

# Validity of *Scorpaena jacksoniensis* and a redescription of *S. cardinalis*, a senior synonym of *S. cookii* (Scorpaeniformes: Scorpaenidae)

Hiroyuki Motomura · Carl D. Struthers ·  
Mark A. McGrouther · Andrew L. Stewart

Received: 29 April 2011 / Revised: 14 June 2011 / Accepted: 14 June 2011  
© The Ichthyological Society of Japan 2011

**Abstract** The *Scorpaena cardinalis* complex, including *S. cardinalis*, *S. jacksoniensis* and *S. orgila*, is defined. The genus *Ruboralga* (type species: *S. jacksoniensis*) is regarded as a junior synonym of *Scorpaena*. *Scorpaena jacksoniensis* Steindachner 1866, previously treated as a junior synonym of *Scorpaena cardinalis* Solander and Richardson 1842, is regarded here as a valid species. *Scorpaena cookii* Günther 1874, previously treated as a valid species, is regarded here as a junior synonym of *S. cardinalis*. Thus, recent recognition of the two Australasian scorpionfishes, i.e., *S. cardinalis* and *S. cookii*, are re-identified in this study as *S. jacksoniensis* and *S. cardinalis*, respectively. *Scorpaena plebeia* Solander 1842 is regarded as a junior synonym of *S. cardinalis*. *Scorpaena jacksoniensis* is distributed along the east coast of Australia from southern Queensland to eastern Victoria, whereas *S. cardinalis* occurs around northern New Zealand, the Kermadec Islands and offshore islands of the Tasman Sea. A neotype is designated for *S. cardinalis*. Morphological changes with growth in the two species are described in detail.

**Keywords** *Ruboralga* · *Scorpaena jacksoniensis* · *Scorpaena cardinalis* · *Scorpaena cookii* · Synonymy

H. Motomura (✉)  
The Kagoshima University Museum, 1-21-30 Korimoto,  
Kagoshima 890-0065, Japan  
e-mail: motomura@kaum.kagoshima-u.ac.jp

C. D. Struthers · A. L. Stewart  
Museum of New Zealand Te Papa Tongarewa,  
P. O. Box 467, Wellington, New Zealand

M. A. McGrouther  
Australian Museum, 6 College Street, Sydney,  
NSW 2010, Australia

## Introduction

During revisionary studies of the genus *Scorpaena* (Scorpaeniformes: Scorpaenidae) by the first author, examination of the holotype of *Scorpaena jacksoniensis* Steindachner 1866a found this nominal species to be a valid species, although it has been treated as a junior synonym of *Scorpaena cardinalis* Solander and Richardson in Richardson (1842) by numerous authors (e.g., Macleay 1881; Allen and Cross 1989; Allen et al. 2006). Subsequently, examination of the original drawing of *S. cardinalis* revealed it to be identical with *Scorpaena cookii* Günther 1874, but distinct from *S. jacksoniensis*. Therefore, *S. cookii*, long regarded as a valid species by numerous authors (e.g., Ogilby 1889; Poss 1999; Allen et al. 2006; Roberts et al. 2009), is placed here as a junior synonym of *S. cardinalis*. Accordingly, the two recently recognized Australasian scorpionfishes, i.e., *S. cardinalis* and *S. cookii*, are re-identified in this study as *S. jacksoniensis* and *S. cardinalis*, respectively. *Scorpaena plebeia* Solander in Richardson (1842) is also considered as a junior synonym of *S. cardinalis*. The genus *Ruboralga* (type species: *S. jacksoniensis*) is regarded as a junior synonym of *Scorpaena*.

The two species, *S. jacksoniensis* (as *S. cardinalis*) and *S. cardinalis* (as *S. cookii*), have been considered to be distributed around both Australia and New Zealand waters (e.g., Paulin 1982; Poss 1999; Allen et al. 2006). Examination of a large number of specimens from the southwestern Pacific Ocean disclosed that the previous distribution range of each species was incorrect owing to misidentifications and that the two species in fact represented allopatric distributions, i.e., *S. jacksoniensis* in the coastal water of eastern Australia; *S. cardinalis* in northern New Zealand and offshore islands of the Tasman Sea.

The two species are redescribed, and a neotype of *S. cardinalis* is designated. Morphological changes with growth in the two species are also described in detail. The *S. cardinalis* complex is defined in this study, and includes *S. cardinalis*, *S. jacksoniensis* and *Scorpaena orgila* Eschmeyer and Allen 1971 (endemic to Easter Island, Chile).

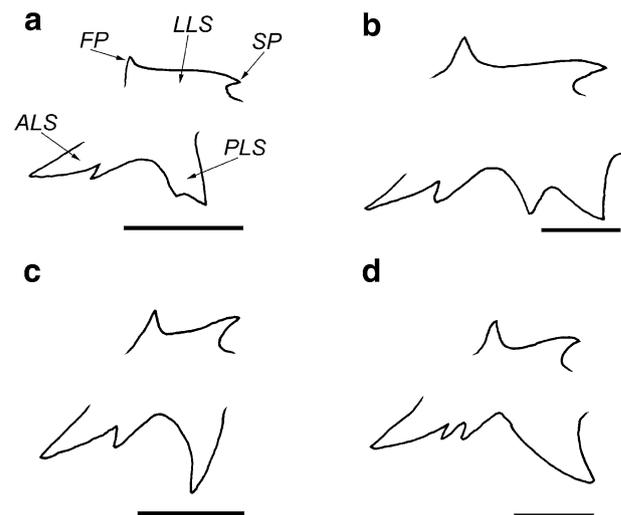
## Materials and methods

Measurements generally follow Motomura (2004a, b), except head width (Motomura et al. 2005b, 2006a) and maxillary depth (Motomura et al. 2006b). Counts follow Motomura et al. (2005a, b, c) and Motomura and Johnson (2006), with predorsal scale counts following Motomura et al. (2006b). The last two soft rays of the dorsal and anal fins are counted as single rays, each pair being associated with a single pterygiophore. Standard and head lengths are expressed as SL and HL, respectively. Terminology of head spines follows (Randall and Eschmeyer 2002: fig. 1) and Motomura (2004b: fig. 1) with the following additions: the spine occurring at the base of the uppermost preopercular spine is referred to as the supplemental preopercular spine (Eschmeyer 1965); the spine occurring at the lateral surface of the lacrimal bone is referred to as the lateral lacrimal spine (Motomura and Senou 2008: fig. 2); the coronal and pretympanic (as an extra spine) spines are figured in Chen (1981: fig. 1) and Motomura et al. (2004: fig. 14b), respectively. Institutional codes follow Leviton et al. (1985), with the exception of the Australian National Fish Collection at the Commonwealth Scientific and Industrial Research Organisation's Marine and Atmospheric Research laboratories, Hobart (CSIRO), Kagoshima University Museum, Kagoshima (KAUM) and Museum of New Zealand Te Papa Tongarewa, Wellington (NMNZ). The following specimens of *Scorpaena orgila* were examined for comparative purposes: CAS 24809, holotype, 246.8 mm SL, off Ahu Akapu, Easter Island, Chile, spear, J. Randall, 3 Feb. 1969; CAS 24810, 2 paratypes, 59.8–109.7 mm SL, off south end of Hanga Roa, Easter Island, Chile, J. Randall and G. Allen, 10 Feb. 1969; CAS 24811, paratype, 75.5 mm SL, wreck about 20 m offshore between Hanga Roa and Hanga Piko, Easter Island, Chile, J. Randall and G. Allen, 27 Jan. 1969.

## The *Scorpaena cardinalis* complex

**Included species.** *Scorpaena cardinalis*, *S. jacksoniensis* and *S. orgila*.

**Diagnosis.** Lateral lacrimal spine with 2 spinous points (Fig. 1).



**Fig. 1** Ontogenetic changes of lacrimal bones of *Scorpaena cardinalis* (a, b) and *S. jacksoniensis* (c, d). a AMS IB.5335, 110.0 mm SL; b NMNZ P.041669, 211.2 mm SL; c KAUM-I.35882, 131.1 mm SL; d AMS I.30310-025, 173.6 mm SL. ALS anterior lacrimal spine, PLS posterior lacrimal spine, LLS lateral lacrimal spine, FP first spinous point, SP second spinous point. Bars 5 mm

**Description.** Dorsal fin with 12 spines and 9 soft rays (rarely XIII, 8); fourth spine (rarely third spine) longest; membrane of spinous portion of dorsal fin moderately incised; second or third (rarely fourth) soft ray longest, its length subequal to that of longest dorsal-fin spine; posterior branch of last soft ray joined by membrane to caudal peduncle for more than half its length. Anal fin with 3 spines and 5 soft rays; second spine longest; all soft rays branched; first soft ray longest, its length longer than that of longest dorsal-fin soft ray; posterior branch of last soft ray joined by membrane to caudal peduncle for less than one-tenth its length. Number of branched pectoral-fin rays increasing with growth; lower unbranched rays thickened; posterior margin of fin rounded. Pelvic fin with 1 spine and 5 soft rays, all soft rays branched; second soft ray longest, its length slightly longer than upper-jaw length; last soft ray joined by membrane to abdomen for about half its length. Caudal fin with 11 branched rays; posterior margin of fin slightly rounded. Gill rakers 14–19, relatively short and spinous, longest raker on first gill arch shorter than gill filaments around angle of gill arch; fourth gill slit closed by membrane. Branchiostegal rays 7. Swimbladder absent.

Body moderately compressed anteriorly, progressively more compressed posteriorly. Nape and anterior body moderately arched. Body depth slightly less than head length. Numerous tiny tentacles on head. Posterior lacrimal spine tentacle linked posteriorly to head by skin. A short tentacle on posterior edge of low membranous tube associated with anterior nostril; the tentacle reaching posterior margin of posterior nostril when laid back. Supraocular

tentacle usually present. Pectoral-fin axil without skin flaps. Exposed cycloid scales covering an area surrounded by opercular margin and tips of upper and lower opercular spines, other parts of head not covered with exposed scales. Cycloid scales covering pectoral-fin base, some scales exposed, some scales embedded by thin skin. Body scales cycloid (often with weak cteni) in adults, ctenoid dorsally in young; body scales extending onto basal rays or membranes of pectoral and caudal fins.

Mouth large, slightly oblique. Lower jaw with a moderate-sized symphyseal knob. Width of symphyseal gap separating premaxillary teeth bands narrower than width of each band. Teeth on vomer and palatines. Underside of lower jaw smooth without ridges. Dorsal profile of snout steep. Nasal spine simple, sharp, directed dorsally, its length greater than anterior nostril diameter. Ascending process of premaxilla not intruding into interorbital space, its posterior margin reaching level with posterior margin of posterior nostril in dorsal view. Median interorbital ridge well developed. Interorbital ridges well developed posteriorly, separated by a deep channel; interorbital ridges initially diverging posteriorly in dorsal view and then conjoined at occipital pit or joined with tympanic spine base. Interorbital space deep, about one-third of orbit extending above dorsal profile of head. Preocular spine simple, directed dorsoposteriorly; tip of spine extending beyond level with upper margin of pupil in lateral view. Supraocular and postocular spines simple, well developed. Tympanic spine simple, strongly pointed, directed posterodorsally. Interorbital, coronal and pretympanic spines absent. Occipital pit moderately deep in young, becoming shallower with growth, occiput nearly flat or slightly convex in large adults; longitudinal length of pit subequal to width of pit. Occipital pit surrounded laterally by tympanic and parietal spines and indistinct ridge between spines. Parietal spine simple, its base curving strongly into occipital pit. Nuchal spine simple; nuchal and parietal spines joined at base. Sphenotic usually with two small spines. Postorbital with tiny spines. Pterotic spine usually simple in young, with 2 or more points in adults in *S. jacksoniensis*. Upper posttemporal spine simple, pointed, its length shorter than that of lower posttemporal spine. Lower posttemporal spine simple, its base length subequal to that of pterotic spine. Supracleithral spine simple. Cleithral spine flattened, with 2 spines.

