A new species of *Soleichthys* (Soleidae: Pleuronectiformes) from tropical seas off northern Australia

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Abstract *Soleichthys maculosus*, described from six specimens collected in shallow waters (37–63 m) off northern Australia, is readily distinguished from congeners by its unique ocular-side pigmentation featuring numerous, conspicuous white spots and blotches nearly as large as the eye diameter on a uniformly dark brown background without any crossbands, and in having two elongated, ocular-side pectoral-fin rays, with the second dorsalmost ray longer than the first, and without scales on the pectoral-fin rays. *Soleichthys maculosus* is most similar to *S. siammakuti*, a poorly-known species collected in the Gulf of Thailand, but differs from *S. siammakuti* in having the second dorsalmost ocular-side pectoral-fin ray longer than the first (vs. first ocular-side pectoral-fin ray longer in *S. siammakuti*), and in having different ocular-side pigmentation than that of *S. siammakuti*, which features yellow spots on dorsal and anal fins, two conspicuous white spots arranged in longitudinal series on the lateral line, and also a series of nine, light brown crossbands on a dark brown body.

Key words Soleidae · *Soleichthys* · New species · Pleuronectiformes

Soleid flatfishes of the genus *Soleichthys* Bleeker, 1860 are small to medium-sized marine fishes found throughout relatively shallow tropical Indo-West Pacific waters from the Red Sea (Goren and Dor, 1994), Mauritius and Reunion Islands (Peters, 1876; Regan, 1905), India (Norman, 1928), Southeast Asia (Bleeker, 1856; Wongratana, 1975; Shen, 1984), Philippine Islands (Evermann and Seale, 1907), Japan (Ochiai, 1963), Australia (Günther, 1862; Ramsay, 1883), to at least Samoa and Fiji in the west-central Pacific (Steindachner and Kner, 1870; Günther, 1909; Fowler, 1959). Based on overall morphology and position of epicranial dorsal-fin pterygiophores (Chapleau et al., unpublished data), *Soleichthys* is hypothesized to belong to a clade within the Soleidae also including species of *Phyllichthys, Strabozebrias, Zebrias, Pseudaesopia*, and *Aesopia*. However, no comprehensive phylogenetic study of the Soleidae has been conducted, and generic concepts within this family remain poorly conceived.

As presently understood, members of *Soleichthys* are distinguished superficially from related genera by the presence of a conspicuously long ocular-side anterior naris that when depressed posteriorly extends beyond the middle of the lower eye, in having two developed pectoral fins, in having the caudal fin nearly entirely separate from the dorsal and anal fins (connected only basally by a thin membrane to posteriormost dorsal- and anal-fin rays), and in having the opercular membrane connected to upper rays of the pectoral fins (McCulloch, 1917; Norman, 1928; Fowler, 1959; Ochiai, 1963).

Most nominal species of *Soleichthys* are poorly represented in museum collections, and no one has conducted a comprehensive systematic revision of the genus. Species currently considered valid in *Soleichthys* include *Soleichthys heterorhinos* (Bleeker, 1856), *Soleichthys microcephalus* (Günther, 1862), *Soleichthys tubiferus* (Peters, 1876), *Soleichthys multifasciatus* (Kaup, 1858), *Soleichthys nigrostriolatus* (Steindachner and Kner, 1870) and *Soleichthys siammakuti* (Wongratana, 1975). *Soleichthys borbonicus* (Regan, 1905) is regarded as a junior synonym of *S. tubiferus* by Fricke (1999), whereas Quéro (1997) considered *S. borbonicus* to be a valid species endemic to Réunion Island. Another nominal species, *Soleichthys lineatus* (Ramsay, 1883), described from a damaged juvenile, has long been considered (McCulloch, 1916) a junior subjective synonym of *S. heterorhinos*, but the status of this species needs further evaluation (McCulloch, 1927).

