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A NEW SPECIES OF THE SURF-INHABITING ATHERINIFORM *ISO* (PISCES: ISONIDAE)

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ABSTRACT

Specimens of an atheriniform fish collected in the American Samoa and Pitcairn Island are described as a new species of *Iso*. On external morphology, it is distinct from all other members of the genus except for *Iso hawaiiensis*, with which it shares gill raker, midlateral and vertebral counts. Using a novel procedure to study small bones with a scanning electron microscope, *Iso nesiotes* is shown to be unique in having a short coracoid, long dorsal processes of the urohyal, and the third orbital possessing a lateral shelf. From its closest relative, *Iso hawaiiensis*, the new species can be distinguished by absence of the intercalar, structure of the pectoral girdle and the shapes of the opercle and haemal spines. Externally, the new species is recognised by the absence of an oval spot on the caudal peduncle. The two populations of *Iso nesiotes* show minor differences in the position of anus and in fin ray, gill raker and scale counts. A key to the species of *Iso* is also given.

INTRODUCTION

Members of the family Isonidae are difficult to catch because of their preferred habitat, the surf. They are therefore not well known and have no common name. Ogilby (1895) referred to them as surf fishes whilst Jordan and Starks (1901) used translations of Japanese: "shore sardines" or alternatively, "flowers of the wave". Since isonids are not sardines, "flowers of the wave" seems to be a more apt description of silvery fish buffeted by the surf.

In the various studies of the group, nomenclatorial and some systematic problems were more or less resolved over the years: *Iso* Jordan and Starks, 1901 replaced the preoccupied name *Tropidostethus* Ogilby, 1895 (Waite 1904). Schultz, in 1948, placed "flowers of the wave" into a subfamily of their own but created confusion by erecting Tropidostethinae, (see Schultz 1948, 1950; Ivantsoff 1984, 1986). Rosen (1964) finally erected Isonidae but based his description on the second genus of the family, *Notocheirus hubbsi* Clark, 1937. On the basis of Said's (1987) more recent studies, it is now clear that the family Isonidae is monogeneric. *Notocheirus hubbsi* which was variously placed together with *Iso* in Notocheirinae, Notocheiridae or Isonidae, warrants a family of its own, Notocheiridae, which is monotypic. Notocheiridae and Isonidae are regarded as sister groups but are distinct from one another on the basis of absence of first dorsal fin, presence of appendages on body scales, pelvic bones with ventral process in Notocheiridae, versus presence of first dorsal fin, lack of appendages on body scales and with no ventral process on pelvics in Isonidae. In addition, other autapomorphic characters distinguish the families (Said 1987).

Isonids have been reviewed on a number of occasions (Herre 1944; Gosline 1952) but the last major study by Said (1983) is still awaiting publication. Said recognised only five nominal species including the one described herein. He considered *Iso flosindicus* Herre (1944) to be indistinct from *I. natalensis* Regan (1919) which has priority.

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MATERIALS AND METHODS

Morphometrics and meristics

Methods of measuring and counting used by previous workers (Herre 1944; Gosline 1952) on the genus *Iso* are used in this study. Standard length (SL) is taken from most anterior tip of mouth to midbase of caudal fin (end of hypural plates). Head length is measured from tip of snout to posterior edge of opercle. Body depth is vertical measurement at origin of pectoral fin. Width of midlateral silvery band is measured along vertical line through origin of anal fin. Length of caudal peduncle is taken from rear of origin of last anal fin ray to end of hypural plates. Caudal peduncle depth is least depth of caudal peduncle near end of lateral band. Eye measurement is the horizontal diameter of orbit. Distance between dorsals is the measurement between origin of two dorsal fins. Snout length is taken from anterior tip of mouth to anterior border of orbit. Anal-anus is the measurement between posterior end of anus and origin of anal fin. Midlateral scales are counted from dorsal origin of pectoral fin to hypural joint. Gill raker count includes all rudiments in the first lower gill arch and rakers in the angle of the arch.

Osteology

Osteological descriptions are those used by Patterson (1964) and Rosen (1964). Specimens were cleared and stained following Taylor (1967). The specimens were then stored in 100% glycerol. The bones were either drawn with the aid of a camera lucida attachment to a dissecting microscope or subjected to further preparation for scanning electron microscopy as described below. Although a similar technique has been used for eggs and larvae (Boehlert 1983) as well as scale preparation and analysis (Hughes 1980) the technique for preparation of small fish bones for minute examination has not, to our knowledge, been described in literature. The technique used is therefore presented below.