Lateral lacrimal spine usually with 2 points. Anterior lacrimal spine with 2 or more points, directed forward, its tip reaching dorsal margin of upper lip. Posterior lacrimal spine with 1 or 2 points, its tip not reaching upper lip; length of posterior lacrimal spine subequal to that of anterior spine. Suborbital with two ridges; first suborbital spine at end of first ridge, located below pupil; second and third suborbital spines on second ridge, located behind

orbit. Space between ventral margin of eye and suborbital ridge moderate. Suborbital pit present. Preopercle with five spines; uppermost spine largest with a supplemental preopercular spine on its base. Preopercle, between uppermost preopercular spine and upper end of preopercle, smooth without serrae or spines. Upper opercular spine simple with a low median ridge; posterior tip of upper opercular spine not reaching opercular margin. Lower opercular spine simple with a distinct median ridge. No ridges between upper and lower opercular spines.

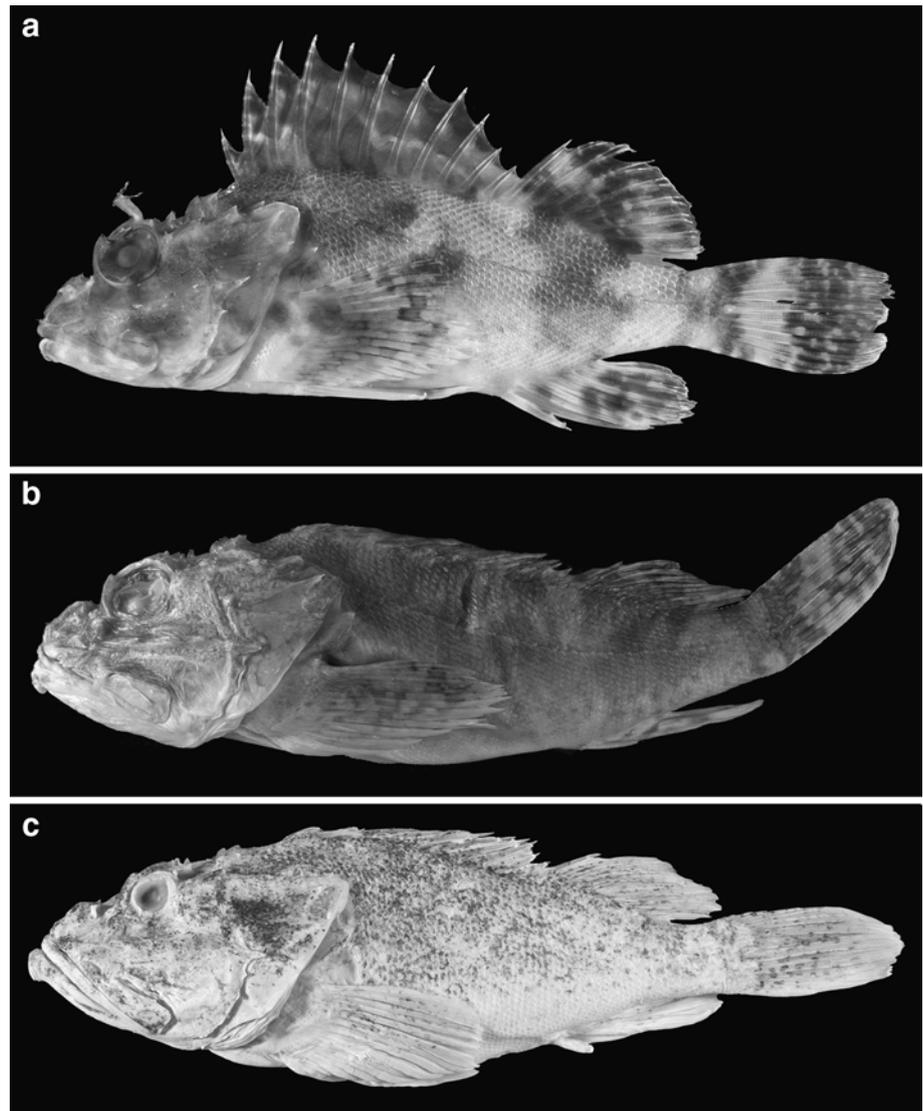
Origin of first dorsal-fin spine above supracleithral spines. Posterior margin of opercular membrane reaching a vertical through fourth dorsal-fin spine base. Posterior tip of pectoral fin not reaching a vertical through first anal-fin spine base. Origin of pelvic-fin spine slightly posterior to origin of pectoral fin. Posterior tip of depressed pelvic fin reaching anus, but not reaching first anal-fin spine base. Origin of first anal-fin spine slightly posterior to origin of last dorsal-fin spine.

**Remarks.** The *Scorpaena cardinalis* complex is known only from the South Pacific and comprises two Australasian species, *S. cardinalis* and *S. jacksoniensis*, and an Easter Island endemic species, *S. orgila*. The complex is characterized by having the lateral lacrimal spine with two spinous points (Fig. 1), a character unique among Indo-Pacific species of *Scorpaena*. Although *S. papillosa* (Schneider and Forster in Bloch and Schneider 1801) has two upwardly directed spines on the lacrimal bone, the anterior spine arises from the anterodorsal margin of the lacrimal bone and is not a part of lateral lacrimal spine.

The posteroventrally directed posterior lacrimal spine has been regarded as a diagnostic character for the Indo-Pacific *Scorpaena* (Poss 1999; Motomura et al. 2005c; Motomura and Senou 2008). However, the posterior lacrimal spine of *S. jacksoniensis* is directed anteroventrally at least in juveniles (posteroventrally in adults; see account of ‘Morphological change with growth’), although, with the exception of the posterior lacrimal spine condition, *S. jacksoniensis* shared all the diagnostic characters of the Indo-Pacific species of *Scorpaena*, i.e., 12 dorsal-fin spines, 9 dorsal-fin soft rays, teeth on the palatine, an occipital pit, cranial bones strongly or moderately ossified, upper and lower opercular spines, some pectoral-fin rays branched, the lateral surface of the body covered with cycloid or ctenoid scales, and the lateral line with pored scales continuing onto the caudal-fin base.

***Scorpaena cardinalis* Solander and Richardson 1842** (Standard English name: Sandy-Bay Cod; Australian name: Cook’s Scorpionfish; New Zealand name: Red Rockcod) (Figs. 1a, b, 2, 3, 4, 5, 6, 9, 10, 11; Tables 1, 3).

**Fig. 2** Preserved specimens of *Scorpaena cardinalis*. **a** NMNZ P.024541, 99.9 mm SL; **b** BMNH 1855.8.16.88, holotype of *Scorpaena cookii*, 216.2 mm SL; **c** NMNZ P.034406, 440.6 mm SL



*Scorpaena cardinalis* Solander and Richardson in Richardson 1842: 212 [original locality: Motuaro, Queen Charlotte's Sound, New Zealand (probably Motuaro, the Bay of Islands, New Zealand; see Paulin 1982); type locality: White Island, New Zealand, 37°30'S, 177°09'E, based on neotype]; Whitley 1931: 326 (New Zealand); Paulin 1982: 439 (between Bay of Islands and White Island, New Zealand); Doak 1984: 26, pls. 5, 59 (New Zealand); Francis 1996: 24, pl. 30 (Three Kings Islands to East Cape, New Zealand); Francis 2001: 33, pl. 38 (Kermadec Islands, New Zealand).

*Scorpaena plebeia* Solander in Richardson 1842: 214 (type locality: Tolaga, New Zealand).

*Scorpaena cookii* Günther 1874: 78, pl. 55 [type locality: Raoul Island (Sunday Island), Kermadec Islands, New Zealand]; Ogilby 1889: 155 (Lord Howe Island, Australia; new records from Australian water); Waite 1904: 220 (Lord Howe

Island); Eschmeyer and Allen 1971: 521 (Norfolk Island and Kermadec Islands); Paulin 1982: 440 (Raoul Island, Kermadec Islands); Kuitert 1993: 119 (offshore reefs in NSW); Francis 1993: 159 (Lord Howe Island, Norfolk Island and Kermadec Islands); Poss 1999: 2304, 2334 (in part, Lord Howe Island, Coffs Harbour, and Middleton and Elizabeth Reefs, NSW; Kermadec Islands); Paulin et al. 2001: 168 (New Zealand); Francis 2001: 34, pl. 39 (Kermadec Islands, New Zealand); Motomura et al. 2005c: 866 (Lord Howe Island and Auckland); Allen et al. 2006: 885 (in part, Lord Howe Island, Coffs Harbour, Middleton and Elizabeth Reefs, and Kermadec Islands); Hirt-Chabbert 2006: 59, unnumbered fig. (northern North Island, New Zealand).

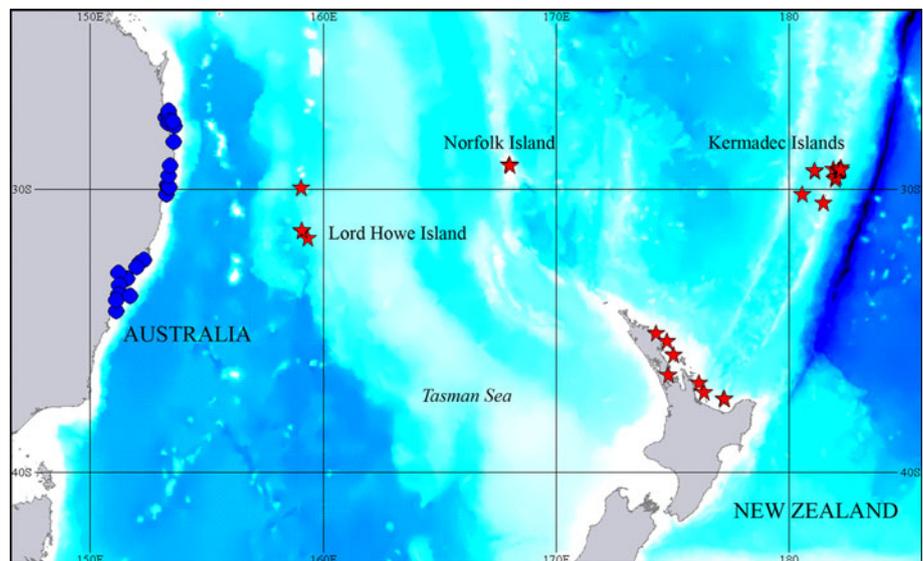
*Ruboralga cardinalis*: Whitley 1968: 84 (New Zealand; new combination; description also contains *S. papillosa*).

*Ruboralga cookii*: Whitley 1968: 84 (New Zealand, new combination).

**Fig. 3** Fresh specimens of *Scorpaena cardinalis*. **a** NMNZ P.039245, 208.1 mm SL (photo: R. McPhee/K. Parkinson); **b** NMNZ P.044152, neotype of *S. cardinalis*, 308.1 mm SL (photo: C. Struthers)



**Fig. 4** Distributional records of *Scorpaena cardinalis* (stars) and *S. jacksoniensis* (circles) based on collected specimens examined in this study



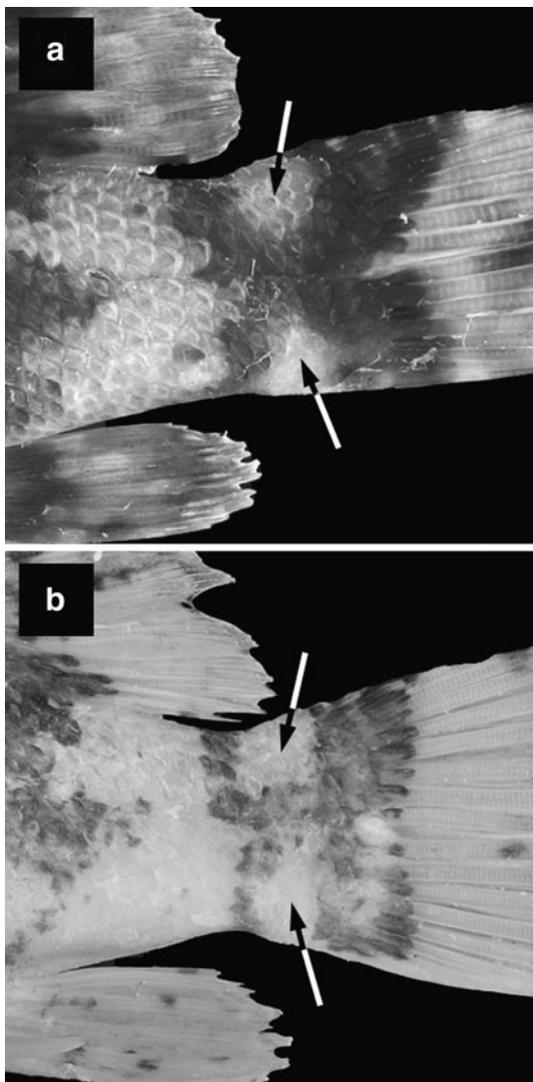
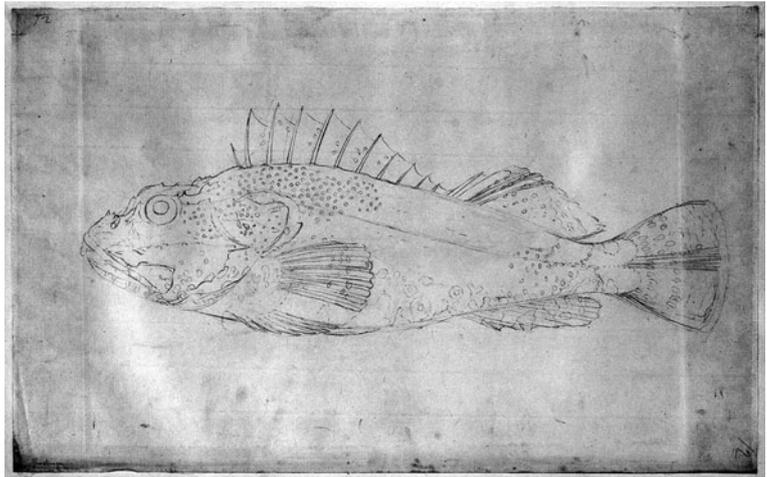
**Neotype.** NMNZ P.044152, 308.1 mm SL, White Island, New Zealand, 37°30'S, 177°09'E, 19–21 m, rod and line, C. Struthers, 16 Mar. 2009.