Six soleid flatfishes collected off northern Australia during the past 20 years, featuring a conspicuous spotted pattern on a dark background, which is coloration unlike that known for any other species of Soleidae, were discovered by the second author in Australian fish collections while conducting research at these facilities. Analysis of internal and external morphology indicated that these fish represent an undescribed species of *Soleichthys*. The purpose of this article is to provide a formal description of this species.

Methods

Counts of dorsal-, anal-, and caudal-fin rays were made from radiographs. Ocular- and blind-side pectoral-fin rays and ocular- and blind-side pelvic-fin rays were counted directly from specimens. Lateral line scales were counted along the lateral line beginning just above the posterior margin of the operculum and continuing to the base of the caudal fin. Vertebral counts and epicranial dorsal-fin pterygiophore patterns were determined from radiographs. Dorsal-fin pterygiophore formulae (after Chapleau, 1989; Desoutter and Chapleau, 1997) refer to numbers of pterygiophores and location of their proximal ends; formulae do not include the erisma (first enlarged modified proximal pterygiophore). The first number in the formula refers to the number of pterygiophores with their proximal ends attached to the dorsal surface of the erisma; the second number is the number of pterygiophores attached or directly over the cranium; and the third number in the formula is the number of pterygiophores attached onto the dorsoposterior surface of the neural spine of the second abdominal vertebra.

All measurements, made to the nearest 0.1 mm with dial calipers or with a dissecting microscope fitted with an ocular micrometer, were taken on the ocular surface, except where noted. Morphometric ratios are expressed in thousandths of standard length (SL) or thousandths of head length. Measurements included Head length (HL), distance from tip of snout to base of pectoral fin; head width (HW), vertical distance from ventralmost origin of opercle to dorsal margin of head; head width at eye (HWeye), vertical distance across head at posterior margin of lower eye; postorbital length (POL), posterior margin of lower eye to posterior margin of opercle at level equal to dorsal origin of pectoral fin; snout length (SNL), anterior tip of snout to anterior margin of lower eye; lower (LED) and upper (UED) eye diameters, greatest horizontal diameter of cornea, not including fleshy tissue surrounding each eye; lower-jaw length (LJL), distance from anterior margin of lower jaw to posterior symphysis of jaws; naris length (NL), length of ocular-side anterior nasal tube (base of fold to tip of naris) when naris is depressed posteriorly; blind-side naris to snout (BN-S), horizontal distance from tip of blind-side snout to base of posterior naris; body depth (BD), greatest body depth; suprapectoral width (DPW), shortest vertical distance from dorsal origin of pectoral fin to dorsal margin of body (not including dorsal fin); subpectoral width (SPW), shortest vertical distance from dorsal origin of pectoral fin to ventral margin of body (not including anal fin); pectoral-fin length (PL), length of fin from base to tip of longest fin ray; pectoral fin to lateral line (P-Ll), vertical distance from dorsal origin of pectoral fin to lateral line; caudal-fin length (CFL), length of fin from base of middle caudal-fin rays to tip of longest ray; caudal peduncle width (CW), distance across body at base of caudal-fin rays.

Institutional codes for material examined follow those listed in Leviton et al. (1985).

Soleichthys maculosus sp. nov.

(Spotted sole)

(Figs. 1–3; Tables 1, 2)

Holotype. QM I.28800, 73.9 mm SL, collected with trawl at 51 m, Gulf of Carpentaria, northwestern Queensland, Australia (12°31′ S, 141°02′ E), 5 Nov. 1993.

Paratypes. CSIRO H4201-03, 71.2 mm SL, Western Australia, North of Nickol Bay (20°01′ S, 116°57′ E), 52 m, 22 Feb. 1983. CSIRO H4202-01, 71.4 mm SL, Western Australia, NNE of Port Hedland (19°29′ S, 118°52′ E), 37 m, 25 Oct. 1983. QM I.30098, 2 (72.2–86.9 mm SL), Gulf of Carpentaria (13°01.3′ S, 140°12′ E), 63 m, 1 Dec. 1990. QM I.23399, 95.1 mm SL, east of Cairns, northeast Queensland (16°53′ S, 146°00′ E), 1987.