The neurocranium and other delicate bones of fresh, stained or preserved specimens can be best observed and studied under the scanning electron microscope (SEM) (Figure 3A-C).

1. If the specimen has been previously cleared and stained, the glycerol is removed by washing in 50% ethanol.
2. The specimen is placed in 1-2% cold solution of sodium hypochlorite (bleaching agent) and examined under a dissecting microscope. Epithelial tissues will dissolve rapidly whilst the ligaments and muscles will persist. A small soft haired paint brush should be used to move away the remaining tissues which can then be picked up by fine forceps. Breaking the skin of the specimen before immersion will reduce the maceration and bleaching time which is important to prevent disarticulation.
3. The specimen is returned to 50% ethanol to arrest the action of the bleaching agent.
4. The specimen is dehydrated by immersion in ever increasing concentration of ethanol (10% increase at each step for 30 minutes) to 100% solution.
5. To avoid damage due to surface tension, the specimen is then dried using the critical point drying method in a Sorvall Critical Point Drying System where the dehydrated specimen is treated with liquid CO_2, taken to a temperature of 31°C and pressure of about 7580kp.
6. The specimen is mounted and attached to an aluminium stub with silver tape treated with an adhesive on both sides. This provides a smooth conductive background and allows the specimen to adhere to the stub.
7. The specimens are coated with thin layer of gold (about 8nm in 8 seconds) in a polatron spatter coater.

The specimen is then ready for examination under a Robinson back-scatter detector in a Scanning Electron Microscope. Mounted specimens should be stored in a cool, dry place for subsequent use.

The material examined has been deposited in the following institutions: The Australian Museum, Sydney (AMS); British Museum (Natural History), London (BMNH); Bernice P. Bishop Museum, Honolulu (BPBM); California Academy of Sciences, San Francisco (CAS); United States National Museum, Washington (USNM).

KEY TO THE SPECIES OF THE GENUS *ISO*

Said's (1983) revision of the genus includes a description of new species and synonymy of another. A new key to the species of *Iso* is therefore presented in this study. The species are best identified on the basis of their osteology but for field identification, external characters are easier to use. A detailed osteological key will be published in a complete revision of both families, Isonidae and Notocheiridae.

1. Midlateral band discontinuous at caudal peduncle with silvery oval spot present near caudal fin base 2

   Midlateral band continuous; no silvery oval spot present near caudal fin base (Figure 1) 3

2. Teeth on external surface of premaxilla clearly visible; palatine teeth usually present. Midlateral scale count 41-66 ..... *I. natalensis*

   No teeth on external surface of premaxilla. Palatine teeth also absent. Midlateral scales 34-55 4

3. Midlateral band extending halfway along caudal peduncle; midlateral scales 35-41 ..... *I. nesiotes*

   Midlateral band extending to hypural joint; midlateral scales 50-63 ..... *I. flosmaris*

4. Midlateral scales 34-39. Teeth extending more than half way along free edge of premaxilla ..... *I. hawaiiensis*

   Midlateral scales 42-55. Teeth restricted to first quarter along free edge of premaxilla in Taiwanese and Japanese populations (c.f. Figure 2A); as for *I. hawaiiensis* in Australian populations ..... *I. rhothophilus*

SYSTEMATICS

Family Isonidae Rosen, 1964
Genus *Iso* Jordan and Starks, 1901
Iso nesiotes sp. nov.

Figures 1-3

Iso sp. Wass 1984: 9.

Holotype

AMS I.24183-001, 25.5 mm SL, Fagasa, Tutuila Island, American Samoa, 14°10'S 169°38'E, collected by R.C. Wass, June 6, 1980.

Paratypes

33 specimens, AMS I.24182-001, (15), 19.2-26.6 mm SL, (including 5 stained specimens); BMNH 1983.10.20.1-2, (2), 23.7-25.1 mm SL; BPBM 29308, (1), 24.6 mm SL; CAS 52304, (3), 25.6-26.1 mm SL; USNM 263125, (3), 23.1-25.3 mm SL. Data as for the holotype. BPBM 16718,(9), West Harbour, Pitcairn Island, 25°04'S 130°06'W, 17.8-25.6 mm SL.

