986), and mounted in Canada balsam. Specimens were examined under a light microscope equipped with differential interference contrast (DIC) and a digital image analysis system (Olympus analySIS auto 5.0); drawings were made with the aid of a drawing attachment. All measurements are given in micrometres (µm) unless otherwise stated. The names of reptiles follow on-line reptile database (<http://www.reptile-database.org>).

Results

Oochoristica koubeki n. sp.
(Figs. 1 – 5)

Description based on 1 fragment with scolex, and 17 strobilae fragments without scolices (n = 10, unless otherwise indicated; range, mean ± standard deviation): Worms flat-

Table 1. List of *Oochoristica* species reported from hosts of family Chamaeleonidae

<i>Oochoristica</i> species	Host	Locality	Reference
<i>O. africana</i> Malan, 1939	<i>Chamaeleo namaquensis</i> Smith, 1831	South West Africa	Prudhoe and Harris (1971) Burrage (1973)
<i>O. agamae</i> Baylis, 1919	<i>Chamaeleo</i> sp.	Kenya	Baylis (1937)
<i>O. agamae</i> Baylis, 1919	<i>Chamaeleo etiennei</i> Schmidt, 1919	Zaire	Southwell and Lake (1939)
<i>O. chavenoni</i> Capron, Brygoo et Broussart, 1962	<i>Furcifer verrucosus</i> (Cuvier, 1829) = syn. <i>Chamaeleo verrucosus</i> Cuvier, 1829	Madagascar	Capron (1962) Brygoo (1963) Junius-Bourdain (2006)
<i>O. courdurieri</i> Capron, Brygoo et Broussart, 1962	<i>Furcifer pardalis</i> (Cuvier, 1829) = syn. <i>Chamaeleo pardalis</i> Cuvier, 1829	Madagascar	Capron et al. (1962) Brygoo (1963) Junius-Bourdain (2006)
<i>O. danielae</i> Capron, Brygoo et Broussart, 1962	<i>Furcifer verrucosus</i> (Cuvier, 1829) = syn. <i>Chamaeleo verrucosus</i> Cuvier, 1829	Madagascar	Capron et al. (1962) Brygoo (1963) Junius-Bourdain (2006)
<i>O. koubeki</i> n. sp.	<i>Chamaeleo senegalensis</i> Daudin, 1802	Senegal	In this study
<i>O. theileri</i> Fuhrmann, 1924	<i>Chamaeleo tempeli</i> Tornier, 1900	Republic of South Africa Tanzania	Della Santa (1956) Spasskii (1951) Schmidt (1986)
<i>O. theileri</i> Fuhrmann, 1924 forma <i>major</i> Baer, 1933	<i>Chamaeleo tempeli</i> Tornier, 1900	Tanzania	Baer (1933) Della Santa (1956)
<i>O. theileri</i> Fuhrmann, 1924 forma <i>minor</i> Baer, 1933	<i>Chamaeleo tempeli</i> Tornier, 1900	Tanzania	Baer (1933) Della Santa (1956)
<i>O. truncata</i> (Krabbe, 1874)	<i>Chamaeleo gracilis</i> Hallowell, 1844	Uganda	Goldberg and Bursey (2008)
<i>O. truncata</i> (Krabbe, 1874)	<i>Chamaeleo gracilis</i> Hallowell, 1844 <i>Chamaeleo etiennei</i> Schmidt, 1919	Africa	Spasskii (1951)