Diagnosis. *Soleichthys maculosus* is readily distinguished from all other species of *Soleichthys* by the combination of an ocular-side pigmentation pattern featuring a series of white spots and blotches without accompanying crossbands (the only member of this genus featuring an

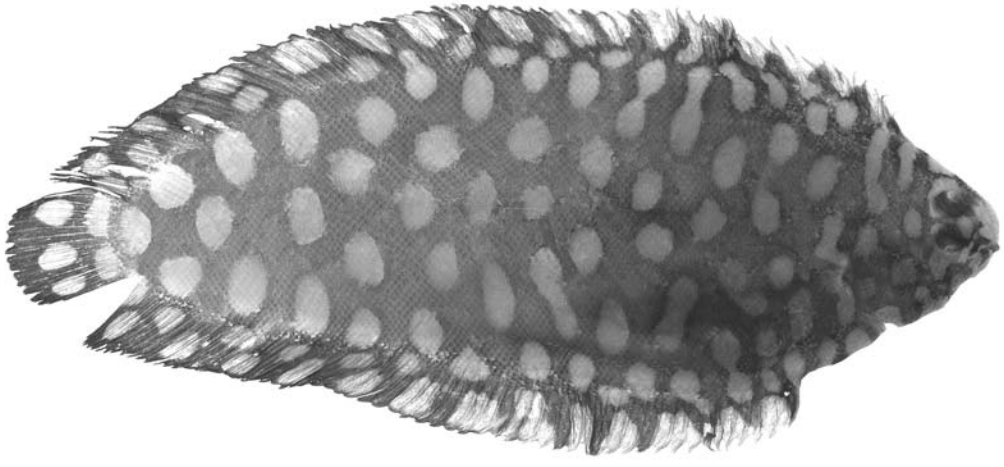

Fig. 1. *Soleichthys maculosus*, sp. nov., holotype, QM I.28800, 73.9 mm SL, collected by trawl in the Gulf of Carpentaria, northwestern Queensland, Australia (12°31′ S, 141°02′ E), 51 m, 5 Nov. 1993

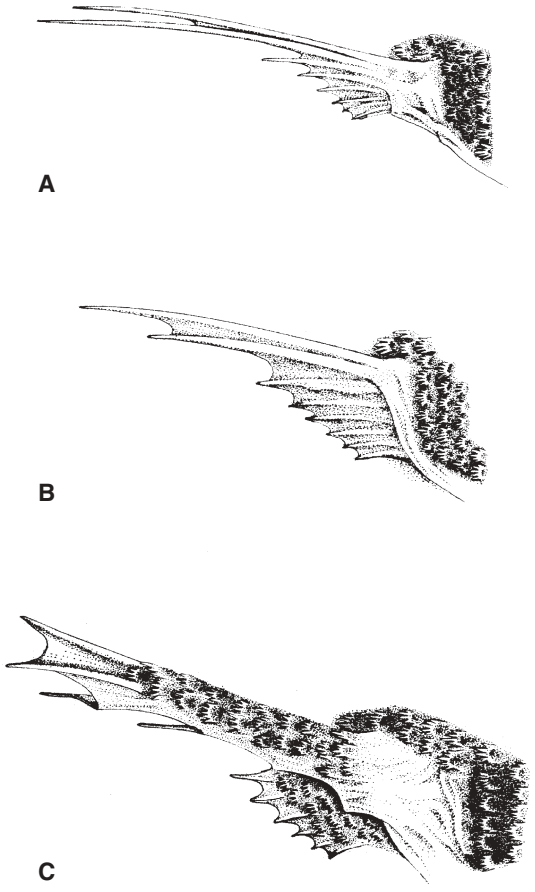

Fig. 2. Diagrammatic illustrations comparing morphology of ocular-side pectoral fins for three species of *Soleichthys*. **A** *S. maculosus.* **B** *S. siammakuti.* **C** *S. microcephalus*

ocular-side color pattern composed of spots without crossbanding); presence of a scaleless, well-developed pectoral fin on the ocular side (Fig. 2); and with the ocular-side pectoral fin having the second dorsalmost ray longer than the first fin ray.