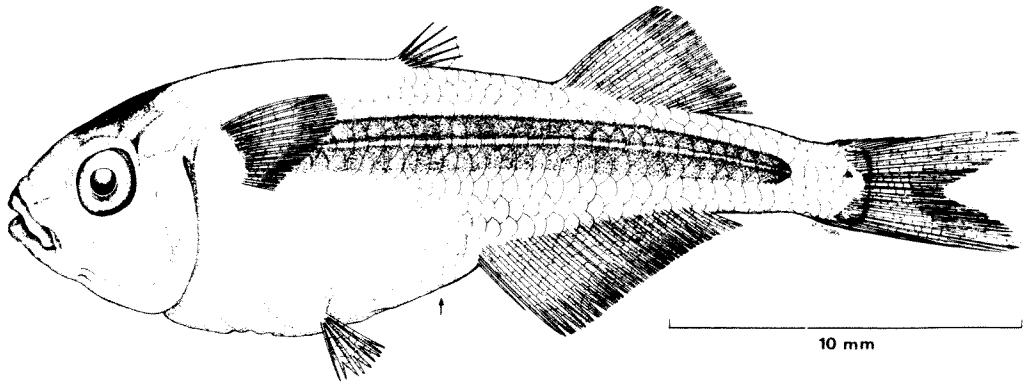


Figure 1 *Iso nesiotes*, paratype AMS I.24182-001, 24.4 mm SL. Arrow indicates position of anus. Second dorsal, ventral, pectoral and anal fin rays are preceded by a weak spine.

One of the nine Pitcairn specimens was specially processed for the osteological study in addition to the paratype AMS I.24182-001. All comparative work was done on the material used by Said (1983).

Diagnosis

Iso nesiotes can be distinguished from all other species of the genus by the following: no oval spot near caudal-fin base (Figure 1); third infraorbital with lateral shelf (Figure 2B). posterior dorsal processes of urohyal very long and extending vertically (Figure 2C a); coracoid very short (Figure 2D a). Intercalar absent in *I. nesiotes* (Figure 3A) but present in *I. hawaiiensis* Gosline, 1952 (Figure 3B). In other species, intercalar absent but with pterotic extending laterally in that region to lie over exoccipital (Figure 3C).

Description

All measurements and counts taken from the holotype, paratypes and specimens by locality are presented in Table 1. Measurements descriptive of the species throughout its known range are presented below.

Morphometrics (expressed as means and ranges)

Head 4.5 (4.1-5.0); greatest body depth 3.4 (2.7-4.1); width of lateral silvery band 15.3 (13.8-17.8); caudal peduncle length 5.6 (4.7-7.3); least depth of caudal peduncle 14.1 (12.5-16.2), all in SL; eye in head 2.6 (2.4-3.0); snout in eye 1.3 (1.0-1.6).

Meristics

Midlateral scales 38.2 (35-41); first dorsal fin 5.0(4-6), second dorsal fin rays 13.9 (12-16); anal fin rays 21.4 (19-24); pectoral fin rays 12.2 (11-13). Rays in last 3 fins preceded by one spine and one unbranched ray. Gill rakers in first lower gill arch 9.7 (9-12). Vertebrae 37.4 (36-39).

External morphology

Body highly compressed, head small, snout rounded. Mouth very oblique to horizontal, upper jaw not protractile; lower jaw deeply elevated posteriorly. Teeth on jaws small, curving backwards into mouth. Gill rakers well developed and moderately long, equal to one diameter of pupil. Gill

Table 1 Measurements and counts for the holotype and paratypes of *Isonesiotes*. Also a comparison of populations from American Samoa and Pitcairn Island expressed as means, ranges and standard deviation. Abbreviations: N, number of specimens; D1, first dorsal fin; D2, second dorsal fin.

