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Eucestoda

Cathetocephalidea Schmidt and Beveridge, 1990 (Order)

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Order Cathetocephalidea

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Chapter 24

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Introduction

Species in the order Cathetocephalidea Schmidt and Beveridge, 1990 are segmented worms and are parasites of the spiral intestine (also called the spiral valve) of sharks. Despite their low species richness, they have an almost cosmopolitan distribution. Cathetocephalidea is one of the 19 orders constituting the class Cestoda (Platyhelminthes). Their name is derived from the Greek terms **kathetos** (= perpendicular) and **kephalē** (= head), which refers the position of the fleshy fixation organ (**scolex**) with respect to the body (**strobila**).

This order was proposed by Schmidt and Beveridge (1990) based on the uniqueness of the scolex of the 2 species known of the family Cathetocephalidae Dailey and Overstreet, 1973 although the strobila and proglottids are similar to those in the orders Tetraphyllidea, Trypanorhyncha, and Lecanicephalidea. However, Euzet (1994) maintained it at the family level and included in the Tetraphyllidea. Currently, the validity of the order was verified using molecular data (Caira et al., 2005).

This order contains the families **Cathetocephalidae** and **Disculicepitidae**. Cathetocephalidae comprises the genera *Cathetocephalus* (with 3 species) and *Sanguilevator* (with 1 species). The genus *Disculiceps* (with 2 species) is included in Disculicepitidae. In addition, 5 taxa are descriptions (nomina nuda = nude names), meaning that a species name was published without the designation of type specimens nor were sufficient data given for valid descriptions (Caira et al., 2017).

Main Morphological Characteristics

The body of individuals within the order Cathetocephalidea Schmidt and Beveridge, 1990 are polyzoic (that is, the strobila is composed of more than 1 proglottid) and are of moderate size, 23 mm-long in *Sanguilevator yearsleyi* and up to 134 mm-long in *Cathetocephalus resendezi*, according Caira and colleagues (2005). The scolex is fleshy and simple (meaning, lacking suckers, bothridia, or armature), is perpendicular to the axis of the strobila, and is T-shaped (except in species of *Disculiceps* spp., in which it is round in cross section). The scolex is divided into 2 regions: An apex that is cushioned with a rugose base (and which is referred to as a collar in species of *Disculiceps*). The anterior region of the scolex in *Cathetocephalus* and *Sanguilevator* possesses bands of minute papillae in the middle portion, but which are absent in *Disculiceps* (Nock and Caira, 1988). A distinctive trait of the scolex of *Sanguilevator* is the presence of 3 dorsoventral pairs of spherical chambers and 2 pairs of elongate transverse channels (1 dorsal and 1 ventral, with numerous lateral posterior branches) located in the center of the scolex proper (Caira et al., 2005; 2017).

The strobila may be fixed to the scolex in any position of the bottom surface of the rugose base. It is acraspedote, that is, without velum (see Palm, 2004), except in *Cathetocephalus australis* whose proglottids have velum, that is, they are slightly craspedote (Dailey and Overstreet, 1973; Schmidt and Beveridge, 1990; Euzet, 1994; Caira et al., 2005; 2017). Most of the species are euapolytic, meaning that there is detachment of the mature proglottids when the eggs are infective (Khalil et al., 1994) or anapolytic, meaning that proglottids remain on the strobila until they senesce and eventually degenerate (Caira et al., 2016), although anapolysis is only observed in both species of *Disculiceps* (Nock and Caira, 1988). The mature proglottids are longer than they are wider in *Cathethocephalus* and *Sanguilevator* and are almost square-shaped in *Disculiceps* (Caira et al., 2017).

Specimens within the order Cathetocephalidea Schmidt and Beveridge, 1990 are hermaphroditic, with numerous testes, varying from 77 (in *Sanguilevator yearleyi*) to 500 (in *Cathetocephalus thatcheri*). The cirrus sac is bent anteriorly and the cirrus is armed. The genital pore alternates irregularly, and is marginal, except in *Disculiceps*, and is equatorial, except in *Cathetocephalus* (where it is post-equatorial). The ovary is bi-lobed and the vagina opens anterior to the cirrus sac at the genital atrium. The uterus is medial and is weakly branched, becoming sacciform in some species. In both species of *Disculiceps,* the uterus opens by longitudinal dehiscence (Nock and Caira, 1988). The vitelline follicles are circum-medullary in cross section. The eggs are clustered in cocoons (Nock and Caira, 1988; Schmidt and Beveridge, 1990; Caira et al., 2005).

Description and Summary of a Representative Species

Note: This work is not intended for the purposes of zoological nomenclature.