Description. Meristic and morphometric features for holotype and five paratypes are summarized in Tables 1 and 2, respectively. A small-sized (to about 95 mm SL), slightly elongate, thin-bodied soleid with greatest depth in anterior one-third of body (usually just posterior to anus), with gradual posterior taper, and with only slight arching to dorsal and ventral body contours. Head relatively small (ca. 0.5 in BD) and pointed anteriorly. Head length approximately 5 times in SL; head wider than long (HW ca. 1.2 HL). Snout short (nearly similar in size to LED) and pointed; slightly hooked; with snout tip about on horizontal through pupil of lower eye. Snout with small cycloid scales on anterior region and ctenoid scales elsewhere. Two ocular-side nostrils. Anterior ocular-side nostril a conspicuously long (slightly greater than LED), slender tube originating just dorsal to midpoint of lower jaw and extending to posterior margin of pupil, or posterior margin, of lower eye when depressed posteriorly. Ocular-side posterior nostril a short, wide, ventrally directed tube located just above upper jaw between posterior base of anterior nostril and anterior margin of lower eye. Two nostrils on blind side of head. Anterior blind-side nostril a slightly elevated, short, wide tube located dorsal to midjaw region and surrounded by circular arrangement of small fleshy cirri. Posterior blind-side nostril a short (about equal to 1/3 length of anterior ocular-side nostril), elongate, posteriorly directed tube located at posterior margin of fringed scales on blind-side of head, at point just slightly dorsal to horizontal through anterior blind-side nostril. Mouth small,

Table 1. Summary of meristic features for holotype (QM I.28800) and five paratypes of *Soleichthys maculosus* from northern Australia

Character	Holotype	Paratypes		
		Mean	SD	Range
Dorsal-fin rays	84	80.0	2.34	78–84
Anal-fin rays	70	66.6	1.82	64–69
Ocular side pectoral-fin rays	11	8.8	0.45	8–9
Blind side pectoral-fin rays	9	8.2	1.10	7–9
Total vertebrae	44	45.4	0.55	45–46
Lateral line scales	93	94.2	4.60	90–100

Table 2. Summary of morphometric features for holotype (QM I.28800) and five paratypes of *Soleichthys maculosus* from northern Australia

Character	Holotype	Paratypes		
		Mean	Range	SD
1. SL	73.9	79.4	71.2–95.1	11.02
2. BD	367	359.8	(353–368)	6.56
3. HL	194	185.0	(174–194)	8.20
4. DPW	196	190.5	(185–205)	8.73
5. SPW	134	128.5	(119–139)	7.71
6. HW	1063	1188.7	(1052–1306)	109.21
7. HWeye	916	966.7	(797–1089)	105.49
8. CFL	832	804.2	(741–858)	45.04
9. CW	433	400.5	(370–433)	22.02
10. PL	685	667.2	(622–704)	34.09
11. LED	245	216.0	(192–245)	18.25
12. UED	252	208.5	(185–252)	24.84
13. SNL	238	212.2	(169–234)	30.71
14. NL	266	249.7	(226–284)	21.52
15. LJL	266	246.2	(185–305)	41.37
16. BN-S	315	286.5	(248–315)	23.67
17. P-Ll	259	257.7	(222–285)	21.23
18. POL	545	558.3	(513–581)	25.89