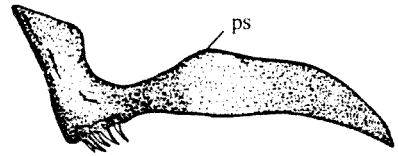
Character	Holotype	Paratypes American Samoa N=25		Paratypes Pitcairn Island N=9		Paratypes Total sample N=35	
Morphometric values							
In SL							
Head	4.5	4.5(4.1-5.0)	0.25	4.4(4.3-4.9)	0.20	4.5(4.1-5.0)	0.23
Body depth	3.0	3.3(2.7-3.8)	0.30	3.6(3.0-4.1)	0.37	3.4(2.7-4.1)	0.31
Width silvery band	14.6	14.9(13.8-16.3)	0.67	16.5(15.0-17.8)	0.96	15.3(13.8-17.8)	0.74
Caudal peduncle Length	5.9	5.5(5.0-6.1)	0.35	5.8(4.7-7.3)	0.77	5.6(4.7-7.3)	0.46
Caudal peduncle Depth	13.4	13.9(12.5-14.9)	0.70	14.7(13.9-16.2)	0.72	14.1(12.5-16.2)	0.71
In Head							
Eye	2.5	2.6(2.5-2.8)	0.10	2.7(2.4-3.0)	0.22	2.6(2.4-3.0)	0.13
Interorbital	2.5	2.7(2.4-3.0)	0.18	3.0(2.6-3.3)	0.22	2.8(2.4-3.3)	0.19
D1-D2	1.2	1.3(1.0-1.6)	0.15	1.4(1.2-1.7)	0.14	1.3(1.0-1.7)	0.15
In Eye							
Snout length	1.3	1.3(1.0-1.6)	0.13	1.4(1.3-1.6)	0.10	1.3(1.0-1.6)	0.12
Anal-anus	1.1	1.2(0.8-1.6)	0.21	1.7(0.8-3.1)	0.78	1.3(0.8-3.1)	0.36
Meristic values							
Pectoral fin rays*	13	12.1(11-13)	0.53	12.3(11-13)	0.71	12.2(11-13)	0.57
D1 fin spines	6	5.1(4-6)	0.40	4.8(4-5)	0.44	5.0(4-6)	0.41
D2 fin rays*	14	14.0(12-16)	1.02	13.8(13-14)	0.44	13.9(12-16)	0.87
Anal fin rays*	23	21.4(19-24)	1.15	21.4(20-22)	0.73	21.4(19-24)	1.03
Gill rakers	9	9.3(9-10)	0.48	10.8(10-12)	0.78	9.7(9-12)	0.90
Midlateral scales	41	38.4(35-41)	2.00	37.8(35-39)	1.28	38.2(35-41)	1.81
Vertebrae	38	37.3(36-39)	0.85	37.9(37-39)	0.26	37.4(36-39)	0.87

* Spines of the fins excluded from the count

slit behind last gill arch present. Anus close to origin of anal fin. First dorsal fin originating about middle of body, its small weak spines of about equal length. Second dorsal fin originating behind vertical through anal origin; both second dorsal and anal fins high anteriorly but tapering downwards posteriorly. Pectoral short and inserted high on body. Scales cycloid and small. Sides of head and anterior part of abdomen naked. Scaled part of body (Figure 1) originating at dorsal origin of pectoral and extending upwards and backwards to first dorsal origin and rest of body. Midlateral band wide, silvery in live fish, extending from base of pectoral and terminating midway along caudal peduncle.

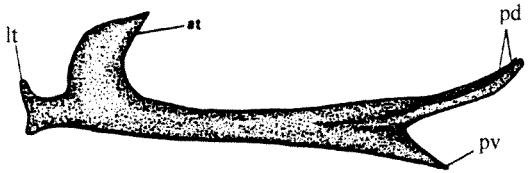
Osteology

Premaxilla with one postmaxillary process; teeth restricted to first anterior fifth of free edge of premaxilla (Figure 2A). Third infraorbital with lateral shelf; dermosphenoid rounded (Figure 2B). Urohyal with short posterior ventral process and with very long posterior dorsal processes extending vertically (Figure 2C a). Cleithrum reaching scapular foramen; cleithrum process absent (Figure 2D a). Opercular notch on dorsal edge present (Figure 2E a). Intercalar absent (Figure 3A); pterotic projection on exoccipital absent (Figure 3A). Parietals small, not forming part of posttemporal fossa. Pelvic girdle with anterior lateral process longer than posterior ventral process. Pleural ribs 9-11. Middle vertebrae with very long posterior ventral zygapophyses.

