



A new species of toothless, short dorsal-fin *Schindleria* (Gobiiformes: Gobiidae) from the Red Sea (Egypt)

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Abstract

We describe a new, tiny species of *Schindleria* from a reef lagoon in the Red Sea off the coast of Hurghada, Egypt. *Schindleria edentata*, new species, belongs to the short dorsal-fin type of *Schindleria*, with the dorsal and anal fins of about equal length. *Schindleria edentata* is characterized by an elongated but relatively deep body (body depth at anal-fin origin 10.8% of SL and at 4th anal-fin ray 10.9% of SL); a short dorsal fin originating just slightly anterior to the anal fin (predorsal-fin length 60.9% of SL, pre-anal fin length 64.8% of SL); a stubby head with a steep frontal profile, a short snout (i.e., 23.1% of head length), and large eye (i.e., 27.7% of the head's length); a long pectoral radial plate (length 7.6% of SL); four dorsal and four ventral procurent caudal-fin rays increasing in length posteriorly; last procurent ray simple without additional spine and, although the longest, not distinctly elongate; 15 dorsal-fin rays; 13 anal-fin rays; the base of the first anal-fin ray positioned below the base of the third dorsal-fin ray; upper and lower jaws toothless; *in vivo* with translucent body; eye black; swim bladder capped by a melanophore blotch; no pigmentation externally on body after preservation.

Keywords

Gobiiformes, morphology, new species, paedomorphosis, progenesis

Introduction

The genus *Schindleria* (Giltay, 1934) (Schindler's fishes or infant fishes) has a large biogeographic range spanning the entire Indo-Pacific from remote South American islands to East and South African coasts, and from the Red Sea to Japan (summarized in Ahnelt and Sauberer 2020). Often found in and close to coral reef lagoons (Leis 1994; Watson 2000; Robitzsch et al. 2021a), also offshore and

deep-water records have been documented (Belyanina 1989; Parin 1991; Ahnelt and Sauberer 2020). *Schindleria* are not only among the smallest vertebrates (8 mm–22 mm, average ca. 17 mm) but also mature rapidly. Some species reach maturity at an average of 37 days and may produce up to nine generations per year (Kon and Yoshino 2002).

Although individuals of *Schindleria* are likely among the most numerous fishes associated with coral reefs (Gosline and Brock 1960; Whittle 2003; Robitzch et al. 2021) these tiny gobioids are easily overlooked and frequently mistaken for larval fishes (Bogorodsky and Randall 2019; Robitzch et al. 2021a). Numerous records are based on a few specimens only (Ahnelt and Sauberer 2019, 2020; Robitzch et al. 2021b) and these were often collected as by-catch of other research surveys. Therefore, almost nothing is known about the biology and ecology of *Schindleria* (Robitzch et al. 2021a). To date, the sister group of *Schindleria* is still unknown and its position among gobioid fishes is still under debate (e.g., Ahnelt 2020; Abu El-Regal et al., 2021). Originally described as species of *Hemirhamphus* (Schindler 1930, 1931, 1932), these tiny fishes were reclassified as a new genus, *Schindleria*, and placed in a new family, Schindleriidae, by Giltay (1934) and demonstrated to belong to the Gobioidae by Johnson & Brothers (1993). However, in two molecular phylogenetic studies *Schindleria* was resolved within the family Gobiidae (Thacker 2009; Agorreta et al. 2013).

Eight nominal species of *Schindleria* have been described so far: *S. brevipinguis* Watson and Walker 2004, *S. elongata* Fricke and Abu El-Regal 2017, *S. macrodentata* Ahnelt and Sauberer 2018, *S. multidentata* Ahnelt 2020, *S. nigropunctata* Fricke and Abu El-Regal 2017, *S. parva* Abu El-Regal et al. 2021, *S. pietschmanni* (Schindler 1931), and *S. praematura* (Schindler 1930). Yet, this number of species underestimates their true diversity as over 25 unrecognized species of *Schindleria* were documented during two surveys on the Ryukyu, Ogasawara, and Palau Islands (Western Pacific), where nearly all of them are endemic to one of these islands (Kon et al., 2007, 2011). Based on short generation time and high levels of endemism Kon et al. (2007) suggested that large numbers of species throughout the entire range of the genus have remained undescribed.