tened dorsoventrally; strobila acraspedote. Maximum width attained in gravid segments. Scolex unarmed (Fig. 1A), poorly demarcated from strobila, 907 ($n = 1$) long by 822 ($n = 1$) wide; 4 slightly oval suckers 256 – 278 (265 ± 9 , $n = 4$) length and 202 – 256 (233 ± 12 , $n = 4$) width. Neck short in length, imperceptible, 781 ($n = 1$) width. Immature juvenile proglottids 72 – 123 (94 ± 16) long by 1460 – 1561 (1510 ± 26) wide. Ratio of immature proglottid length to width 4.92 – 8.18 % (6.19 ± 1.04 %). Mature proglottids 367 – 400 (382 ± 13 , $n = 7$) length and 1948 – 2118 (2034 ± 44 , $n = 7$) width. Ratio of mature proglottid length to width 17.41 – 20.55 % (18.80 ± 0.97 %, $n = 7$). Gravid proglottids wider than long, 416 – 1007 (719 ± 145 , $n = 15$) long by 1663 – 2186 (1997 ± 140 , $n = 15$) wide. Ratio of gravid proglottid length to width 22.74 – 55.66 % (36.23 ± 7.49 %, $n = 15$). Testes oval, arranged in 1 cluster slightly narrowed under vitelline gland, occupying central region between osmoregulatory

canals, mostly posterior to ovary and vitelline gland, however testes reach the posterior margin of ovary. Testes numbering 50 – 65 (57.6 ± 5.2) per proglottid, 18 – 51 (31 ± 6) long by 48 – 82 (68 ± 9) wide. Cirrus sac elongated, with clear, thick external wall, narrowing markedly at proximal end where vas deferens enters, exceeding osmoregulatory canals, 233 – 295 (262 ± 20) in length and 56 – 75 (67 ± 5) in width. Ratio of cirrus sac length to mature proglottid width 11.50 – 14.33 % (12.86 ± 1.08 %, $n = 7$). Genital ducts passing between the osmoregulatory canals. Genital atrium conspicuous, sphincter like, armed, encircled and strengthened by bands of circular and radial musculature. Genital pores alternating irregularly, situated in anterior fourth of proglottid. Ovary lobulated, medial, in anterior half of proglottid, 132 – 224 (161 ± 18) long by 393 – 758 (628 ± 78) wide. Lobes of ovary not reaching lateral osmoregulatory canals. Ratio of the width of the ovary to the

Figs. 1 – 5. *Oochoristica koubeki* n. sp.; line drawings. Fig. 1. Scolex. Bar = 500 μ m; Fig. 2. Fully formed oncosphere. Bar = 50 μ m; Fig. 3. Mature proglottids of strobilar fragment. Bar = 600 μ m; Fig. 4. Detail of terminal genitalia. Bar = 200 μ m; Fig. 5. Terminal gravid proglottid. Bar = 500 μ m.

mature proglottid 18.56 – 38.92 %. ($32.09\% \pm 3.94\%$, $n = 7$). Vitelline gland medial, compact, oval in shape, postovarian, 81 – 134 (106 ± 13) long by 202 – 347 (251 ± 35) wide, with small rounded lobules. Vitelline duct arises from dorsal surface of vitelline gland, Mehlis' gland not visible. Vagina opens into genital atrium, posterior to cirrus sac. Uterus not detectable in proglottids, replaced by eggs. Eggs located individually and embedded singly in the parenchyma of the proglottid. Number of eggs more than 1000. Whole egg with outer envelope 37 – 43 (39 ± 2) in diameter, hexacanth with inner envelope 31 – 38 (34 ± 2) in diameter, hexacanth size 24 – 31 (27 ± 2) in diameter (Fig. 4). Oncosphere hooks length 15 – 19 (17 ± 1). Two dorsal and 2 ventral osmoregulatory canals present.

Taxonomic summary

Type specimens: Holotype and 19 paratypes (Cat. C-615) deposited in the Helminthological Collection of the Institute of Parasitology, the Academy of Sciences of the Czech Republic, Branišovská 31, 370 05, České Budějovice, Czech Republic.

Type host: *Chamaeleo senegalensis* Daudin, 1802 (Chamaeleonidae), Senegal Chameleon.

Site of infection: Small intestine.

Type locality: Simenti, Niokolo Koba National Park, East Senegal, Africa ($13^{\circ}01'33.4''N$, $13^{\circ}17'40.4''W$).

Prevalence: One of two examined hosts, i.e., 50 %.

Intensity of infection: Three tapeworms in a single chameleon.

Etymology: Specific epithet in honor of prof. Petr Koubek, Institute of Vertebrate Biology, Academy of Sciences of the Czech Republic, a specialist in wildlife ecology and principal investigator of the project “Species diversity and ecology of selected West African vertebrates”.