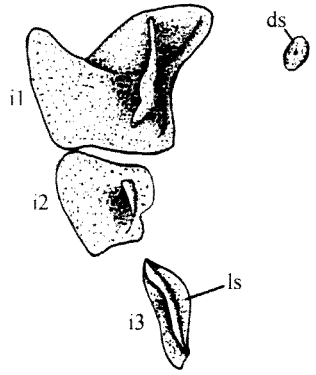


2A

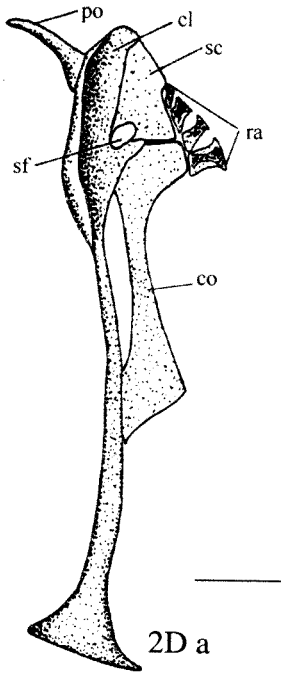
2C a



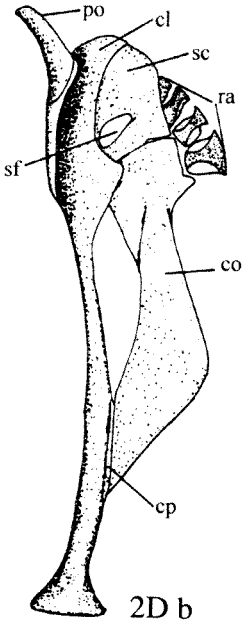
2C b



2B



2D a



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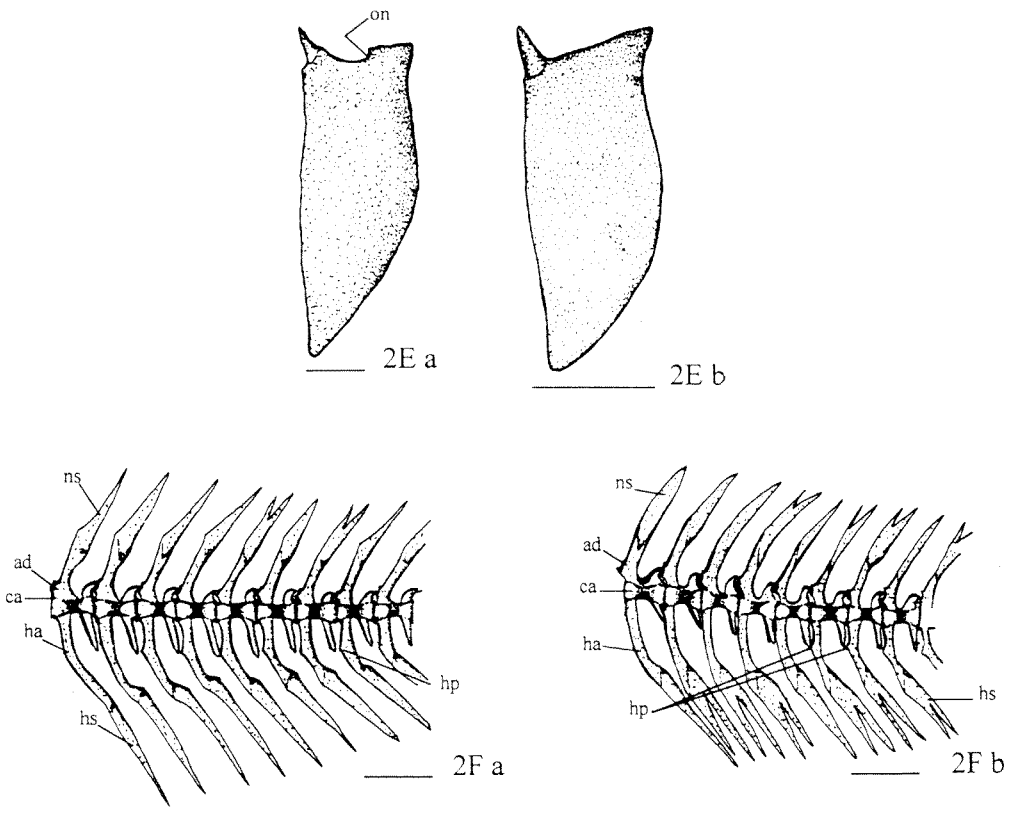

Figure 2 *Iso nesiotes*, American Samoa, AMS I.24182-001, 26.6 mm SL, cleared and stained specimen. Scale 1 mm.