Schindleria are extremely progenetic (Johnson and Brothers 1993) and are among the most short-lived vertebrates (Kon and Yoshino 2002, Zák et al. 2021). Adult *Schindleria* have a reduced larva-like, elongate, translucent, and scaleless body with a straight gut and a characteristic caudal complex (comprising two modified last vertebrae, an extremely elongate urostyle, and fused hypurals forming a triangular plate (Johnson & Brothers 1993) and a pair of elongated muscles on each side of the urostyle) (Ahnelt and Sauberer 2018). Many morphological characteristics important for species-level diagnoses in gobioid fishes, mainly involving features of the pelvic and first dorsal fins, are missing in *Schindleria* (Schindler 1932; Johnson and Brothers 1993). However, *Schindleria* species are morphologically more diverse than often assumed, having relatively few but distinct characters, which allow the identification of species (Watson and Walker 2004; Kon et al., 2010; Ahnelt and Sauberer 2018, Ahnelt 2020; Abu El-Regal et al. 2021; Robitzch et al. 2021b). For instance, the relative position of the dorsal and anal fins to each other, the number of their fin rays, the number of myomeres and vertebrae (Schindler 1930,

1931; Kon et al. 2007; Fricke and Abu El-Regal 2017a, b), the shape of the pectoral radial plate, the shape of the last procurent caudal-fin rays, the shape of the lower jaw arch, and details of the dentition of the oral jaws (Ahnelt and Sauberer 2018; Ahnelt 2019, 2020) are helpful in diagnosing species.

In an attempt to group *Schindleria* specimens morphologically (Ahnelt 2019; Abu El-Regal et al. 2021), two characters seem most useful: (1) relative length of dorsal and anal fins (Ahnelt 2019, 2020) and (2) dentition (Watson and Walker 2004; Ahnelt 2020). The dentition of the jaws allows distinction of two main groups: species with jaw teeth and species that lack teeth in one or both jaws. In six out of the eight described species of *Schindleria*, teeth are present on both, the premaxilla and the dentary (Ahnelt 2020). Among the remaining two species of *Schindleria*, *S. parva* has a toothless dentary but a toothed premaxilla (Abu El-Regal et al. 2021) and *S. brevipinguis* lacks teeth in both jaws (Watson and Walker 2004). These two species share a very small size (<12 mm SL and <9 mm, respectively). In the present study we describe another tiny species of *Schindleria* with toothless jaws.

Material and methods

The holotype of *Schindleria edentata* is deposited in the Natural History Museum in London, Great Britain, and registered as BMNH 2007.5.20.1 (Abu El-Regal and Kon 2008). The specimen was collected with a plankton net (500 mm mouth diameter, 0.5 mm mesh size). Already dead when the net was emptied, it was preserved in 10% buffered formalin and later stored in 70% ethanol (Abu El-Regal and Kon 2008). Counts were taken and measurements were made with a stereomicroscope and a micrometer eyepiece to the nearest of 0.1 mm by HA. The length of the urogenital papilla was measured from the anterior point of the ventral attachment of the papilla to its most distal tip.

Morphometric and meristic differences between *S. edentata*, *S. brevipinguis* and *S. parva*, the only three species lacking teeth in one or both jaws, are highlighted in grey in Table 1 and Table 2.

Due to its subsequent preservation, the specimen has now a dark brown to blackish color (Fig. 1A). Hence, the exact position of the swim-bladder was determined using a photograph taken by MAE-R of the holotype shortly after its collection (Fig. 1B). The caudal fin is now partly damaged and its shape has been described from the same original photograph.

We follow Thacker (2009) and Agorreta et al. (2013) who considered Schindleriidae as junior synonym of Gobiidae, a view also adopted by Gill and Mooi (2010), Nelson et al. (2016), Betancur-R et al. (2017) and Parenti (2021). Other authors have continued to classify *Schindleria* in its own family Schindleriidae (e.g., Fricke and Abu El-Regal 2017; Abu El-Regal et al. 2021).



Figure 1. **A** Holotype of *Schindleria edentata* (BMNH 2007.5.20.1), male, SL 9.0 mm; Egypt, Hurghada. Arrows indicate position of broken-off first and second dorsal fin rays. Scale bar = 1 mm. Photo H. Ahnelt. **B** Same specimen, but photo taken shortly after initial collection. Grey arrow indicates position of last dorsal fin ray, black arrow indicates position of swim bladder. Scale = 1 mm. Photo M. Abu El-Regal.