**Other material examined.** 66 specimens, 25.3–472.5 mm SL. **NORFOLK ISLAND:** AMS IB.5335, 110.0 mm SL, off Kingston, 29°03'S, 167°57'E, B. Marsh and L. Marsh, 16 Feb. 1961; AMS IB.5348, 306.2 mm SL, off Kingston, 29°03'S, 167°57'E, 60 m, B. Marsh and L. Marsh, 31 Mar. 1961; NMNZ P.014089, 256.9 mm SL,

29°05'S, 167°59'E, P. Roberts, 5 Sept. 1972; NMNZ P.024541, 99.9 mm SL, Slaughter Bay, 29°04'S, 167°58'E, 2 m, M. Francis, 23 Nov. 1989; NMNZ P.024542, 2, 161.1–190.2 mm SL, Duncombe Bay, 29°04'S, 167°58'E, 15 m, M. Francis, 15 Nov. 1989; NMNZ P.026902, 136.4 mm SL, Crystal Pool, 29°05'S, 167°59'E, 4 m, rotenone, M. Francis and J. Randall, 15 Feb. 1991.

**LORD HOWE ISLAND:** AMS I.5846, 236.4 mm SL, E. Waite and A. McCulloch, 1903; AMS I.10623, 226.7 mm

**Fig. 5** Drawing by S. Parkinson (404 mm total length). Basis for original description of *Scorpaena cardinalis* by Solander and Richardson in Richardson (1842). ©The British Museum of Natural History, London



**Fig. 6** Typical caudal-fin base color patterns of *Scorpaena cardinalis*. **a** NMNZ P.026902, 136.4 mm SL; **b** NMNZ P.039107, 272.2 mm SL. Arrows indicate white blotches on the caudal-fin base

SL, Lord Howe Rise, 31°31'S, 159°05'E, P. Pedley, 1910; AMS I.17359-013, 190.6 mm SL, Sylphs Hole, 31°32'S, 159°04'E, 2–4 m, spear, G. Allen et al., Feb. 1973; AMS I.17364-020, 246.1 mm SL, 31°32'S, 159°04'E, 1–2 m, D. Hoese, 8 Feb. 1973; AMS I.17369-003, 4, 67.5–228.3 mm SL, Salmon Beach, 31°32'S, 159°04'E, 1–2 m, G. Allen et al., 14 Feb. 1973; AMS I.41368-001, 248.9 mm SL, 31°33'S, 159°05'E, Sept. 2001; AMS I.42728-004, 242.3 mm SL, Lord Howe Rise, 31°48'S, 159°20'E, 66–88 m, orange roughy trawl, NORFANZ Expedition, RV *Tangaroa*, 23 May 2003; BMNH 1926.6.30.76, 141.8 mm SL, W. Baxter; BPBM 38878, 46.4 mm SL, 6 m, rotenone, J. Randall et al., 7 Feb. 1973; BPBM 38879, 46.1 mm SL, 25 m, rotenone, J. Randall et al., 24 Feb. 1973; CAS 109141, 3, 171.2–224.7 mm SL, AMS team; NMNZ P.039107, 272.2 mm SL, off Balls Pyramid, Lord Howe Rise, 31°48'S, 159°20'E, 66–88 m, orange roughy trawl, NORFANZ Expedition, RV *Tangaroa*, 23 May 2003; NMNZ P.039245, 208.1 mm SL, 31°30'S, 159°04'E, 30–50 m, rod and line, A. L. Stewart and B. Wood, RV *Tangaroa*, 22 May 2003; QM I. 22913, 279.3 mm SL, Elizabeth Reef, Qld, 29°55'S, 159°02'E, R. McKay and J. Short.

KERMADEC ISLANDS: BMNH 1855.8.16.88, holotype of *Scorpaena cookii*, 216.2 mm SL, Raoul Island; NMNZ P.005982, 462.0 mm SL, Curtis Island, 30°30'S, 178°34'W, 15 m, hand-line, H. Finlayson, 24 May 1974; NMNZ P.007536, 67.2 mm SL, Macauley Island, 30°10'S, 179°30'W, J. Yaldwyn and W. Spiekman, 1975; NMNZ P.007537, 215.2 mm SL, Raoul Island, 29°13'S, 178°10'W, E. McGregor, 1975; NMNZ P.009350, 222.2 mm SL, Napier Rock, 29°14'S, 177°52'W, hand-line, K. Bailey and M. Francis, 18 Aug. 1985; NMNZ P.009559, 1 of 2, 328.0 mm SL, Raoul Island, 29°10'S, 177°50'W; NMNZ P.013517, 151.7 mm SL, Raoul Island, 29°10'S, 177°50'W, 1961; NMNZ P.015666, 191.8 mm SL, Boat Cove, Raoul Island, 29°10'S, 177°50'W, hand-line, Kingsford and Smith,

**Table 1** Meristics and morphometrics, expressed as percentages of standard length, of *Scorpaena cardinalis*

	Neotype of <i>S. cardinalis</i> NMNZ P.44152	Holotype of <i>S. cookii</i> BMNH 1855.8.16.88	Non-types of <i>S. cardinalis</i> ( <i>n</i> = 65)	
Standard length (SL, mm)	308.1	216.2	25.3–472.5	
Meristics				Modes
Dorsal-fin rays	XII, 9	XII, 9	XII, 8–9	XII, 9
Pectoral-fin rays <sup>a</sup>	i + 7 + x = 18/18	i + 6 + xi = 18/18	i–ii + 3–12 + v–xvi = 16–18/16–18	i + 5 + xi = 17/17
Scale rows in longitudinal series	62	73	60–74	68
Pored lateral-line scales	24	24	23–25	24
Scales above lateral line	8	8	6–9	8
Scales below lateral line	22	21	21–26	22
Scale rows between 6th dorsal-fin spine base and lateral line	8	9	8–9	9
Scale rows between last dorsal-fin spine base and lateral line	10	10	8–11	10
Pre-dorsal scale rows	8	6	4–8	6
Gill rakers <sup>b</sup>	5 + 11 = 16	5 + 12 = 17	4–5 + 9–13 = 14–16	5 + 12 = 17
Morphometrics (%SL)				Means
Body depth	33.7	28.6	28.6–36.7	32.7
Body width	23.2	21.0	18.7–26.0	22.7
Head length	43.6	43.3	41.7–47.6	44.7
Snout length	14.0	12.3	12.1–15.6	13.8
Orbit diameter	7.8	9.8	6.9–13.4	9.4
Interorbital width <sup>c</sup>	6.5	4.9	4.9–7.1	5.9
Interorbital width <sup>d</sup>	5.6	5.2	4.7–6.2	5.3
Head width	13.8	13.1	12.7–14.1	13.4
Upper-jaw length	22.2	21.7	20.4–24.1	22.2
Maxillary depth	6.1	5.9	5.5–7.2	6.3
Suborbital space	3.1	3.1	2.2–4.4	3.3
Postorbital length	23.4	22.1	19.9–25.6	23.1
Between tips of opercular spines	6.2	5.4	4.7–7.1	5.9
Occipital pit length	5.6	6.0	5.5–6.6	6.0
Occipital pit width	5.9	6.0	5.6–6.9	6.0
Post-occipital pit length	8.5	9.7	7.7–10.2	8.9
Predorsal-fin length	36.1	37.6	34.7–41.1	37.3
Preanal-fin length	72.1	70.2	69.9–77.7	73.0
Prepelvic-fin length	40.8	38.0	36.2–52.1	41.5
1st dorsal-fin spine length	7.1	6.2	3.8–9.5	7.1
2nd dorsal-fin spine length	Damaged	11.1	7.6–15.7	11.9
3rd dorsal-fin spine length	15.2	14.7	12.5–19.6	15.9
4th dorsal-fin spine length	15.1	14.2	12.4–20.5	16.2
5th dorsal-fin spine length	14.9	14.4	13.1–19.6	15.8
11th dorsal-fin spine length	5.7	5.0	4.2–7.1	5.6
12th dorsal-fin spine length	11.2	Damaged	8.9–14.4	11.6
Longest dorsal-fin soft ray length	16.7	17.3	14.8–20.6	17.3
1st anal-fin spine length	10.2	10.3	6.1–12.1	9.3
2nd anal-fin spine length	Damaged	15.4	10.3–22.5	16.7
3rd anal-fin spine length	13.5	14.0	10.6–19.6	14.7
Longest anal-fin soft ray length	21.4	21.8	17.0–24.0	21.1

**Table 1** continued

	Neotype of <i>S. cardinalis</i> NMNZ P.44152	Holotype of <i>S. cookii</i> BMNH 1855.8.16.88	Non-types of <i>S. cardinalis</i> ( <i>n</i> = 65)	
Pectoral-fin ray length	26.8	29.9	23.2–31.7	27.8
Pelvic-fin spine length	13.2	14.3	10.3–18.9	14.6
Longest pelvic-fin soft ray length	24.2	24.1	19.7–26.6	23.4
Caudal-fin length	25.8	27.3	20.9–30.4	26.1
Caudal-peduncle length	15.9	17.6	15.6–20.4	17.3
Caudal-peduncle depth	10.5	10.5	9.4–11.6	10.5

<sup>a</sup> Upper unbranched ray + branched ray + lower unbranched rays = total rays on left side of body/total rays on right side

<sup>b</sup> Rakers on upper limb + rakers on lower limb = total rakers

<sup>c</sup> At vertical midline of eye

<sup>d</sup> At posterior end of preocular spine base

20 Mar. 1984; NMNZ P.017782, 2, 221.2–360.3 mm SL, Meyer Island, 29°10'S, 177°50'W, hand-line, M. Francis and K. Baile, 18 Aug. 1985; NMNZ P.028550, 4, 25.3–166.4 mm SL, Boat Harbour, Meyer Island, 29°14'S, 177°52'W, 0–3 m, rotenone, M. Francis and C. Ward, 3 June 1992; NMNZ P.028585, 76.6 mm SL, Denham Bay, Raoul Island, 29°16'S, 177°57'W, 12 m, rotenone, M. Francis and C. Ward, 4 June 1992; NMNZ P.034404, 433.5 mm SL, Raoul Island, 29°35'S, 178°05'W, 129 m, drop-line, N. Mitchell, 7 June 1997; NMNZ P.034405, 369.2 mm SL, Raoul Island, 29°35'S, 178°05'W, 116 m, drop-line, N. Mitchell; NMNZ P.034406, 3, 334.8–440.6 mm SL, Raoul Island, 29°32'S, 178°05'W, 117 m, drop-line, N. Mitchell, 9 June 1997; NMNZ P.034409, 2, 343.8–359.2 mm SL, Raoul Island, 29°35'S, 178°05'W, 146 m, drop-line, N. Mitchell, 8 June 1997; NMNZ P.034412, 1 of 2, 454.2 mm SL, Raoul Island, 29°34'S, 178°05'W, 114 m, drop-line, N. Mitchell, 8 June 1997; NMNZ P.034423, 1 of 2, 446.3 mm SL, Raoul Island, 29°30'S, 178°02'W, 154 m, drop-line, N. Mitchell, 6 June 1997; NMNZ P.034424, 2, 416.2–472.5 mm SL, Raoul Island, 29°30'S, 178°02'W, 144 m, drop-line, N. Mitchell, 6 June 1997; NMNZ P.034428, 364.7 mm SL, Raoul Island, 29°35'S, 178°05'W, 130 m, drop-line, N. Mitchell, 9 June 1997; NMNZ P.034429, 455.3 mm SL, Raoul Island, 29°34'S, 178°05'W, 120 m, N. Mitchell, 9 June 1997; NMNZ P.041669, 211.2 mm SL, 500 m off Smith's Bluff, Denham Bay, Raoul Island, 29°16'S, 178°57'W, 14–16 m, rotenone, A. L. Stewart et al., 10 Nov. 2004.