A. Premaxilla
B. Left infraorbitals
C. a. Urohyal b. Urohyal of *I. hawaiiensis* for comparison
D. a. Pectoral girdle b. Pectoral girdle of *I. hawaiiensis* for comparison
E. a. Opercle b. Opercle of *I. hawaiiensis* for comparison
F. a. Haemal elements. b. Haemal elements of *I. hawaiiensis* for comparison

Abbreviations

ad	anterior dorsal zygapophysis	hp	haemal arch process	pd	posterior dorsal process of urohyal
at	antero-dorsal process of urohyal	hs	haemal spine	po	posttemporal
ca	first caudal vertebra	il-i3	infraorbitals 1-3	ps	postmaxillary process of premaxilla
cl	cleithrum	lt	process of ligament to hypohyal	pv	posterior ventral process of urohyal
co	coracoid	ls	lateral shelf of third infraorbital	ra	proximal radials
cp	cleithrum process	ns	neural spine	sc	scapular
ds	dermosphenoid	on	opercular notch	sf	scapular foramen
ha	haemal arch				

Colour

Preserved specimens from type locality whitish, with silvery midlateral band. Pitcairn specimens uniformly brown with darker brown midlateral band.

Variability

A number of minor variations were observed (Table 1) between the populations from American Samoa and Pitcairn Island. The Samoan population exhibits a wider range in the number of second dorsal rays, anal rays and midlateral scales. The mean for the width of the silvery midlateral band in the Pitcairn Island population is higher. The range of variation for the position of anus in relationship to the origin of anal is greater in the Pitcairn Island specimens. In the Samoan fish, the gill raker count and the ratios of anus to anal fin in eye, and least depth of caudal peduncle

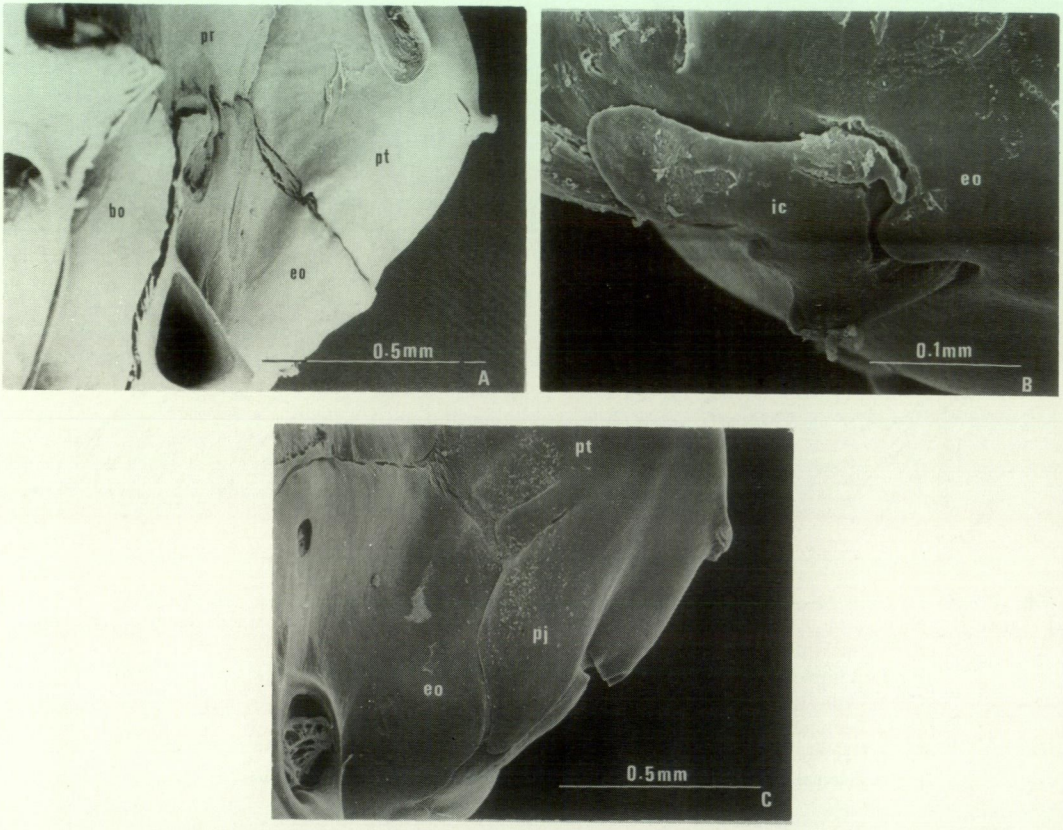

Figure 3 Scanning electron micrographs showing posteroventral views of skulls of **A**, *Iso nesiotes*, AMS I.24183-001 paratype, 25 mm SL, American Samoa. **B**, *I. hawaiiensis*, BPBM 10012, 28 mm SL, Hawaiian Islands. **C**, *I. flosmaris*, SOSC VGS-68-30*, 52 mm SL, Taiwan.