Abbreviation of collections

AMS – Australian Museum, Sydney, Australia

BMNH – Natural History Museum, London, Great Britain

CAS – California Academy of Sciences, San Francisco, USA

NMW – Naturhistorisches Museum Wien, Vienna, Austria

SMF – Senckenberg Museum Frankfurt, Frankfurt, Germany

ZMUC – Statens Naturhistoriske Museum, Zoologisk Museum København, Copenhagen, Denmark

Comparative material

Schindleria brevipinguis: Paratype (AMS I 2632-003), 6.6 mm standard length (SL), Australia, Queensland, Carter Reef, 18 January 1982. Photographs of the holotype (AMS I 23552-006).

Schindleria elongata: Photographs of the holotype (SMF 35780) and paratype (SMF 35781).

Schindleria macrodentata: Holotype (ZMUC 77624), 16.5 mm SL, Molucca Sea, Indonesia, between the islands of Sulawesi and Halmahera, March 1929. Paratype specimen (ZMUC 77617), 18.7 mm SL. Sulu Sea, Philippines, northwest of the north tip of the Island Panaya, 27 June 1929.

Schindleria nigropunctata: Holotype (SMF 35956), 15.9 mm SL, female, Red Sea, Egypt,

Magawish Island, 23 April 2016. Paratype (SMF 35957), male, 13.9 mm SL, same data as holotype.

Schindleria parva: Holotype (SMF 38020), 11 mm SL, female, Red Sea, Shaara Public Beach, Jeddah, Saudi Arabia. Paratype (SMF 38021), 9 mm SL, male, same data as holotype.

Schindleria pietschmanni: 42 syntypes (NMW 99182), 15.1–17.0 mm SL, North West Hawaiian Islands, French Frigate Shoal. May 1928.

Schindleria praematura: 49 syntypes (NMW 99183), 18.3–20.5 mm SL, North West Hawaiian Islands, French Frigate Shoal. May 1928.

Results

Schindleria edentata, sp. nov.

<http://zoobank.org/B629D76D-0FC8-4817-851B-F03D22E-FAA0B>

Figures 1–2; Tables 1–2

Schindleria sp. Abu El-Regal & Kon (2008).

Schindleria sp. Fricke & Abu El-Regal (2017a, b).

Schindleria sp. Abu El-Regal & Kon (2019).

Holotype. BMNH 2007.5.20.1. Male, 9.0 mm SL. Red Sea, Egypt, Hurghada, reef lagoon, 27.285°N, 33.772778°E. 05 February 2005, M. Abu El-Regal.

Diagnosis. A member of the SDF group of *Schindleria*, which can be distinguished from all members of the LDF group by the combination of following charac-

Table 1. Body proportions in % of standard length of holotype of *Schindleria edentata* sp. nov., BMNH 2007.5.20.1 and males of the two other dwarf species, *S. brevipinguis*, AMS-I-26323-003 and *S. parva*, SMF 38021. Data for *S. parva* were calculated from measurements in Abu El-Regal et al. (2021) (Table 1). Differences between *S. edentata* and other species highlighted in grey. * TL from Abu El-Regal and Kon (2008).