Standard length (SL) in mm; measurements 2–5 in thousandths of SL; measurements 6–18 in thousandths of head length (HL)
BD, body depth; DPW, suprapectoral width; SPW, subpectoral width; HW, head width; HWeye, head width at eye; CFL, caudal-fin length; CW, caudal peduncle width; PL, pectoral-fin length; LED, lower eye diameter; UED, upper eye diameter; SNL, snout length; NL, naris length; LJL, lower jaw length; BN-S, blind-side naris to snout; P-Ll, pectoral fin to lateral line; POL, postorbital length (see text)

terminal; jaws curved ventroposteriorly at their midpoint; posterior margin of jaws at vertical through anterior margin of lower eye. Ocular-side lower lip with obvious, fleshy quadrangular dermal process on midpoint. Blind-side lips without obvious plicae. Ocular-side upper lip connected to snout by frenum. Ocular-side jaws without teeth; blind-side jaws with wide band of small, villiform teeth; tooth band on lower jaw wider than that on upper jaw. Eyes dextral, oval, large (LED slightly larger to slightly smaller than SNL), about equal in position; upper regions of eyes covered with small ctenoid scales. Eyes nearly contiguous; interorbital space narrow, about equal to 1/2–3/4 diameter of pupil of lower eye, slightly elevated, and covered with 3–6 ctenoid scales. Operculum with unrestricted opening; gill covers connected to each other and free from isthmus. A small, dorsal, interbranchial foramen present. Ocular-side operculum connected by thin membrane to upper part of 4th dorsalmost pectoral-fin ray; blind-side operculum connected by thick membrane to 1st and 2nd pectoral-fin rays. Ocular-side opercular margin without cirri; blind-side opercular margin with few to many, short, fleshy cirri around gill opening. Dermal papillae absent on ocular-side head; dermal papillae and fleshy cirri present on blind-side snout and anterior head region adjacent to dorsal-fin base. Anus on body midline surrounded by pelvic fins. Urogenital papilla a short, bluntly pointed tube about equal to 4/5 length of posteriormost ocular-side pelvic-fin ray; urogenital papilla broadly attached by membrane throughout most of its length to posteriormost ocular-side pelvic-fin ray and connected posteriorly by thin membrane to body region just anterior to anal fin, but not connected to anal fin. Dorsal-fin origin slightly on blind side of head about at vertical through point slightly anterior to base of anterior nostril. Dorsal fin extending to posterior end of body; posteriormost dorsal-fin ray connected at its base by thin membrane to base of caudal fin. Anterior dorsal-fin rays relatively short, those in midbody region longer, with longest fin rays in posteriormost part of fin. Anterior dorsal-fin rays unbranched; those in middle and posterior portions of fin branched. Dorsal-fin pterygiophore formula: 1-1-1 (holotype and two paratypes) or 1-1-2 (three paratypes). Anal fin inserting immediately posterior to anus; relative shape, posterior extension and fin-ray branching similar to that of dorsal fin; posteriormost anal-fin ray connected at its base by thin membrane to caudal fin. Blind sides of dorsal and anal fins completely lacking scales except for few small ctenoid scales present at bases of fin rays; anterior regions of ocular sides of dorsal and anal fins with a few, small, ctenoid scales along fin-ray bases; posterior regions of ocular sides of dorsal and anal fins with small ctenoid scales present to about 1/2 proximal length of fin rays. Caudal fin moderately large, rectangular; separate for most of its length from dorsal and anal fins (membranous connection basally); with 18 fin rays (2 dorsalmost and 2 ventralmost usually unbranched; remainder branched). Proximal portions of blind- and ocular sides of caudal fin with ctenoid scales; distal halves on both sides of caudal fin lacking scales. Pectoral fins asymmetrical in size; ocular-side pectoral fin larger than its counterpart; falciform; scaleless; with 8–11 unbranched fin rays. Two dorsalmost ocular-side pectoral-fin rays elongated (Fig. 2); elongated fin rays nearly equal in size to POL. Dorsalmost ocular-side pectoral-fin ray somewhat shorter than second, prolonged fin ray; 3rd through last pectoral-fin rays progressively shorter. Blind-side pectoral fin rudimentary; rectangular in shape and relatively short; scaleless; with 7–9 fin rays. Pelvic fins short and symmetrical in position; each with 5 unbranched fin rays. Pelvic fins separate from each other posteriorly and separate from anal fin. Ocular-side pelvic fin slightly longer than blind-side pelvic fin. Pelvic-fin rays when depressed posteriorly reaching to 1st anal-fin ray. Interpelvic region scaly. Both sides of body and head covered with small, strongly ctenoid, scales; scales rounded posteriorly and with relatively long ctenii covering about 3/4 of their posterior margin. Single, median lateral line present on ocular side, originating just anterior to operculum and continuing posteriorly as straight line to distal 4/5 of caudal fin. Strongly dorsally arched supratemporal branch of lateral line present on ocular-side head extending to about region dorsal to midpoint of upper eye. Single, median lateral line on blind side of body similar in length and shape to that of ocular side. Lateral line scales on both sides of body relatively small, cycloid, and more elongate than other body scales, with obvious elevated canal on central region and distinct pore toward their posterior margin.