Abbreviations

bo	basioccipital	ic	intercalar	pr	prootic
eo	exoccipital	pj	pterotic projection	pt	pterotic

* Smithsonian Oceanographic Sorting Center, Washington D.C., field registration number.

Table 2 Comparison of measurements and counts of five species of *Iso* (from Said 1983). Data presented as in Table 1.

Character	*I. rhothophilus*[1] N=83	*I. natalensis*[2] N=121	*I. flosmaris*[3] N=53	*I. hawaiiensis*[4] N=15	*I. nesiotes*[5] N=35
Body depth/SL	3.9(3.1-5.1) 0.43	4.1(3.3-5.1) 0.43	4.5(3.4-5.4) 0.38	3.9(3.3-4.6) 0.45	3.4(2.7-4.1) 0.36
Gill rakers	11.3(9-14) 1.04	11.2(10-14) 0.97	13.6(12-15) 0.87	10.4(9-12) 0.86	9.7(9-12) 0.90
Midlateral scales	48.8(42-55) 2.87	50.9(41-66) 6.15	57.6(50-63) 3.49	37.4(34-39) 1.20	38.2(35-41) 1.88
Vertebrae	41.6(38-45) 1.68	40.3(38-42) 0.87	43.2(41-45) 0.93	38.6(37-40) 0.85	37.4(36-39) 0.87

[1] East and west coasts of Australia, Japan and Taiwan.
[2] South Africa, Seychelles and India.
[3] Japan and Taiwan.
[4] Hawaii, Rapa and Marshall Islands.
[5] American Samoa and Pitcairn Island.

in SL, are lower. These differences are not regarded as sufficient to separate these populations into two species especially since the sample size from Pitcairn Island is too small to be representative.

Distribution

I. nesiotes is presently known only from American Samoa and Pitcairn Island. It is probable this species may have a much wider range than presently indicated. Like all other isonids, it lives in the surf near the shore, frequently close to rocky outcrops. Because of the nature of this habitat, isonids are difficult to collect.

Etymology

The name *nesiotes* is a Greek noun or its derivative, meaning insular. The species presently is only known from two islands in the Pacific.

Relationship to other species

Meristic analysis suggests that *I. nesiotes* (Table 2) is most closely related to *I. hawaiiensis* on the basis of the midlateral scale and vertebral counts. With the exception of *I. flosmaris*, however, the counts almost overlap, suggesting a close relationship amongst all *Iso* species. Osteologically, *Iso* species are distinct but their phylogeny is difficult to establish. Of the 45 osteological characters examined, *I. nesiotes* shares 25 with *I. hawaiiensis* but of these, only one (pterotic projection on exoccipital absent) advanced character is uniquely shared between these species. In *I. hawaiiensis*, the presence of intercalars is unique. *I. nesiotes* is unique in possessing: (1) long posterior dorsal process on the urohyals (Figure 2C a,b) (2) short coracoid (long in all other species, Figure 2D a,b) (3) third infraorbital with a lateral shelf which is absent in all other species (4) continuous lateral stripe which does not reach the caudal peduncle. The presence of the opercular notch (Figure 2E a,b) in *I. nesiotes* distinguishes it from *I. hawaiiensis*, *I. flosmaris* and most populations of *I. natalensis* but not from *I. rhothophilus*. The haemal spines are always double in *I. hawaiiensis* (Figure 2F a,b), double or single in *I. rhothophilus*, *I. flosmaris* and single in *I. nesiotes* and *I. natalensis*. *I. nesiotes* can therefore be clearly distinguished from all other species of *Iso* on the basis of its unique characters and by the combination of other osteological characters examined (Said 1983). A complete revision of the genus by the two senior authors is now in progress. This study will provide details on distribution, variability and an additional analysis of systematic relationships of all *Iso* species.

ACKNOWLEDGEMENTS

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