Species	<i>S. edentata</i>	<i>S. brevipinguis</i>	<i>S. parva</i>
Specimen	Holotype	Paratype	Paratype
Sex	male	male	male
Total length (TL) in mm	10.0*	7.3	10.1
Standard length (SL) in mm	9.0	6.6	9
% Standard length			
Predorsal-fin length	60.9	63.0	65
Preanal-fin length	64.8	66.7	72
Preanus length	56.1	61.2	–
Gut length	41.4	42.4	–
Base of dorsal fin	29.8	28.5	–
Base of anal fin	24.3	23.0	–
Tail length (excluding caudal fin)	36.2	39.4	–
Head length	14.9	18.4	22
Head width	11.6	10.6	–
Caudal-fin length	damaged	10.6	12
Body depth at pectoral-fin base	7.3	10.3	5
Body depth at anus	9.6	13.3	–
Body depth at origin of anal-fin	10.8	13.3	8
Body depth at base of 4 th anal-fin ray	10.9	11.5	–
Position of swim bladder along body	44.6	45.5	–
Caudal peduncle length	8.2	11.5	–
Caudal peduncle depth (min.)	2.1	2.8	–
Pectoral radial plate length	7.6	5.8	–
Pectoral radial plate width (at origin)	2.7	3.6	–
Pectoral radial plate width (max.)	3.4	5.6	–
Snout length	3.4	4.3	–
Eye diameter horizontal	4.1	5.7	5
Eye diameter vertical	4.1	6.1	–
Postorbital length	6.9	8.5	–
Interorbital width	4.6	6.7	–
Urogenital papilla length	4.8	7.6	3
% of caudal peduncle length			
Caudal peduncle depth	25.6	25.0	–
% of head length			
Snout length	23.1	23.0	23
Eye diameter horizontal	27.7	31.1	20
Eye diameter vertical	27.7	32.8	–
Postorbital length	46.2	45.9	–
Interorbital width	30.8	35.2	–
Head width	35.9	55.7	–
% of eye diameter horizontal/vertical			
Interorbital width	111.1	112.0	–
% of pectoral radial plate length			
Pectoral radial plate width (at origin)	36.4	53.7	–
Pectoral radial plate width (max.)	45.5	97.9	–

ters (i) length of dorsal fin nearly equal to that of anal fin (vs. dorsal fin significantly longer than anal fin); (ii) body deeper (10.8% in SL vs. 4.5–5.4% in SL); (iii) body depth significantly increasing from pectoral-fin base to 4th anal-fin ray (vs. not or only slightly increasing); (iv) head short and wide with steep profile (vs. elongated and

narrow with flat profile) and (v) both jaws toothless (vs. both jaws with teeth).

From the other species of the SDF group, *Schindleria edentata* can be distinguished as follows 15 dorsal-fin rays (vs. 9–13 in *S. parva* and *S. brevipinguis*, 16–18 in *S. pietschmanni*), 13 anal-fin rays (vs. 7–11 in *S. par-*

Table 2. Meristic information for holotype of *Schindleria edentata* sp. nov., BMNH 2007.5.20.1 and males of the two other dwarf species *S. brevipinguis*, AMS-I-26323-003 and *S. parva*, SMF 38021. Data for *S. parva* from Abu El-Regal et al. (2021) (Table 1). Differences between *S. edentata* and other species highlighted in grey. d = damaged. * Data from Abu El-Regal and Kon (2008).

Species	<i>S. edentata</i>	<i>S. brevipinguis</i>	<i>S. parva</i>
Specimen	holotype	paratype	paratype
Sex	male	male	male
Total length (TL) in mm	10.0*	7.3	10.1
Standard length (SL) in mm	9.0	6.6	9.0
Dorsal fin rays	15	13	9
Anal fin rays	13	11	7
Pectoral fin rays (left/right)	14/d	14	13
Caudal fin rays (dorsal/ventral)	13 (7/6)	13 (7/6)	13
Procurrent rays (dorsal/ventral)	4/4	6/6	–
1 st anal fin ray ventral to dorsal fin ray x	3	3	4
Gut ends ventral to dorsal fin ray x	1	1	–
Total number of myomeres	36	36	39
Number of abdominal myomeres	21	20	23
Number of caudal myomeres	15	15	16
Number of vertebrae	37	35	–
Position of swim-bladder at myomere x	13	12–13	–
Position of first dorsal fin ray at myomere x	21	20	24
Position of last dorsal fin ray at myomere x	35	33	36
Position of first anal fin ray at myomere x	23	23	26
Position of last anal fin ray at myomere x	35	33	36
Teeth on premaxillary	no	no	small
Teeth on dentary	no	no	no
Pigmentation preserved (except eyes)	no	no	no

va and *S. brevipinguis*, 19–21 in *S. pietschmanni*), pre-anal-fin length 64.8 % SL (vs. 72% in *S. parva*, 66.7% in *S. brevipinguis*, 54% in *S. pietschmanni*), predorsal-fin length 60.9% SL (vs. 65.0% in *S. parva*, 63.0% in *S. brevipinguis*, 58.3% in *S. pietschmanni*); length of tail excluding caudal fin 36.2% SL (vs. 28.2% in *S. parva*, 39.4% in *S. brevipinguis*, 42.1% in *S. pietschmanni*), length of urogenital papilla 4.8% SL (vs. 3.0% in *S. parva*, 7.6% in *S. brevipinguis* and < 0.5% in *S. pietschmanni*), eye diameter 27.7% HL vs. 20.0% in *S. parva*, 31.1% in *S. brevipinguis*, 23.1% in *S. pietschmanni*), mouth terminal (vs. superior in *S. parva*, *S. pietschmanni*, *S. brevipinguis*).