NEW ZEALAND: BMNH 1886.11.18.17, 247.7 mm SL, Auckland; NMNZ P.002190, 295.1 mm SL, White Island, 37°31'S, 177°11'E, 7.3 m, A. Black, 25 Mar. 1957; NMNZ P.005652, 336.5 mm SL, Oke Bay, Bay of Islands, 35°14'S, 174°16'E, 37 m, hand-line, A. Baker, Nov. 1971; NMNZ P.005779, 213.2 mm SL, north of Auckland, ca. 36°S, 175°E, trawl, 1970; NMNZ P.005946, 197.5 mm SL, Poor Knights Islands, 35°30'S, 174°44'E, 6–7 m, W.

Palmer, June 1973; NMNZ P.007712, 264.2 mm SL, White Island, 37°31'S, 177°11'E, 100 m, hook and line, RV *Tangaroa*, 19 Jan. 1979; NMNZ P.018162, 1 of 3, 295.8 mm SL, east side of Mayor Island, 37°18'S, 176°18'E, 37–91 m, set net, FV *Asterix*, 19 Feb. 1986; NMNZ P.019957, 240.9 mm SL, Oke Bay, Bay of Islands, 35°14'S, 174°16'E, 37 m, hand-line, A. Baker, Nov. 1971; NMNZ P.021469, 367.2 mm SL, southeast of Ruamahuanui Island, Alderman Islands, 36°58'S, 176°05'E, 40 m, spear, G. Hardy, 7 Dec. 1987; NMNZ P.037092, 276.9 mm SL, White Island, 37°30'S, 177°09'E, 19–21 m, rod and line, C. Struthers, 16 Mar. 2009. LOCALITY UNKNOWN: AMS I.43239-001, 213.5 mm SL, purchased at Pymont Fish Market, Sydney, 2004.

**Diagnosis.** A species of *Scorpaena* with the following combination of characters: dorsal-fin soft rays 9 (8 rays in one specimen); fourth (rarely third) dorsal-fin spine longest; pectoral-fin rays 16–18 (mode 17); scale rows in longitudinal series 60–74 (68); pored lateral-line scales 23–25 (24); scales above lateral line 6–9 (8), below 21–26 (22); scale rows between sixth dorsal-fin spine base and lateral line 8 or 9 (9); scale rows between last dorsal-fin spine base and lateral line 8–11 (10); pre-dorsal scale rows 4–8 (6); gill rakers on upper limb 4–6 (5), lower limb 9–13 (12) [8–10 (9) and 1–4 (3) rakers on ceratohyal and hypobranchial, respectively], total rakers 14–18 (17); exposed cycloid scales covering pectoral-fin base and anteroventral surface of body (some scales covered by thin skin, especially in large adults); lateral surface of maxilla without a longitudinal ridge; lateral lacrimal spine with 2 spinous points; anterior lacrimal spine with 1–3 small spinous points on its posterior margin; posterior lacrimal spine with 1–3 spinous points, directed posteroventrally throughout life; median interorbital ridge present; coronal spines absent; occipital pit and supplement preopercular spine present; pterotic spine simple, smooth distally throughout life; space between upper and lower opercular

spines covered by thin skin without sensory pores or canals; a few skin flaps or tentacles on anterodorsal surface of body; no large black blotch on spinous portion of dorsal fin in both sexes; 2 large white blotches, their diameters subequal to pupil diameter, on caudal-fin base; largest recorded specimen, 472.5 mm SL.

**Distribution.** The species is distributed around northern New Zealand (north of Tolaga Bay, including the Kermadec Islands) and offshore islands of the Tasman Sea (Norfolk and Lord Howe Islands, and Middleton and Elizabeth Reefs, New South Wales, Australia) (Fig. 4). Although Poss (1999) and Allen et al. (2006) included Coffs Harbour on the northern coast of New South Wales in range of *S. cardinalis* (as *S. cookii*) on the basis of a single specimen (AMS I.19696-007, 64.0 mm SL), the specimen is re-identified here as *S. jacksoniensis*. Accordingly, *S. cardinalis* has not been recorded from the coastal waters of Australian mainland.

Collection data for 87 specimens of *S. cardinalis* deposited at NMNZ indicate that the species inhabits rocky reefs in depths of less than 154 m.

**Remarks.** *Scorpaena cardinalis* Solander and Richardson in Richardson (1842) was originally described on the basis of Solander's unpublished manuscript and a line drawing by S. Parkinson. The unfinished drawing, reproduced by Whitehead (1969: pl. 31), shows that the fish (404 mm total length) has a relatively elongate body, the posterior lacrimal spine with 4 points and a pair of distinct blotches on the caudal-fin base (see Fig. 5). These characters agree with those of specimens from New Zealand considered here as *S. cardinalis* (see 'Comparisons'). Typical color patterns on the caudal-fin base of *S. cardinalis* are shown in Fig. 6, which is consistent with that of the drawing (Fig. 5).

No type specimen of *S. cardinalis* is known, and the specimen on which the drawing is based is no longer extant. The erection of a neotype for *S. cardinalis* is herein justified, owing to the similarity of *S. cardinalis* to *S. jacksoniensis* and *S. orgila* and the confusion in the literature between the former two species. A specimen (NMNZ P.044152, 308.1 mm SL; Fig. 3b) collected from White Island, New Zealand, is proposed as the neotype for the species. Accordingly, White Island becomes the type locality of *S. cardinalis* under Article 76.3 [ICZN (The International Commission on Zoological Nomenclature) 1999]. Incidentally, Paulin (1982), discussing the original type locality of *S. cardinalis*, regarded it as Motuaro (Motuarohia) in the Bay of Islands, although Richardson (1842) quoted it as Motuara Island in Queen Charlotte Sound from Solander's manuscript. *Scorpaena cardinalis* is not known to occur south of about 38°S, and Motuara Island in Queen Charlotte Sound is at 41°S.

Richardson (1842) quoted the name *Scorpaena plebeia*, also from Solander's unpublished manuscript, based on the

fish from Tolaga [Bay], New Zealand. *Scorpaena plebeia* was not described as a new species by Richardson (1842), who wrote "he [= Solander] describes merely its colors, and there is no drawing of it extant, nothing is known of its form. He distinguishes *Scorpaena plebeia*, probably from the contrast which its duller general tints make with his *cardinalis*", indicating that Richardson did not believe that *S. plebeia* was a new species. The name *S. plebeia* is most likely unavailable (ICZN 1999: article 11.6), and we regard *S. plebeia* as a junior synonym of *S. cardinalis* even if *S. plebeia* is an available name.

*Scorpaena cookii* was originally described by Günther (1874) on the basis of a single specimen (BMNH 1855.8.16.88, 216.2 mm SL; Fig. 2b) from Raoul Island (as its old name, Sunday Island), Kermadec Islands, New Zealand. It has long been regarded by numerous authors (see synonym list) as a valid species, distributed along the Australian east coast, the Tasman Sea's offshore islands and around northern New Zealand. However, comparison of the holotype of *S. cookii* with the neotype and a large number of non-type specimens of *S. cardinalis* showed them to be identical. *Scorpaena cookii* is therefore regarded here as a junior synonym of *S. cardinalis*. The meristics and morphometrics of the neotype and non-type specimens of *S. cardinalis* and the holotype of *S. cookii* are given in Table 1.

In his review of New Zealand scorpionfishes, Paulin (1982) described *S. cardinalis* (= *S. jacksoniensis* in this study) and *S. cookii* (= *S. cardinalis*) on the basis of 6 (NMNZ P.002190, P.005652, P.005779, P.005982, P.007712) and 7 specimens (NMNZ P.007536, P.007537), respectively. Re-examination of those specimens during this study showed them to be *S. cardinalis*. Paulin's (1982) figures 3 (*S. cardinalis*) and 4 (*S. cookii*) were also clearly *S. cardinalis*.

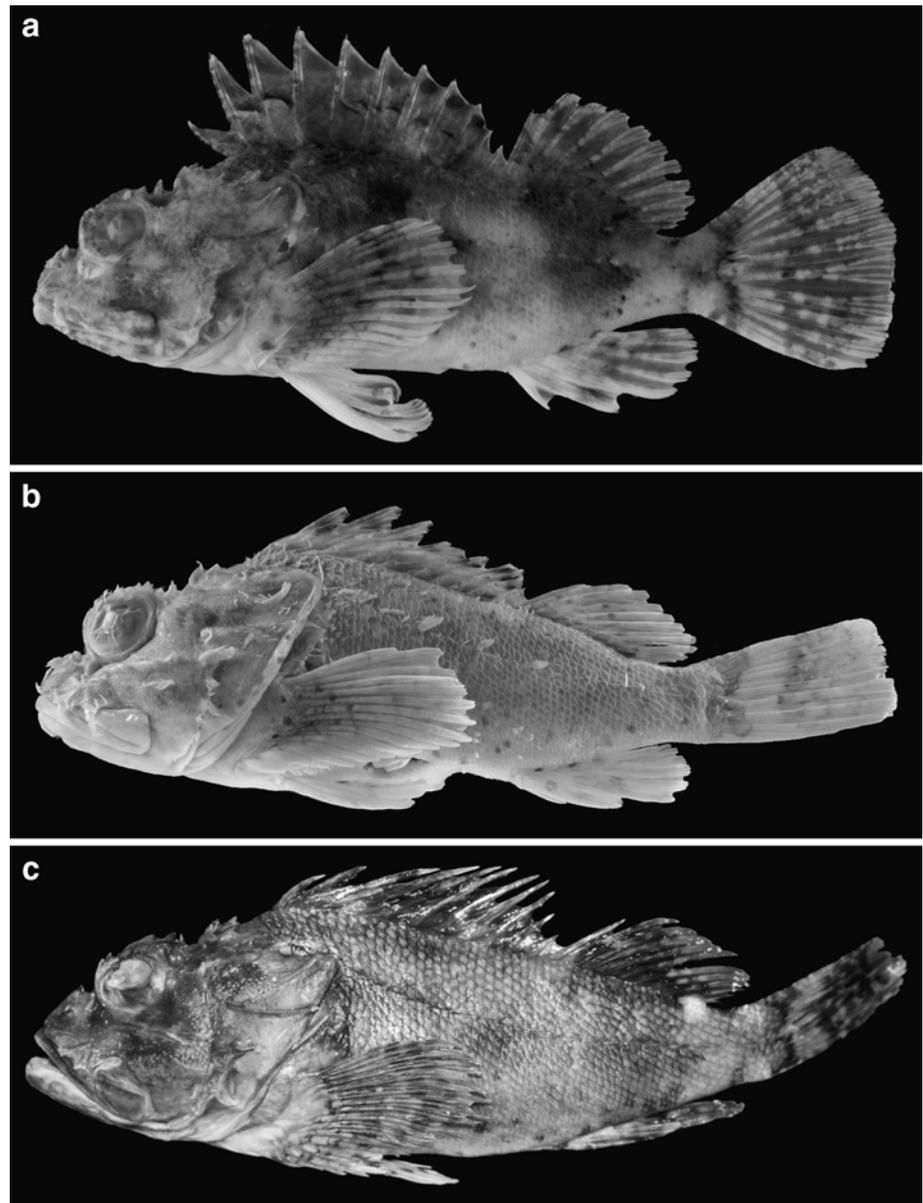
Common names of *S. cardinalis* are as follows: Sandy-Bay Cod (standard English name; Poss 1999), Cook's Scorpionfish (standard Australian name; Yearsley et al. 2006), and Red Rockcod (New Zealand name; Roberts et al. 2009).