Remarks

The new species is placed in *Oochoristica* Lühe, 1898 (Anoplocephalidae: Linstowiinae) because of the acraspedote proglottids, unarmed scolex with four suckers, genital aperture single and alternating irregularly, vagina posterior to the cirrus sac, lobed median and lightly poral ovary, median and post ovarian vitellaria, uterus ephemeral, capsules with a single egg, numerous testes, which are posterior and lateral to the vitelline gland (Spasskii, 1951; Okafor, 1988; Beveridge, 1994). About ninety species of genus *Oochoristica* parasitizing reptiles and mammals are currently worldwide recognized (Bursey *et al.*, 1996; Arizmendi-Espinosa *et al.*, 2005; Guillén-Hernández *et al.*, 2007; Mašová *et al.*, 2010). However there exist a problem with validity and synonymy of these species and a revision of this genus is needed (Beveridge, 1994; Mašová *et al.*, 2010). You can see older incomplete

species lists and compendia for example by Meggitt (1934); Hughes (1940), Hughes *et al.* (1941); Spasskii (1950), Wardle and McLeod (1952), Della Santa (1956), Schmidt (1986) and others. About 20 species are distributed in the Ethiopian realm (Schmidt, 1986; Bursey *et al.*, 1994). Out of these, 7 species are parasites of chameleons, from which 3 species are described from Madagascar. Table 1 summarizes all known data regarding occurrences of *Oochoristica* species in chameleon hosts. Important distinguishing features of *O. koubeki* sp. n. and other (below mentioned) similar species from all other species of *Oochoristica* are morphology and shape of proglottids. The new species can be readily distinguished from most species of *Oochoristica* by proglottids, which are wider than long and this feature persists in whole length of strobila. There exists a group of the *Oochoristica* species from different hosts having mature proglottids markedly wider than long: e. g., *O. gallica* Dollfus, 1954; *O. darenensis*, Dollfus, 1957; *O. pseudocotylea* Dollfus, 1957; *O. rostellata* Zschokke, 1905; *O. oklahomensis* Peery, 1939; *O. procyonis* Chandler, 1942; *O. chavenoni* Capron, Brygoo et Broussart, 1962; *O. courdurieri* Capron, Brygoo et Broussart, 1962; *O. danielae* Capron, Brygoo et Broussart,

Table 2. Comparison of basic morphological features and measurements (in μm) of *O. koubeki* n. sp. and morphologically most-similar species of *Oochoristica*

Features	<i>O. theileri</i> Fuhrmann, 1924	<i>O. theileri</i> Fuhrmann, 1924 f. <i>major</i> Baer, 1933	<i>O. celebensis</i> Yamaguti, 1954	<i>O. rostellata</i> Zschokke, 1905 var. <i>agamicolla</i> Dollfus, 1957	<i>O. koubeki</i> n. sp.
Scolex	300 – 400	410 – 576	650 – 750	580 – 680	907 × 822
Cirrus sac	120	106 – 125 × 57 – 65	—	150 – 230	233 – 295 × 56 – 75
Genital atrium	Armed	Not armed	Not armed	Not armed	Armed
Ovary	200 – 240	—	240 – 500	120 – 520	132 – 224 × 393 – 758
Vitellarium	80 – 100	—	120 – 260	150 – 200	81 – 134 × 202 – 347
No. of testes	26 – 30	30–35	22 – 31	69 – 80	50 – 65
No. of testes clusters	2	1	1	1	1
Testes shape	Round	Slightly oval	Slightly oval	Round	Oval
No. of capsules	< 100	< 100	< 100	< 100	> 1000
Host	<i>Agama hispida</i> (Kaup, 1827) (Agamidae)	<i>Chamaeleo tempeli</i> Tornier, 1900 (Chamaeleonidae)	<i>Mabuya</i> sp. (Scincidae)	<i>Agama bibroni</i> Duméril et Bibron, 1851 (Agamidae)	<i>Chamaeleo senegalensis</i> Daudin, 1802 (Chamaeleonidae)
Locality	South Africa	central East Africa	East Indonesia	North Africa	West Africa
Reference	Fuhrmann (1924)	Della Santa (1956)	Yamaguti (1954)	Dollfus (1954)	In this study