Schindleria edentata can be further distinguished from *S. brevipinguis* and *S. pietschmanni* by a wider head (35.9% HL vs. 55.7% in *S. brevipinguis*, 43.2% in *S. pietschmanni*) and a lower number of caudal procurrent rays (4/4 vs. 6/6 in *S. brevipinguis* and *S. pietschmanni*).

Schindleria edentata can be further distinguished from *S. parva* and *S. pietschmanni* by its toothless jaws (vs. upper jaw toothed in *S. parva* both jaws toothed in *S. pietschmanni*), and head shape (stubby, oval with steep profile vs. elongated, narrow with flat profile in *S. parva* and *S. pietschmanni*).

Schindleria edentata can be further distinguished from *S. parva* by fewer myomeres (36 vs. 39), the first dorsal-fin inserted at myomere 21 (vs. myomere 24), the first anal-

fin ray at myomere 23 (vs. myomere 26) and a greater body depth at pectoral-fin base (7.3% SL vs. 5%).

Schindleria edentata can be further distinguished from *S. brevipinguis* by a shorter caudal peduncle (8.2% SL vs. 11.5%), pectoral-radial plate longer than wide (vs. nearly as long as wide) and a pigmented swim bladder (vs. unpigmented swim-bladder).

Description. Morphometric information for the holotype is given in Table 1 and meristic data in Table 2. Body elongate, increases gradually in depth from about myomere 8 to about middle of tail, rapidly decreasing in depth to end in long narrow caudal peduncle, length ca. 25% of SL); head oval with steep profile; snout short, rounded; jaws short, reaching below origin of eye; lower jaw curved towards midline (Fig. 2).

First dorsal fin and pelvic fin absent; dorsal-fin rays 15; anal-fin rays 13; pectoral-fin rays 14; principle caudal-fin rays 7+6=13; caudal fin truncated; procurrent rays 4 dorsal and 4 ventral; procurrent rays gradually increasing in length, last procurrent ray simple, with no additional spine, not distinctly elongated; base of first dorsal-fin ray at myomere 21, that of last dorsal-fin ray at myomere 35; base of first anal-fin ray at myomere 22, that of last anal-fin ray at myomere 35; total number of myomeres 36 with 21 abdominal and 15 caudal; vertebrae 37, with 21 abdominal and 16 caudal (incl. urostyle); Branchiostegal rays 5; pectoral-radial plate longer than wide, of paddle-like shape, narrow at origin and wide distally; gut



Figure 2. Holotype of *Schindleria edentata* (BMNH 2007.5.20.1), male, SL 9.0 mm; head in lateral view. Scale bar = 0.2 mm. Photo H. Ahnelt.