***Scorpaena jacksoniensis* Steindachner 1866** (Standard English name: Northern Scorpionfish; Australian name: Eastern Red Scorpionfish) (Figs. 1c–d, 4, 7, 8, 9, 10, 11; Tables 2, 3).

*Scorpaena jacksoniensis* Steindachner 1866a: 50 (Port Jackson, NSW, Australia; abstract of Steindachner 1866b); Steindachner 1866b: 438, pl. 3, figs. 2, 2a (Port Jackson, NSW, Australia; detailed description).

*Scorpaena cardinalis* (not of Solander and Richardson): Günther 1860: 116 (Australian Seas); Macleay 1881: 431 (Port Jackson, NSW); McCulloch 1912: 17 (NSW);

**Fig. 7** Preserved specimens of *Scorpaena jacksoniensis*. **a** KAUM-I. 35882, 131.1 mm SL; **b** AMS I.30310-025, 173.6 mm SL; **c** NMW 75379, holotype of *Scorpaena jacksoniensis*, 182.9 mm SL



McCulloch 1922: 116 (NSW); McCulloch 1930: 383 (NSW, Qld, Tas); Kuitert 1993: 119 (southern Qld to eastern Vic); Hutchins and Swainston 1986: 42, 126, fig. 176 (Noosa Head, Qld to Jervis Bay, NSW); Allen and Cross 1989: 447 (Moreton Bay, Qld to Mallacoota, Vic); Kuitert 1996: 86, 2 unnumbered figs. (southern Qld and NSW); Johnson 1999: 727 (north to Fraser Island, Qld); Poss 1999: 2304, 2334 (southern Qld to Tas); Yearsley et al. 1999: 192, unnumbered fig. (Australia); Motomura et al. 2005c: 866 (Qld to NSW); Allen et al. 2006: 844 (Fraser Island, Qld to Mallacoota, Vic); Motomura et al. 2011: 11 (NSW).

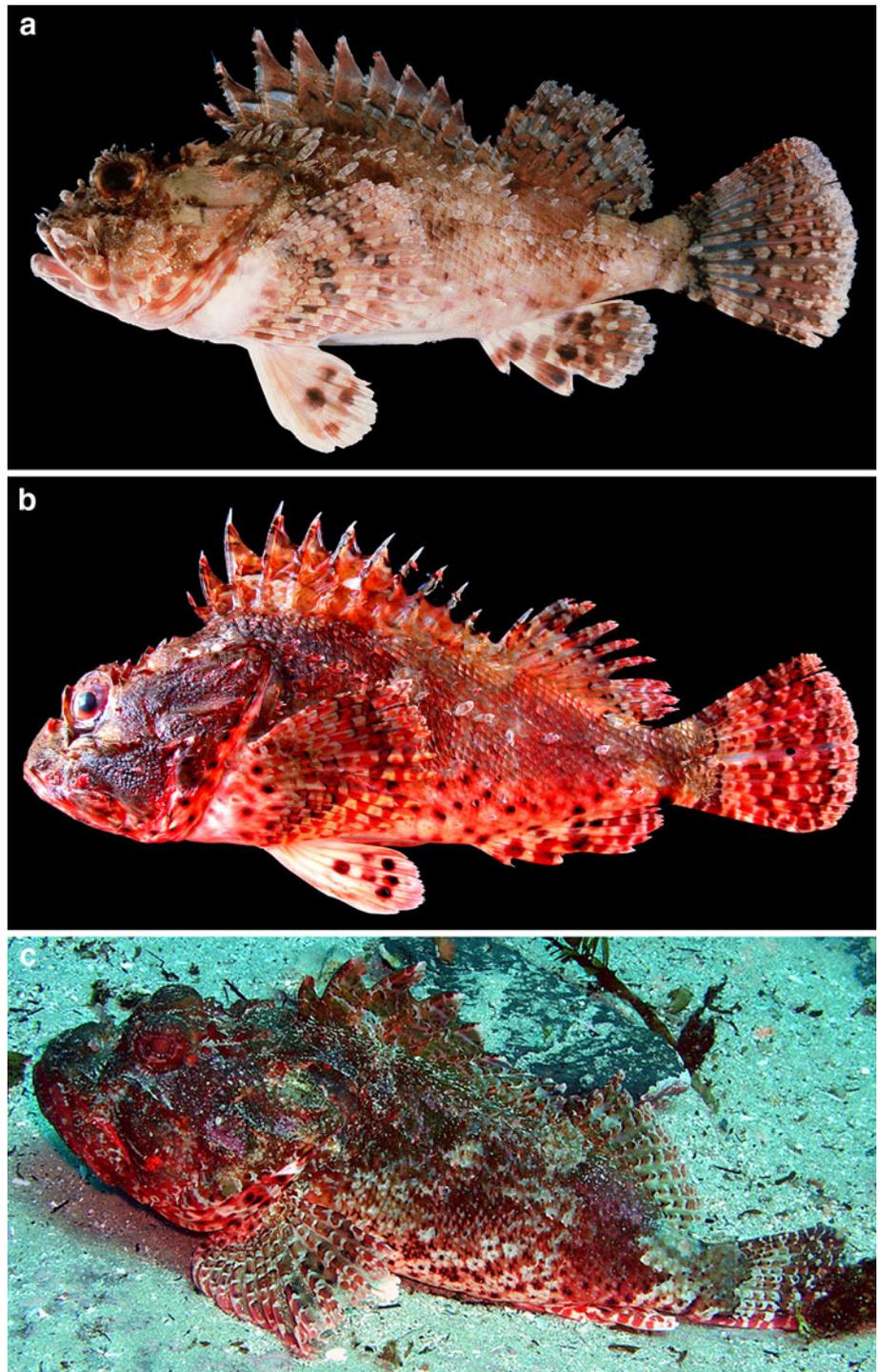
*Scorpaena cruenta* (not of Solander in Richardson): Ogilby 1893: 63, pl. 20 (NSW); Stead 1908: 108, pl. 75 (NSW).

*Ruboralga jacksoniensis*: Whitley 1931: 326 (described as new genus); Whitley 1964: 56 (Australia).

**Holotype.** NMW 75379, 182.9 mm SL, Port Jackson, NSW, Australia, 22 Jan. 1866.

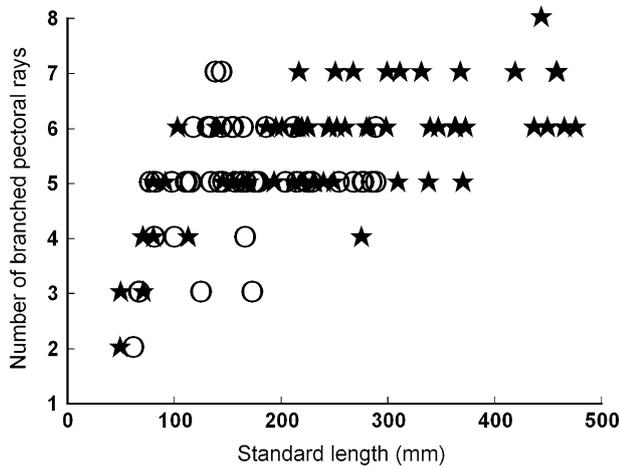
**Other material examined.** 60 specimens, 25.1–336.5 mm SL. AUSTRALIA: AMS IA.246, 153.9 mm SL, off North Head, NSW, 33°17'S, 151°36'E, 37–73 m, McNeill and Livingston, 18 June 1921; AMS IB.6850, 78.2 mm SL, Minnie Water, NSW, 29°50'S, 153°18'E, AMS party, 2 Nov. 1963; AMS IB.7346, 3, 112.5–169.8 mm SL, near Quarantine Beach, North Head, Sydney, NSW, 33°50'S, 151°18'E, rotenone, AMS party and D. Francois, 11 Jan.

**Fig. 8** Fresh specimens and live individual of *Scorpaena jacksoniensis*. **a** BPBM 27828, 141.0 mm SL (photo: J. Randall); **b** AMS I.43647-001, 281.9 mm SL (photo: H. Motomura); **c** ca. 42 cm total length, off Ulladulla, 12 m depth, 26 Mar. 2006 (photo: S. Schulz)



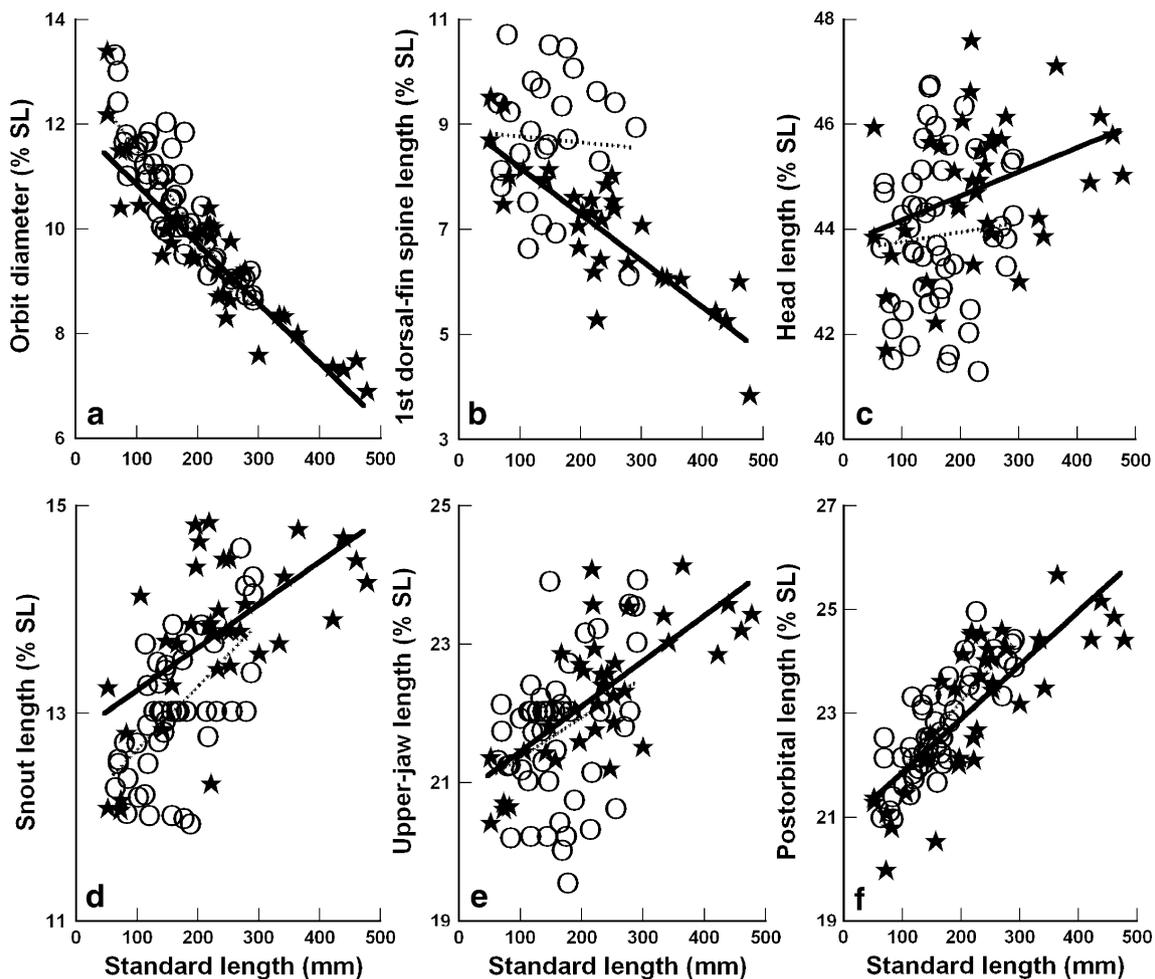
1965; AMS IB.7406, 208.9 mm SL, Nelson Bay, Port Stephens, 32°43'S, 152°08'E, T. Castle, 1965; AMS I.9538, 225.4 mm SL, near Sydney, NSW, Fisheries Dept., 1908; AMS I.9539, 274.0 mm SL, same data as AMS I.9538; AMS I.9684, 161.3 mm SL, Port Jackson, NSW, 33°05'S, 151°13'E, W. Macleay, 1908; AMS I.16890-003, 2, 58.7–128.4 mm SL, Jervis Bay, 35°03'S, 150°44'E, 13–15 m, trawl, D. Pollard, 22 Sept. 1971; AMS I.19696-