Pigmentation in alcohol.—Ocular side of head, body, and vertical fins conspicuously dark brown with several irregular longitudinal series of more or less rounded, off-white, spots and blotches (Fig. 1). Spots nearly equal to, or slightly larger in size than, eye diameter. Spots and blotches begin on anterior snout near eyes and continue posteriorly over entire ocular surface including distal portions of dorsal and anal fins and to middle region of caudal fin. Dark brown background pigmentation slightly greater in total surface coverage than that of white spots. Ocular-side snout conspicuously white. Ocular-side anterior nostril dark brown or black, sharply contrasting to snout and head coloration. Inner lining of lower jaw darkly pigmented; roof of mouth less heavily pigmented. Ocular-side outer opercular surface with same coloration as body; inner surfaces of ocular-side and blind-side opercles and isthmus with heavy concentration of dark brown pepperdots; isthmus generally more heavily pigmented on blind side of body. Blind side of body uniformly pale white; occasionally with pepperdots scattered throughout body, but especially dense along bases of dorsal and anal fins and also on blind-side head and opercle. Peritoneum lightly spotted.

Background coloration of dorsal and anal fins generally darker than that of body. Ocular-side dorsal and anal fins spotted basally and medially with submarginal dark brown or black band; fin rays generally darker than connecting membranes; distal tips of fin rays whitish. Blind-side dorsal and anal fins with dark pepperdots on fin rays and membranes, but without white spots. Ocular-side caudal fin with 5–7 white spots arranged in two rows (usually 2 spots in row on base of fin and 3 in row on distal portion) separated by medial dark black band, and with submarginal dark black band and with distal tips of fin rays white. Ocular-side pectoral fin with pepperdots throughout; blind-side pectoral fin

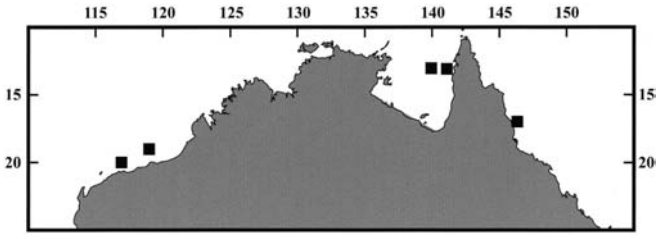

Fig. 3. Capture locations of *Soleichthys maculosus* off northern Australia

usually off-white, but occasionally with some pepperdots on fin and on body behind fin. Ocular-side pelvic fin with whitish leading edge and posterior region with dark brown blotch. Ocular face of blind-side pelvic fin with dense concentration of brown pepperdots; blind-side surface of blind-side pelvic fin whitish, occasionally with dense concentration of pepperdots. Interpelvic region with dense concentration of pepperdots.