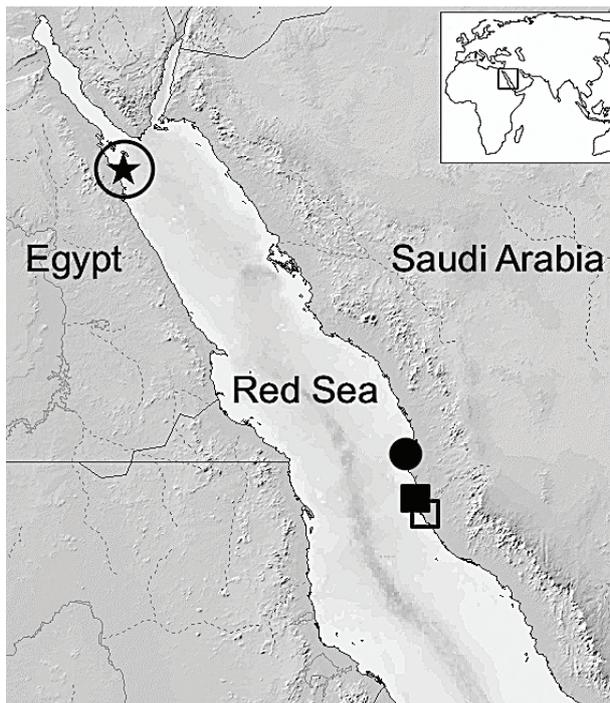


Figure 3. Records of *Schindleria* in the Red Sea. Circle = *S. elongata*, *S. nigropunctata*, Hurghada (Fricke & Abu El-Regal, 2017a, b) and *S. praematura*, Hurghada (Abu El-Regal and Kon 2019); black star = sampling site of *S. edentata* nov. spec., Hurghada; black dot = *Schindleria* sp., Thuwal (Robitzsch et al. 2021); black square = *S. parva*, Jeddah (Abu El-Regal et al. 2021); empty square = *Schindleria* sp., Jeddah (Al-Solami and Abu El-Regal 2020). Map is based on https://www.landkarten-index.de/kostenlos/cliparts/cliparts_gruppe_1/saudiarabien.gif

straight; male urogenital papilla elongated, tubular, tapering towards posteriorly curved tip, tip without distinct lobes at opening; swim bladder small, inconspicuous,

pigmented dorsally, located at myomere 13, in posterior half of abdomen, .

Coloration in life. Transparent; the only pigment is a melanophore cap on top of the swim bladder and the black pigmentation of the eye (see also Abu El-Regal and Kon 2008).

Coloration preserved. Due to subsequent preservation artifacts, the entire specimen is now dark brown to blackish (Fig. 1A).

Distribution. *Schindleria edentata* is only known from a shallow (7 m) reef lagoon near Hurghada (Egypt), Red Sea (27.285° N, 33.772778° E) (Fig. 3).

Habitat. The bottom of the lagoon was sandy and covered with algae and seagrass. The specimen was sampled at a depth of 1 m.

Etymology. The name *edentata*, derived from the Latin *e* = without, and *dentatus* = toothed, refers to the absence of teeth in both jaws, an adjective.

Discussion

The new species *Schindleria edentata* from the Red Sea is the ninth in the genus and the fourth species endemic to the Red Sea. Six of nine species of *Schindleria* are known from the margins of the distributional range of the genus: *S. edentata*, *S. elongata*, *S. nigropunctata*, and *S. parva* from the Red Sea and *S. pietschmanni* and *S. praematura* from the Hawaiian Islands (Northern Central

Pacific). The three other species are known from the Society Islands (*S. multidentata*), from Queensland, Australia (*S. brevipinguis*) and from the Malayan Archipelago (*S. macrodentata*) (Ahnelt, 2020). The recent discoveries of three new species endemic to a relatively small area in the extreme north of the Red Sea (Fricke and Abu El-Regal 2017a, b; this study) support Kon et al.'s (2011) view that there are high levels of endemism and potentially unrecognized species in the genus *Schindleria*.

Adults of *Schindleria* are characterized in life by a translucent body with blackish eyes and a black-capped swim bladder, features otherwise common among many larval fishes (Johnson and Brothers 1993). Life coloration of *S. nigropunctata* (Fricke and Abu El-Regal 2017b) and *S. praematura* (Whittle 2003), has been described as including orange blotches extending along the ventral surface of the body. Some studies have reported dark spots or dots on the body in *S. nigropunctata* (Fricke and Abu El-Regal 2017b) and *S. praematura* and *S. pietschmanni* (Watson 2000). But such a type of pigmentation is likely to disappear after preservation (*S. nigropunctata*) and is not species specific (Ahnelt 2019) as it is shared by *S. praematura* and *S. pietschmanni*. Schindler (1930, 1931) mentioned that individuals of the latter two species were not pigmented except for the swim bladder and the eyes, an observation confirmed by Johnson and Brothers (1993). In some species identified as *S. praematura*, juveniles and larvae had black melanophores in the ventral midline but no such pigment was reported in adults (Sardou 1974; Ozawa and Mazui 1978). Based on our current state of knowledge, preserved adult specimens have no pigmentation on the body.