007, 65.0 mm SL, South Solitary Island, off Coffs Harbour, NSW, 30°12'S, 153°16'E, 5–20 m, spear, B. Russell and R. Kuitert, 27 Sept. 1976; AMS I.19848-002, 163.4 mm SL, Broughton Island, NSW, D. Hoese, 18 Apr. 1976; AMS I.30310-025, 3, 107.8–173.6 mm SL, southwest side in small bay, North Solitary Island, NSW, 29°56'S, 153°23'E, 12–14 m, rotenone and derris, AMS and NSW Fisheries, 5 May 1977; AMS I.31124-002, 2, 138.9–163.7 mm SL,



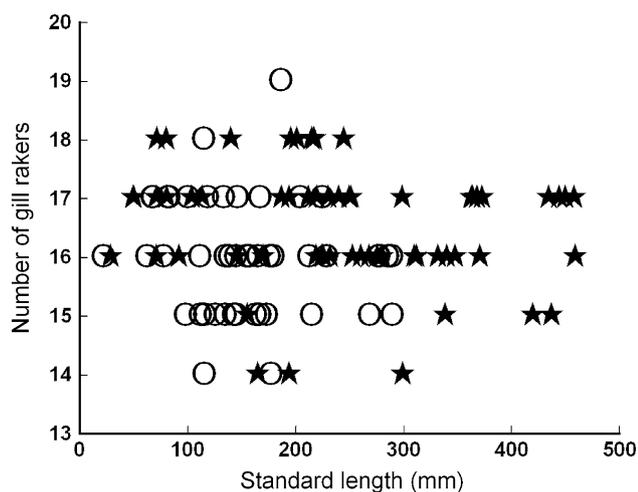
**Fig. 9** Relationship of number of branched pectoral-fin rays to standard length in *Scorpaena cardinalis* (closed stars) and *S. jacksoniensis* (open circles)

North Solitary Island, NSW, 29°56'S, 153°24'E, 15 m, rotenone, A. Hogget and L. Vail, 9 Feb. 1982; AMS I.31125-001, 264.9 mm SL, south of Cronulla Beach, Qak Park, NSW, 34°27'S, 151°09'E, 2 m, hook and line, P. Phillis, 17 Dec. 1990; AMS I.31253-033, 2, 74.0–79.3 mm SL, Washhouse Beach, Camden Head, NSW, 31°38'30"S, 152°50'24"E, 4 m, rotenone, AMS party, 8 May 1991; AMS I.32218-003, 94.5 mm SL, off Newcastle, NSW, 32°53–54'S, 152°00–01'E, 73 m, prawn trawl, RV *Kapala*, 20 June 1991; AMS I.40829-016, 129.8 mm SL, northeast corner of Clarke Island, Sydney Harbour, NSW, 33°51'43"S, 151°14'26"E, 1.5–11.8 m, rotenone, AMS party, 27 Apr. 2001; AMS I.40840-043, 96.9 mm SL, Sydney Harbour, NSW, 33°50'50"S, 151°16'17"E, 1–8 m, rotenone, AMS party, 4 May 2001; AMS I.41285-027, 63.8 mm SL, rock pool adjacent to Blue Pool, Angourie, NSW, 29°28'44"S, 153°21'50"E, 2 m, rotenone and



**Fig. 10** Relationships of: **a** orbit diameter; **b** first dorsal-fin spine length; **c** head length; **d** snout length; **e** upper-jaw length; and **f** postorbital length (all as % of standard length) to standard length in

*Scorpaena cardinalis* (closed stars, solid lines) and *S. jacksoniensis* (open circles, dotted lines)



**Fig. 11** Relationship of number of gill rakers to standard length in *Scorpaena cardinalis* (closed stars) and *S. jacksoniensis* (open circles)

dipnets, A. Gill et al., 25 Mar. 2002; AMS I.43420-019, 2, 108.4–111.9 mm SL, 100 m off Fairlight Beach, Sydney Harbour, NSW, 33°48'04"S, 151°16'29"E, 2–8 m, rotenone and spear, J. Cooper et al., 19 Aug. 2004; AMS I.43647-001, 281.9 mm SL, Avalon to Maroubra Beach, NSW, 33°30'–34°00'S, 151°15'–18'E, 5–25 m, spear, NSW Spear Fishing Association, 7 Aug. 2005; AMS I.43647-003, 285.4 mm SL, same data as AMS I.43647-001; AMS I.43647-027, 211.6 mm SL, same data as AMS I.43647-001; BMNH 1870.11.30.69, 221.1 mm SL, Coral Sea, A. Thomson; BMNH 1890.9.23.142, 142.8 mm SL, Evans Reef, NSW; BMNH 1890.9.23.143, 172.1 mm SL, same data as BMNH 1890.9.23.142; BPBM 27828, 141.0 mm SL, Sydney Harbour, NSW, 33°51'S, 151°16'E, rotenone, R. Kuitert, 6 Sept. 1981; CAS 13712, 3, 149.3–208.3 mm SL, Evans Head (purchased at Sydney Fish Market), W. Eschmeyer, 4 Nov. 1969; CAS 60395, 87.7 mm SL, Sydney Harbour, NSW, 0–1.8 m, B. Collette; CAS 120760, 2, 193.5–203.0 mm SL, Port Hacking, NSW, D. Stead; CSIRO H 4313-11, 201.0 mm SL, Sydney Fish Market, NSW, G. Yearsley, 6 Aug. 1996; KAUM-I. 35882, 131.1 mm SL, same data as AMS I.43420-019; KAUM-I. 35883, 111.7 mm SL, same data as AMS I.43420-019; NMNZ P.014679, 48.0 mm SL, Clovelly Pool, Sydney, NSW, 33°55'S, 151°44'E, J. Moreland and J. Yaldwyn, 30 Mar. 1967; QM I. 2417, 226.3 mm SL, Moreton Bay, Qld, 27°15'S, 153°15'E; QM I. 3612, 141.4 mm SL, Cowan Cape, Moreton Bay, Qld, 27°08'S, 153°22'E, J. Palmer; QM I. 3613, 135.5 mm SL, same data as QM I. 3612; QM I. 12348, 131.3 mm SL, off Peel Island, Moreton Bay, Qld, 27°29'S, 153°21'E, W. Bindley, 20 Apr. 1951; QM I. 22141, 5, 25.1–58.6 mm SL, Cook Island, NSW, 28°12'S, 153°35'E, 12–15 m, J. Johnson, 2 Feb. 1986; QM I. 29253, 150.9 mm SL, Tangalooma Wrecks, Moreton Bay, Qld,

27°01'S, 153°22'E, 3–6 m, J. Johnson and J. Short, 6 June 1994; QM I. 29740, 152.4 mm SL, Amity Point, Qld, 27°24'S, 153°26'E, 2–9 m, J. Johnson, 14 Mar. 1995; QM I. 34187, 114.9 mm SL, east of Stradbroke Island, Qld, 27°35'S, 153°37'E, 71 m, Qld Fisheries Service, 16 Oct. 2001; QM I. 36484, 62.0 mm SL, Manta Ray Bommie, Point Lookout, north of Stradbroke Island, Qld, 27°25'S, 153°33'E, 8–9 m, J. Johnson, 23 Feb. 2005; QM I. 37688, 251.0 mm SL, Manta Ray Bommie, Point Lookout, north of Stradbroke Island, Qld, 27°25'S, 153°33'E, 7–11 m, J. Johnson and M. Ekins, 14 Dec. 2005; QM I. 37689, 175.6 mm SL, same data as QM I. 37688. LOCALITY UNKNOWN: NMW 12176, 285.8 mm SL.

**Diagnosis.** A species of *Scorpaena* with the following combination of characters: dorsal-fin soft rays 9; fourth (rarely third) dorsal-fin spine longest; pectoral-fin rays 16–18 (mode 17); scale rows in longitudinal series 52–61 (55); pored lateral-line scales 22–24 (23); scales above lateral line 4–6 (5), below 20–25 (22); scale rows between sixth dorsal-fin spine base and lateral line 6–8 (7); scale rows between last dorsal-fin spine base and lateral line 7–9 (9); pre-dorsal scale rows 1–4 (2); gill rakers on upper limb 4–6 (5), lower limb 10–13 (11) [7–9 (8) and 2–5 (3) rakers on ceratohyal and hypobranchial, respectively], total rakers 14–19 (16); embedded cycloid scales covering pectoral-fin base (some scales exposed); embedded cycloid scales on anteroventral surface of body (covered by thick skin, not visible without dissection); lateral surface of maxilla without a longitudinal ridge; lateral lacrimal spine with 2 (rarely 3) spinous points; anterior lacrimal spine with 1 or 2 small spinous points on its posterior margin; posterior lacrimal spine simple, directed anteroventrally in juveniles and young less than 100 mm SL, ventrally or posteroventrally in adults; median interorbital ridge present; interorbital and coronal spines absent; occipital pit and supplement preopercular spine present; pterotic spine usually simple in young, with 2 or more points in large adults usually more than 280 mm SL; space between upper and lower opercular spines covered by thick skin with sensory pores and canals; numerous skin flaps and tentacles on anterodorsal surface of body; a large black blotch distally on posterior spinous portion of dorsal fin in males; no distinct white blotches on caudal-fin base; largest recorded specimen, 336.5 mm SL.

**Distribution.** *Scorpaena jacksoniensis* is distributed along the coastal water of eastern Australia (Fig. 4) from southern Queensland to Victoria. The species is common on rocky coastal reefs of New South Wales (Stewart and Hughes 2010, reported as *S. cardinalis*) in depths of 1–73 m (based on collection data for specimens examined in this study).

It is rare in Victoria; only two old specimens (NMV A 15898, dry, Victoria, collected in 1890 and NMV R 13360,

**Table 2** Meristics and morphometrics, expressed as percentages of standard length, of *Scorpaena jacksoniensis*

	Holotype of <i>S. jacksoniensis</i> NMW 75379	Non-types of <i>S. jacksoniensis</i> ( <i>n</i> = 60)	
Standard length (SL, mm)	182.9	25.1–336.5	
Meristics			Modes
Dorsal-fin rays	XII, 9	XII, 9	XII, 9
Pectoral-fin rays <sup>a</sup>	i + 6 + xi = 18/18	i–ii + 3–7 + ix–xiii = 16–18/16–18	i + 5 + xi = 17/17
Scale rows in longitudinal series	57	52–61	55
Pored lateral-line scales	23	22–24	23
Scales above lateral line	6	4–6	5
Scales below lateral line	22	20–25	22
Scale rows between 6th dorsal-fin spine base and lateral line	7	6–8	7
Scale rows between last dorsal-fin spine base and lateral line	9	7–9	9
Pre-dorsal scale rows	4	1–4	2
Gill rakers <sup>b</sup>	6 + 13 = 19	4–6 + 10–13 = 14–19	5 + 11 = 16
Morphometrics (%SL)			Means
Body depth	35.6	34.0–38.5	35.6
Body width	23.8	21.2–29.0	24.2
Head length	43.3	40.7–46.7	43.9
Snout length	11.9	11.9–14.6	13.0
Orbit diameter	10.1	8.6–13.3	10.6
Interorbital width <sup>c</sup>	6.2	5.2–7.1	6.4
Interorbital width <sup>d</sup>	6.2	5.1–6.4	5.7
Head width	–	13.3–16.0	14.4
Upper-jaw length	20.7	19.5–23.9	21.7
Maxillary depth	5.4	5.3–7.0	6.2
Suborbital space	2.7	1.6–2.8	2.2
Postorbital length	23.0	20.9–24.9	22.7
Between tips of opercular spines	6.8	5.6–8.0	7.1
Occipital pit length	–	4.9–7.0	5.8
Occipital pit width	–	5.5–7.0	6.1
Post-occipital pit length	–	6.8–9.6	8.4
Predorsal-fin length	36.2	34.9–40.8	37.1
Preanal-fin length	72.4	67.6–75.6	71.2
Prepelvic-fin length	36.2	36.2–43.7	39.2
1st dorsal-fin spine length	8.1	6.1–10.7	8.7
2nd dorsal-fin spine length	Damaged	8.2–17.7	13.7
3rd dorsal-fin spine length	17.4	11.6–21.0	17.4
4th dorsal-fin spine length	18.8	13.1–21.7	18.0
5th dorsal-fin spine length	18.3	12.5–20.4	16.4
11th dorsal-fin spine length	5.5	3.3–8.7	5.7
12th dorsal-fin spine length	12.6	7.8–15.3	11.8
Longest dorsal-fin soft ray length	18.2	15.9–21.3	18.1
1st anal-fin spine length	8.2	5.9–12.5	8.9
2nd anal-fin spine length	16.3	12.2–22.4	17.5
3rd anal-fin spine length	14.8	11.1–19.3	15.2
Longest anal-fin soft ray length	21.0	19.2–24.8	21.9
Pectoral-fin ray length	26.5	24.7–33.2	28.8