1962; *O. freitasi* Rêgo et Ibáñez, 1965; *O. bezyi* Bursey et Goldberg, 1992; *O. islandensis* Bursey et Goldberg, 1992; *O. maccoyi* Bursey et Goldberg, 1996; and *O. leonregagnonae* Arizmendi-Espinosa, García-Prieto et Guillén-Hernández, 2005. However, these species have gravid proglottids longer than wide. There exists only a small group of *Oochoristica* species, which don't lose ratio of side, which remain in wider than long or maximally quadratic shape. These are: *O. theileri* Fuhrmann, 1924; *O. theileri* Fuhrmann, 1924 f. *major* Baer, 1933; *O. celebensis* Yamaguti, 1954; and *O. rostellata* Zschokke, 1905 var. *agamicolla* Dolfus, 1957.

Oochoristica koubeki sp. n. can be readily distinguished from the forenamed species with persisting ratio of proglottids wider than long by following features: noticeably wider scolex and proportions of cirrus sac, ovary and vitelline follicles are separated or slightly overlapping. The new species exhibits a greater number of testes than all other species, except for *O. rostellata* var. *agamicolla*. Only *O. koubeki* sp. n. and *O. theileri* have a strengthened genital atrium. The new species differs from *O. theileri* in testes position. Testes of *O. theileri* form two separate fields and their shape is rounded. Contrary to this arrangement, *O. koubeki* sp. n. has oval testes forming one uninterrupted field. Further essential feature is enormous number of egg capsules, which is unique for this new species. The similar species have also different hosts. Basic distinguishing features of related species are mentioned in Table 2.

Discussion

The genus *Oochoristica* Lühe, 1898 was established on a basis of very low knowledge of tapeworms from the host *Lacerta ocellata* Daudin, 1802 [synonymum of *Timon lepidus* (Daudin, 1802)] from locality Algeciras in Spain. It was described by Rudolphi (1819) as *Taenia tuberculata*. This species is considered for genotype of the genus *Oochoristica*. Dollfus (1954, 1957) extensively evaluated the series of revisions, which the original diagnosis by Lühe (1898) gone through it. It should be noted that up to these days, many authors have contributed to expansion eventually to narrowing of the generic diagnosis of *Oochoristica*. For instance the following: Zschokke (1905), Baer (1927, 1933), Meggitt (1934), Hsü (1935), Joyeux and Baer (1936), Malan (1939), Hughes (1940), Spasskii (1951), Wardle and McLeod (1952), López-Neyra (1954), Dollfus (1954, 1957), Della Santa (1956), and Schmidt (1986). Beveridge (1994) gives the latest genus characteristics. Each author modified the diagnosis according to contemporary knowledge about number of species, their hosts and distribution. On the basis of our results and studying of literature, we have reached to the conclusion that the last generic diagnosis of *Oochoristica sensu* Beveridge (1994) needs emendation.

Diagnosis after Beveridge (1994): Strobila small. *Proglottids* acraspedote, *longer than wide*. Genitalia single. Genital pores alternate irregularly. Genital ducts lie between

canals. Internal and external seminal vesicles absent. *Testes posterior to vitellarium*. Ovary central. Vagina posterior to cirrus-sac. Seminal receptacle present or absent. Uterus ephemeral. *Vitellarium compact*. In reptiles, mammals. Cosmopolitan. Type species *O. tuberculata* (Rudolphi, 1819). For synonyms see Beveridge (1994), page 357. (The parts of diagnosis in italics are emended as follows.)

Emended diagnosis

Anoplocephalidae, Linstowiinae, *Oochoristica*

Strobila with all proglottids wider than long, alternatively quadratic or longer than wide; gravid proglottids frequently longer than wide or rarely quadratic. Testes posterior or posterior and lateral to vitellarium. Vitellarium compact, postovarian.

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