A reliable character to group species of *Schindleria* is the relative length of their dorsal and anal fins. Already the first two described species, *S. praematura* and *S. pietschmanni*, are easily distinguished by this feature (Schindler 1932). In *S. praematura*, the dorsal fin is distinctly longer than the anal fin; while in *S. pietschmanni* both fins are of about equal length (Schindler 1932). This character is, however, not diagnostic at the species level but rather serves the initial separation into two groups, the LDF and SDF groups. There is evidence for various unrecognized species within both groups (Kon et al. 2007) and samples from the Indo-Pacific Ocean (Ahnelt and Sauberer 2018, 2019) match either the LDF type of *S. praematura* or the SDF type of *S. pietschmanni* (Kon et al. 2007; summarized in Ahnelt and Sauberer 2020). All currently valid species of *Schindleria* can be assigned into one of these two groups. The new species *S. edentata* is a SDF species together with *S. brevipinguis*, *S. parva*, and *S. pietschmanni* (Ahnelt 2019, 2020; Abu El-Regal et al. 2021). Although three of the four SDF species are among the smallest *Schindleria* (<12 mm SL), this feature is likely not size related. With up to 20 mm, the SDF *S. pietschmanni* is among the larger *Schindleria*.

An important morphological character system to distinguish species is the diverse dentition pattern. *Schindleria* can be separated into species with jaw teeth and those that lack teeth in one or both jaws (Watson and Walker 2004; Ahnelt and Sauberer 2018; Ahnelt 2020;

Abu El-Regal et al. 2021). In most species (*S. elongata*, *S. macrodentata*, *S. multidentata*, *S. nigropunctata*, *S. praematura*, and *S. pietschmanni*), teeth are developed on the premaxilla and the dentary (Ahnelt 2020). In the majority of these species, the teeth are tiny, numerous, and densely set. In general, there are differences in the dentition of both jaws. On the premaxilla teeth extend in a single row along the entire length of its ventral edge. On the dentary teeth are positioned in up to three rows on a bony ridge that extends from the symphysis posterolaterally (Johnson and Brothers 1993; Ahnelt 2020). Exceptions are *S. macrodentata*, with few, large and widely spaced teeth (Ahnelt and Sauberer 2018) and *S. multidentata*, with additional teeth on the dorsal edge of the posterior half of the dentary (Ahnelt 2020). In three species, teeth are missing either in one or both jaws. In *S. parva* the dentary is toothless but the premaxilla is toothed (Abu El-Regal et al. 2021). In *S. brevipinguis* (Watson and Walker 2004) and in *S. edentata*, teeth are missing in both jaws. These three species have in common that they are very small in size (8 mm–12 mm SL). We speculate that partial or complete reduction of the dentition in these latter three species may be linked to their small size with the two smallest species (*S. edentata* and *S. brevipinguis*) having completely toothless jaws. Specimens thought to be adult were actively feeding and had their guts filled with content that could not be further identified and it is still unclear on what and how *Schindleria* are feeding.

The generation time and the developmental time for the two toothless species are unknown but it is conceivable that the smaller species may have an even shorter lifespan and faster development. For instance, the specimens of the “*S. praematura*”-type (LDF) from Ogasawara (Japan) reach a size of 16 mm – 18 mm SL after an average of just 31 days (Kon and Yoshino 2002). During development of many gobiid fishes teeth appear first in larvae of 4 mm – 9 mm TL (e.g., Peters 1983; Daoulas et al. 1993; Strydom and Neira 2006; Kondo et al. 2012; Zanella et al. 2017; Hwang et al. 2018). In *Schindleria* sp., teeth were first found at a size of 4.2 mm – 4.5 mm SL (Watson 2000) and in *S. pietschmanni* at 4.5 mm – 5 mm SL (Watson & Walker 2004), with teeth first forming on the premaxilla and subsequently on the dentary. Whether toothlessness in *S. brevipinguis* and *S. edentata* is the result of a more truncated development than that in *S. parva*, a species with a toothed premaxilla but a toothless dentary, needs to be confirmed in future studies.

Authors contributions

H.A. and M.A.E.-R. conceived the idea. M.A.E.-R. sampled the material. H.A., V.R. and M.A.E.-R. analyzed, interpreted, and discussed the data, contributing significantly to the final version of the manuscript.

Competing interest's statement

The authors declare no competing interests.

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