**Table 2** continued

	Holotype of <i>S. jacksoniensis</i> NMW 75379	Non-types of <i>S. jacksoniensis</i> (n = 60)	
Pelvic-fin spine length	13.9	11.1–19.1	14.6
Longest pelvic-fin soft ray length	22.4	22.3–28.5	24.9
Caudal-fin length	27.1	23.6–33.3	28.2
Caudal-peduncle length	18.2	15.7–20.9	18.0
Caudal-peduncle depth	11.3	10.3–17.3	11.6

<sup>a</sup> Upper unbranched ray + branched ray + lower unbranched rays = total rays on left side of body/total rays on right side

<sup>b</sup> Rakers on upper limb + rakers on lower limb = total rakers

<sup>c</sup> At vertical midline of eye

<sup>d</sup> At posterior end of preocular spine base

–, data not taken

**Table 3** Frequency distribution of selected meristics of *Scorpaena cardinalis* and *S. jacksoniensis*

	Pectoral-fin rays					Pored lateral-line scales					Scales above lateral line													
	16/16	16/17	17/17	17/18	18/18	22	23	24	25	4	5	6	7	8	9									
<i>S. cardinalis</i>	2	4	35	8	17 <sup>N</sup>	9	56 <sup>N</sup>	1				12	23	25 <sup>N</sup>	4									
<i>S. jacksoniensis</i>	4	5	47	1	3 <sup>H</sup>	2	52 <sup>H</sup>	3		2	36	17 <sup>H</sup>												
	Scale rows in longitudinal series																							
	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	
<i>S. cardinalis</i>									2	2	4 <sup>N</sup>	5	3	8	8	8	13	3	3	1	1	2	1	
<i>S. jacksoniensis</i>	1	4	7	17	14	7 <sup>H</sup>	3	3	1	1														
	Scale rows between 6th DS and LL					Scale rows between last DS and LL					Pre-dorsal scale rows													
	6	7	8	9	7	8	9	10	11	1	2	3	4	5	6	7	8							
<i>S. cardinalis</i>			6 <sup>N</sup>	17		1	5	58 <sup>N</sup>	2				1	11	37	13	3 <sup>N</sup>							
<i>S. jacksoniensis</i>	8	44 <sup>H</sup>	3		2	24	34 <sup>H</sup>			1	25	21	7 <sup>H</sup>											

<sup>N</sup> and <sup>H</sup> include neotype of *S. cardinalis* and holotype of *S. jacksoniensis*, respectively

DS dorsal-fin base, LL lateral line

293 mm SL, Western Port, Victoria, 1933) from Victorian water have been deposited at the Museum Victoria (D. Bray, personal communication). Accurate localities of the two specimens are unknown because the latter specimen was probably purchased from a fish market in Western Port, Victoria. The southernmost record of *S. jacksoniensis* based on voucher specimens is Jervis Bay, New South Wales (35°03'S).

A specimen (QM I. 16624, otoliths only, off Mooloolaba, Queensland, 26°41'S) represents the northernmost record of the species on the basis of a voucher specimen (J. Johnson, personal communication). However, *S. jacksoniensis* is regularly caught off Fraser Island, Queensland (25°13'S) (Johnson 1999), and occasionally reported as taken on the southern end of the Great Barrier Reef (J.

Johnson, personal communication), although no museum specimens have been retained from there.

**Biological notes.** Biological information on *S. jacksoniensis* (as *S. cardinalis*) was reported by Stewart and Hughes (2010), who estimated the oldest individual to be 33 years old. They also found that the spawning peak in New South Wales waters was March, and the species had a highly specialized ovary adapted for the production of a floating gelatinous egg mass.

**Remarks.** *Scorpaena jacksoniensis* was originally described by Steindachner (1866a) on the basis of a single large specimen (NMW 75379, 182.9 mm SL; Fig. 7c) from Port Jackson, New South Wales, Australia. Since its original description, numerous authors (see synonym list) have regarded *S. jacksoniensis* as a junior synonym of *S.*

*cardinalis*. However, the nominal name, *S. cardinalis*, applies to a species that has long been regarded as *S. cookii* (see ‘Remarks’ of *S. cardinalis*), and *S. cardinalis* does not occur around the Australian mainland (see ‘Distribution’ of *S. cardinalis*). Examination of the holotype of *S. jacksoniensis* found it to be identical with species nominally identified as *Scorpaena* ‘*cardinalis*’ from the coastal water of the Australian mainland. Accordingly, *S. jacksoniensis* is herein restored as a valid species. The meristics and morphometrics of the holotype and non-type specimens of *S. jacksoniensis* are given in Table 2.

*Scorpaena cruenta* reported by Ogilby (1893: pl. 20) and Stead (1908: pl. 75) from NSW is re-identified here as *S. jacksoniensis*. *Scorpaena cruenta* is currently known as a junior synonym of *S. papillosa* (Paulin 1982; Motomura, unpublished data).

Whitley (1931) proposed a new genus, *Ruboralga*, for *S. jacksoniensis* and included three other Australian species, *S. ergastulora* (as *ergastulorum*), *S. sumptuosa* and *S. bellicosa*, and a New Zealand species, *S. cardinalis*. Subsequently, Whitley (1968) added *S. cookii* to *Ruboralga*. Whitley’s (1931, 1968) *R. cardinalis* is most likely to include *S. papillosa* and *S. cardinalis*. Although Whitley (1931) stated that “*Scorpaena* from the Mediterranean Sea seems to have a very different facies... [from] the Australian form” and described general characters of scorpioidfishes, e.g., “orbital crests and bony stay of cheek with several spines”, “second anal spine longer than third”, and “general coloration mainly reddish”, he did not give diagnostic characters to separate *Ruboralga* from *Scorpaena*. In addition, *S. bellicosa* that Whitley (1931) included in *Ruboralga* was recently described by Motomura et al. (2009) as a junior synonym of *Parascorpaena aurita* (Rüppell 1838). Moreover, we found no generic characters to justify distinguishing *Ruboralga* from *Scorpaena*, although all valid species of *Scorpaena* were examined (Motomura, unpublished data). Therefore, *Ruboralga* is regarded as a junior synonym of *Scorpaena*.

Common names of *S. jacksoniensis* are as follows: Northern Scorpionfish (standard English name; Poss 1999) and Eastern Red Scorpionfish (standard Australian name; Yearsley et al. 2006).

**Morphological changes with growth.** In common with most members of the genus *Scorpaena* (see Motomura et al. 2005b), the number of the branched pectoral-fin rays in *S. cardinalis* and *S. jacksoniensis* tend to increase with growth until they attain ca. 200 mm SL (Fig. 9).

The scales enclosed by the posterior tips of the upper and lower opercular spines and opercular margin also change with growth from cycloid to ctenoid in *Scorpaena bulacephala* and *S. onaria* (see Motomura et al. 2005b, c, respectively). However, those of *S. cardinalis* and *S. jacksoniensis* remain cycloid throughout life. Furthermore,

whereas the occipital pit of *S. bulacephala* becomes deeper with growth, those of *S. cardinalis* and *S. jacksoniensis* become shallower.

The distal margins of the pterotic spines of young *S. jacksoniensis* are smooth (a typical condition in *Scorpaena*), and those of large adults (usually more than 280 mm SL) have two or more points, whereas those of *S. cardinalis* remain smooth throughout life.

Juveniles and young *S. jacksoniensis* less than 100 mm SL have an anteroventrally directed posterior lacrimal spine (Fig. 1c), the direction of the spine changes to ventrally or posteroventrally directed with growth (Fig. 1d). The direction of the posterior lacrimal spine of *S. cardinalis* does not change throughout life (Fig. 1a, b).

Changes in relative lengths of some body parts with growth, especially fin spines and soft rays, are well known in Scorpaenidae. However, except for studies of *S. bulacephala* and *S. onaria* by Motomura et al. (2005b: fig. 4; 2005c: fig. 7 respectively), no detailed descriptions of such changes, including accurate measurement data, have been reported for other species of *Scorpaena*. Analyses of 37 measurements in *S. cardinalis* and *S. jacksoniensis* found that relative lengths of the orbit, head, snout, upper jaw, postorbit and all fin rays of the two species changed significantly with growth. The orbit diameter and lengths of all fin rays as a percentage of SL (only first dorsal-fin spine length is given in Fig. 10 as an example) decrease with growth (Fig. 10a, b) as found in other species of *Scorpaena*. However, the head, snout, upper-jaw and postorbital lengths become significantly longer as a percentage of SL with growth (Fig. 10c–f). These changes have not been previously reported in Scorpaenidae. As a result of these changes, the heads of the two species appear to become more elongate with growth (see Figs. 2, 7).

There is considerable variation in the number of gill rakers in *S. cardinalis* and *S. jacksoniensis*, i.e., 14–19 rakers in both species (Tables 1, 2). Although the number of gill rakers in several fish species generally decreases with growth due to changes in diet, those of the two species of *Scorpaena* do not represent the growth-related change (Fig. 11). Moreover, the differences in number of gill rakers are not reflected by capture localities. The wide range in the number of gill rakers in the two species is therefore regarded as an individual variation of each species.

**Comparisons.** Ontogenetic differences (posterior lacrimal and pterotic spines) between *S. cardinalis* and *S. jacksoniensis* are noted above. *Scorpaena cardinalis* is readily distinguished from *S. jacksoniensis* by having exposed cycloid scales covering on the anteroventral surface of the body (some scales covered by thin skin, especially in large adults) (vs. scales embedded in thick skin, not visible without dissection in *S. jacksoniensis*), and thin

skin without sensory pores or canals covering on a space between the upper and lower opercular spines (vs. thick skin with sensory pores and canals covering the area).

*Scorpaena cardinalis* has smaller scales than *S. jacksoniensis*, having higher counts of pored lateral-line scales [23–25 (mode 24) in *S. cardinalis* vs. 22–24 (23) in *S. jacksoniensis*], scales above the lateral line [6–9 (8) vs. 4–6 (5)], scale rows in the longitudinal series [60–74 (68) vs. 52–61 (55)], scale rows between the sixth dorsal-fin spine base and lateral line [8 or 9 (9) vs. 6–8 (7)], and scale rows between the last dorsal-fin spine base and lateral line [8–11 (10) vs. 7–9 (9)] (Table 3). The space between the dorsal-fin origin and occipital pit of *S. jacksoniensis* is broadly covered by thick skin, and only 1–4 scale rows (pre-dorsal scale rows) are exposed, whereas that of *S. cardinalis* lacks the thick skin and 4–8 scale rows are exposed (Table 3).

In addition, *S. cardinalis* differs from *S. jacksoniensis* in having the posterior lacrimal spine with 1–3 (usually 2) spinous points (vs. simple in *S. jacksoniensis*; Fig. 1), and the anterodorsal surface of the body with a lower number of skin flaps or tentacles than *S. jacksoniensis*.

The two species can also be distinguished by coloration; *S. cardinalis* has two large white blotches, each diameter subequal to pupil diameter, on the upper and lower caudal peduncle at the caudal-fin base (Figs. 3, 5, 6), whereas *S. jacksoniensis* lacks the distinct blotches. Males of *S. jacksoniensis* have a large, elongate, black blotch distally on the posterior spinous portion of the dorsal fin (Fig. 8b), whereas *S. cardinalis* lacks the blotch in both sexes. *Scorpaena cardinalis* grows larger than *S. jacksoniensis* (largest recorded size, 472.5 vs. 336.5 mm SL).