Geographical distribution and habitat. Off tropical northern Australia (Fig. 3) from north of Nickol Bay, Western Australia (20°01′ S, 116°57′ E) and northeast of Port Hedland (19°29′ S, 118°52′ E), including the Gulf of Carpentaria, northwestern Queensland (12°–13° S, 141° E) to east of Cairns, northeast Queensland (16°55′ S, 145°46′ E), at depths of 37–63 m.

Etymology. From the Latin, *maculosus*, in reference to the conspicuous white spots and blotches forming the distinctive coloration pattern for this species.

Comparisons. *Soleichthys maculosus* is readily distinguished from all other species of *Soleichthys* by its unique ocular-side pigmentation. This is the only species in the genus with an ocular-side pigmentation pattern completely lacking crossbands and featuring obvious white, rounded spots and blotches overlaid onto a conspicuously dark brown background. The new species is also distinct from nearly all congeners, except for *S. microcephalus* and an undescribed species from Australian waters (Munroe and Menke, in press) in having the second dorsalmost ocular-side pectoral-fin ray longer than the first ray (vs. first ocular side pectoral-fin ray longer in other species of *Soleichthys*). *Soleichthys maculosus* is further distinguished from *S. microcephalus* and the undescribed Australian species in lacking distinctive crossbands characteristic of these other species and by its scaleless (vs. scaly) ocular-side dorsalmost pectoral-fin rays (see Fig. 3). *Soleichthys maculosus* also has more lateral line scales than does *S. microcephalus* (90–100 vs. 81–88).

Soleichthys maculosus is further distinguished from congeners, except *S. siammakuti* and *S. nigrostriolatus*, in lacking scales on the blind sides and anterior portions of the ocular sides of the dorsal and anal fins. *Soleichthys maculosus* differs further from *S. tubiferus* in having a lightly spotted peritoneum (vs. black in *S. tubiferus*). *Soleichthys maculosus* differs further from *S. heterorhinos, S. lineatus, S. multifasciatus*, and *S. nigrostriolatus* in its much lower and non-overlapping counts of dorsal-fin rays (78–84 vs. 85–105 in these others), anal-fin rays (64–70 vs. 74–91), total vertebrae (44–46 vs. 48–53), and lateral line scales (90–100 vs. 100–124). *Soleichthys maculosus* also differs from *S. heterorhinos* and *S. nigrostriolatus* in having bifurcated (versus trifurcated) dorsal- and anal-fin rays.

Soleichthys maculosus is most similar to, and perhaps most closely related to, *S. siammakuti*, a species known from only two specimens collected in the Gulf of Thailand (Wongratana, 1975). *Soleichthys maculosus* and *S. siammakuti* share a number of similar features, including overlapping numbers of dorsal-fin rays (78–84 vs. 80 in *S. siammakuti*), anal-fin rays (64–70 vs. 66–67), and total vertebrae (44–46 vs. 44 in *S. siammakuti*); similar degree of scale development on dorsal and anal fins; elongated ocular-side pectoral-fin rays without scales; and these are the only species in the genus featuring a dark brown ocular side with spots on ocular-side dorsal, anal, and caudal fins. *Soleichthys maculosus* differs distinctly from *S. siammakuti* in having the second dorsalmost ocular-side pectoral-fin ray longer than the first (vs. first ocular-side pectoral-fin ray longer in *S. siammakuti*), and the ocular-side pigmentation of *S. maculosus* consists only of white spots (all about evenly intensely pigmented) on a dark background, whereas *S. siammakuti* has yellow spots on its fins, with two conspicuous white spots arranged in longitudinal series on the lateral line, and with a series of nine, light brown crossbands on a dark brown body.

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