***Cathetocephalus resendezi* Caira et al., 2005**

The worms are relatively large (29–134 mm-long) with 79–340 proglottids, and they are acraspedote and euapolytic. The body is covered by michrotriches (tegumentary projections with an apical electro-dense portion, following Chervy, 2009). The morphology of the scolex is described for the order, with the rugose base inconspicuous, covered by palmate microthrix. There is a papillate band with a folded base. The papillae are relatively short throughout the anterior one-half to two-thirds. Mature proglottids are longer than they are wider, bearing 128–285 testes arranged in a single layer. The cirrus sac is bent anteriorly, with blade-like spinitriches (which are a type of microthrix with > 200 nm in basal width; see Chervy, 2009). The genital pore is post-equatorial. The ovary is H-shaped in the ventral view. The vagina opens anterior to the cirrus sac at the genital atrium. The uterus is slightly sinusoidal. The vitellaria are follicular and distributed along the entire proglottid (see Caira et al., 2005).

Taxonomic summary.

Type host: Bull shark, *Carcharhinus leucas.*

Site of infection: Spiral intestine.

Type locality: Bahía de Los Ángeles (28° 85′ 50″ N, 113° 83′ 20″ W), Baja California, Gulf of California, Mexico.

Type specimens are listed here and additional details can be found in the original paper where this species was described (that is: Caira et al., 2005): Holotype (CNHE 5300); paratypes (CNHE 5301; USNM 96411; LRP 3717–3722).

Order Cathetocephalidea Schmidt and Beveridge, 1990 in Relation to Each Other

To date, 3 valid species are recognized in the genus *Cathetocephalus*: *Cat. thatcheri*, parasitizing the bull shark *Carcharinus leucas* from the Gulf of Mexico, United States (Dailey and Overstreet, 1973), *Cat. australis*, parasitizing the copper shark *Car. brachyurus* from Goolwa, South Australia (Schmidt and Beveridge, 1990), and *Cat. resendezi*, found in the spiral intestine of the bull shark *Car. leucas* collected in the Gulf of California, Mexico (Caira et al., 2005). The morphological differentiation among the 3 species of the genus is mainly based on features of the scolex: In *Cat. thatcheri* the papillae are slender and elongate, arranged in the distal third of the papillar band (versus the short, thick, and irregular papillae in *Cat. resendezi,* distributed from the distal one-half to two-thirds of the band). In the third species, *Cat. australis*, the papillae are disposed in 2 bands separated by a medial smooth band. In addition, the configuration of the rugose base of the scolex follows a gradient-like pattern, ranging from inconspicuous in *Cat. resendezi*, to slightly rugose in *Cat. thatcheri*, and conspicuous in *Cat. australis*.

Another distinctive feature is the presence of lobulated margins of the ovary of *Cathetocephalus resendezi*, which is unlike the other 2 species, in which continuous margins are evident (Dailey and Overstreet, 1973; Schmidt and Beveridge, 1990; Caira et al., 2005).

Despite the lack of bothridia and the presence of bands of papillae on its scolex, Cathetocephalidae was placed in the order Tetraphyllidea. However, Schmidt and Beveridge (1990) considered that these characteristics warranted the establishment of a new order for this family. Fifteen years later, Cathetocephalidea was the first order formally recognized since the disintegration of Tetraphyllidea, based on molecular evidence using the gene fragments 18S and 28S (Caira et al., 2005). Other closely related groups that derive from Tetraphyllidea are Phyllobothriidea and Onchoproteocephalidea, these being the sister taxa of Cathetocephalidea (Waeschenbach and Littlewood, 2017). Unlike Cathetocephalidea, specimens from both of those other orders have suckers, bothridia, or armature. In the phylogenetic analysis of Caira and colleagues (2014), Cathetocephalidea is closely grouped among the acetabulate orders of cestodes. Based on these results, the authors suggest the derived condition of the non-acetabulate scolex.

Life Cycles

To date, the life cycle of members of this order remains unknown. Notwithstanding, members of this group show a high affinity to Carcharhiniformes sharks, particularly

Carcharhinidae and Sphyrnidae. This host-parasite association seems to suggest the oioxenous (that is, a 1:1 relationship between parasite and host species) nature of these cestodes. According to the original description of the 6 species known for this order, their distribution is almost worldwide. However, Caira and colleagues (2017) pointed out that they have not been recorded from the Arctic and Southern Ocean marine realms as established by Spalding and colleagues (2007).

Unique Features of the Order Cathetocephalidea Schmidt and Beveridge, 1990

The multistrobilization (that is, the formation of multiple strobilae attached to a single scolex) observed by Dailey and Overstreet (1973) in *Cathetocephalus thatcheri* (occasionally with 14 to 24 strobilae per individual) seems to be an exclusive character of this species more than a general feature at the order level, since it has not been found in other members of this group and only reported in 1% of the specimens collected by Dailey and Overstreet (1973). According to these authors, a more detailed examination of this phenomenon must be conducted to determine if it represents a type of asexual multiplication or an abnormal condition of the specimens studied by them.

The accumulation of blood cells in the chambers and channels of the *Sanguilevator yearsleyi* escolex is a feature that distinguishes it within the Cathetocephalidea and the cestodes in general. According to Caira and colleagues (2005), there is no plausible explanation for how the cestodes separate the host's cells as well as what the purpose of this accumulation may be.

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