*Scorpaena orgila*, the third species of the *S. cardinalis* complex, is similar to *S. cardinalis* in overall body appearance, having exposed cycloid scales covering the anteroventral surface of the body (some scales covered by thin skin), thin skin without sensory pores or canals covering a space between the upper and lower opercular spines, 24 pored lateral-line scales and 8–10 scales above the lateral line. However, *S. orgila* differs from *S. cardinalis* in having a lower number of scale rows in the longitudinal series [50–59, based on data for specimens examined in this study and given by Eschmeyer and Allen (1971) vs. 60–74 (mode 68); Tables 1, 3]. Because *S. orgila* is restricted to Easter Island and known only from type specimens, more specimens are required to clarify these taxonomic characters.

**Acknowledgments** We are especially grateful to A. Hay and S. Reader (AMS), J. Maclaine (BMNH), W. Eschmeyer, T. Iwamoto, D. Catania and M. Hoang (CAS), P. Last, A. Graham and W. White (CSIRO), H. Wellendorf and C. Prenner (NMW) and J. Johnson (QM) for their kind assistance during the first author's visits to their institutions. We thank J. Randall, L. O'Hara and A. Suzumoto (BPBM) for the specimen loan, and D. Bray (NMV) and J. Johnson (QM) for

providing distributional information on *S. jacksoniensis* in Victoria and Queensland, respectively. We are grateful to L. Moore and all staff of the Fish Section of NMNZ for their generous support during this study, and S. Schulz (Sydney, Australia), J. Randall (BPBM) and R. McPhee (NMNZ) for providing some photographs of *S. jacksoniensis* and *S. cardinalis*. This work was also supported (in part) by the NZ Foundation for Research Science and Technology through the Te Papa Biosystematics of NZ EEZ Fishes subcontract within NIWA's marine Biodiversity and Biosecurity OBI programme (contract C01X0502) and a Grant-in-Aid for Young Scientists (B) from the Ministry of Education, Science, Sports and Culture, Tokyo (19770067).

## References

- Allen GR, Cross N (1989) Scorpaenidae. In: Paxton JR, Hoese DF, Allen GR, Hanley JE (eds) Zoological catalogue of Australia. Vol. 7. Pisces. Petromyzontidae to Carangidae. Australian Government Publishing Service, Canberra, pp 438–452
- Allen GR, Cross NJ, Hoese DF (2006) Scorpaenidae. Lionfishes, rockfishes, scorpionfishes, stingfishes, stonefishes, waspfishes. In: Hoese DF, Bray DJ, Paxton JR, Allen GR (eds) Zoological catalogue of Australia. Vol. 35, parts 1–3: fishes. CSIRO Publishing, Collingwood, pp 876–892
- Bloch ME, Schneider JG (1801) Systema ichthyologiae iconibus ex illustratum. Post obitum auctoris opus inchoatum absolvit, correxit, interpolavit J. G. Schneider, Saxo Berolini. Berolini, Berlin
- Chen L-C (1981) Scorpaenid fishes of Taiwan. Quart J Taiwan Mus 34:1–60
- Doak W (1984) Fishes of New Zealand region. Hodder and Stoughton, Auckland
- Eschmeyer WN (1965) Western Atlantic scorpionfishes of the genus *Scorpaena*, including four new species. Bull Mar Sci 15:84–164
- Eschmeyer WN, Allen GR (1971) Three new species of scorpionfishes (family Scorpaenidae) from Easter Island. Proc Calif Acad Sci (Ser 4) 37:515–527
- Francis MP (1993) Checklist of the coastal fishes of Lord Howe, Norfolk, and Kermadec Island, southwest Pacific Ocean. Pacif Sci 47:136–170
- Francis MP (1996) Coastal fishes of New Zealand. An identification guide, revised edition. Reed Publishing Ltd, Auckland
- Francis MP (2001) Coastal fishes of New Zealand. An identification guide, third edition. Reed Publishing Ltd, Auckland
- Günther A (1860) Catalogue of the acanthopterygian fishes in the collection of the British Museum. Vol. 2. Squamipinnes, Cirrhitidae, Triglidae, Trachinidae, Sciaenidae, Polynemidae, Sphyraenidae, Trichiuridae, Scombridae, Carangidae, Xiphiidae. British Museum, London
- Günther A (1874) Andrew Garrett's fische der Südsee, band 1, heft. 3. J Mus Godeffroy 2:58–96
- Hirt-Chabbert J (2006) Fish species of New Zealand. A photographic guide. Reed Publishing Ltd, Auckland
- Hutchins B, Swainston R (1986) Sea fishes of southern Australia. Swainston Publishing, Perth
- ICZN (The International Commission on Zoological Nomenclature) (1999) International code of zoological nomenclature, 4th edition. Adopted by the General Assembly of the International Union of Biological Sciences. International Trust for Zoological Nomenclature, London
- Johnson JW (1999) Annotated checklist of the fishes of Moreton Bay, Queensland, Australia. Mem Qld Mus 43:709–762
- Kuiter RH (1993) Coastal fishes of south-eastern Australia. University of Hawaii Press, Honolulu

- Kuiter RH (1996) Guide to sea fishes of Australia. A comprehensive reference for divers and fishermen. New Holland Publishers, Sydney
- Leviton AE, Gibbs RH Jr, Heal E, Dawson CE (1985) Standards in herpetology and ichthyology: Part I. Standard symbolic codes for institutional resource collections in herpetology and ichthyology. *Copeia* 1985:802–832
- Macleay W (1881) Descriptive catalogue of the fishes of Australia. Part I. *Proc Linn Soc NSW* 5:302–444
- McCulloch AR (1912) Notes on some Western Australian fishes. *Rec West Aust Mus* 1:78–97
- McCulloch AR (1922) Check list of the fish and fish-like animals of New South Wales, part 3. *Aust Zoologist* 2:86–130
- McCulloch AR (1930) A check-list of the fishes recorded from Australia. *Mem Aust Mus, Sydney* 5:329–436
- Motomura H (2004a) New species of scorpionfish, *Scorpaena cocosensis* (Scorpaeniformes: Scorpaenidae) from the Cocos Islands, Costa Rica, eastern Pacific Ocean. *Copeia* 2004:818–824
- Motomura H (2004b) Revision of the scorpionfish genus *Neosebastes* (Scorpaeniformes: Neosebastidae) with descriptions of five new species. *Indo-Pacif Fish* 37:1–75
- Motomura H, Johnson JW (2006) Validity of the poorly known scorpionfish, *Rhinopias eschmeyeri*, with redescription of *R. frondosa* and *R. aphanes* (Scorpaeniformes: Scorpaenidae). *Copeia* 2006:500–515
- Motomura H, Senou H (2008) A new species of the scorpionfish genus *Scorpaena* (Scorpaenidae) from Izu Peninsula, Pacific coast of Japan. *J Fish Biol* 72:1761–1772
- Motomura H, Yoshino T, Takamura N (2004) Review of the scorpionfish genus *Scorpaenopsis* (Scorpaeniformes: Scorpaenidae) in Japanese waters with three new records and an assessment of standard Japanese names. *Jpn J Ichthyol* 51:89–115
- Motomura H, Fricke R, Eschmeyer WN (2005a) Redescription of a poorly known scorpionfish, *Scorpaena canariensis* (Sauvage), and a first record of *Pontinus leda* Eschmeyer from the Northern Hemisphere (Scorpaeniformes: Scorpaenidae). *Stuttg Beitr Naturk Ser A (Biol)* 674:1–15
- Motomura H, Last PR, Yearsley GK (2005b) *Scorpaena bulacephala*, a new species of scorpionfish (Scorpaeniformes: Scorpaenidae) from the northern Tasman Sea. *Zootaxa* 1043:17–32
- Motomura H, Paulin CD, Stewart AL (2005c) First records of *Scorpaena onaria* (Scorpaeniformes: Scorpaenidae) from the southwestern Pacific Ocean, and comparisons with the Northern Hemisphere population. *New Zealand J Mar Freshwater Res* 39:865–880
- Motomura H, Last PR, Gomon MF (2006a) A new species of the scorpionfish genus *Maxillicosta* from the southeast coast of Australia, with a redescription of *M. whitleyi* (Scorpaeniformes: Neosebastidae). *Copeia* 2006:445–459
- Motomura H, Last PR, Yearsley GK (2006b) New species of shallow water scorpionfish (Scorpaenidae: *Scorpaena*) from the central coast of Western Australia. *Copeia* 2006:360–369
- Motomura H, Sakurai Y, Senou H, Ho H-C (2009) Morphological comparisons of the Indo-West Pacific scorpionfish, *Parascorpaena aurita*, with a closely related species, *P. picta*, with first records of *P. aurita* from East Asia (Scorpaeniformes: Scorpaenidae). *Zootaxa* 2191:41–57
- Motomura H, Béarez P, Causse R (2011) Review of Indo-Pacific specimens of the subfamily Scorpaeninae (Scorpaenidae), deposited in the Muséum national d'Histoire naturelle, Paris, with description of a new species of *Neomerinthe*. *Cybium* 35:55–73
- Ogilby JD (1889) Notes on some fishes new to the Australian fauna. *Proc General Meetings Sci Business Zool Soc London* 1889:151–158
- Ogilby JD (1893) Edible fishes and crustaceans of New South Wales. C. Potter, Government Printer, Sydney
- Paulin CD (1982) Scorpionfishes of New Zealand (Pisces: Scorpaenidae). *New Zealand J Zool* 9:437–450
- Paulin CD (2004) New Zealand scorpionfishes (genus *Scorpaena*). *Seafood* 12:61–63
- Paulin C, Stewart A, Roberts C, McMillan P (2001) New Zealand fish. A complete guide. Museum of New Zealand Te Papa Tongarewa, Wellington
- Poss GS (1999) Scorpaenidae. Scorpionfishes (also, lionfishes, rockfishes, stingfishes, stonefishes, and waspfishes). In: Carpenter KE, Niem VH (eds) FAO species identification guide for fishery purposes. The living marine resources of the western central Pacific. Vol. 4. Bony fishes part 2 (Mugilidae to Carangidae). FAO, Rome, pp 2291–2352
- Randall JE, Eschmeyer WN (2002) Revision of the Indo-Pacific scorpionfish genus *Scorpaenopsis*, with descriptions of eight new species. *Indo-Pacif Fish* 34:1–79
- Richardson J (1842) Contributions to the ichthyology of Australia. *Ann Mag Nat Hist (New Ser)* 9:207–218
- Roberts CD, Paulin CD, Stewart AL, McPhee RP, McDowall RM (2009) Checklist of New Zealand Chordata. Living lancelets, jawless fishes, cartilaginous, and bony fishes. In: Gordon GP (ed) New Zealand inventory of biodiversity. Canterbury University Press, Christchurch
- Stead DG (1908) The edible fishes of New South Wales: their present importance and their potentialities. Government of the State of New South Wales, Sydney
- Steindachner F (1866a) Über die Fische von Port Jackson in Australien. *Anzeiger K Akad Wiss Math-Naturwiss Cl* 3:50–54
- Steindachner F (1866b) Zur Fischfauna von Port Jackson in Australien. *Sitzungsberichte K Akad Wiss Math-Naturwiss Cl* 53:424–481
- Stewart J, Hughes JM (2010) Life-history traits of the southern hemisphere eastern red scorpionfish, *Scorpaena cardinalis* (Scorpaenidae: Scorpaeninae). *Mar Freshwater Res* 61:1290–1297
- Waite ER (1904) Catalogue of the fishes of Lord Howe Island. *Rec Aust Mus* 5:187–230
- Whitehead PJP (1969) Forty drawings made by the artists who accompanied Captain James Cook on his three voyages to the Pacific, 1768–71, 1772–75, 1776–80, some being used by authors in the description of new species. British Museum (Natural History), London
- Whitley GP (1931) New names for Australian fishes. *Aust Zoologist* 6:310–334
- Whitley GP (1964) Presidential address. A survey of Australian Ichthyology. *Proc Linn Soc NSW* 89:11–127
- Whitley GP (1968) A check-list of the fishes recorded from the New Zealand region. *Aust Zoologist* 15:1–102
- Yearsley GK, Last PR, Ward RD (1999) Australian seafood handbook. An identification guide to domestic species. CSIRO Marine Research, Hobart
- Yearsley GK, Last PR, Hoese DF (2006) Standard names of Australian fishes. CSIRO Mar Atmospheric Res Pap 9:1–65