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Hemitriakis falcata n.sp. and *H. abdita* n.sp., Two New Houndsharks (Carcharhiniformes: Triakidae) from Australia

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ABSTRACT. Two new species of the genus *Hemitriakis* Herre, 1923 (Carcharhiniformes: Triakidae) are described from tropical Australia. *Hemitriakis falcata* is described from ten specimens from the outer continental shelf of Western Australia at depths of 146 to 197 m. *Hemitriakis abdita* is described from five specimens from the Coral Sea Plateau off north-eastern Queensland at 225 to 401 m. *Hemitriakis falcata* and *H. abdita* are separable from their two named congeners *H. leucoperiptera*, from the Philippine Islands, and *H. japanica*, from Japan, Taiwan, China and Korea, by a combination of vertebral counts, first dorsal position, fin and eye shape, and juvenile colouration. *Hemitriakis falcata* additionally differs from *H. japanica* in chondrocranial morphology. *Hemitriakis falcata* and *H. abdita* are sibling species separated by wide, non-overlapping differences in vertebral counts as well as by slight differences in morphometrics, tooth counts, colouration, and cranial morphology. These species represent the first record of *Hemitriakis* from Australia. A nominal record of *H. japanica* from Ambon is uncertain while another record of *H. japanica* from New Caledonia may be based on *H. abdita*. A key to species of *Hemitriakis* is presented.

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Recent trawl collections on the outer continental shelves and upper slopes of Australia have yielded numerous sharks and other chondrichthians (Gloerfelt-Tarp & Kailola, 1984; Davis & Ward, 1984; Sainsbury *et al.*, 1985; Gorman & Graham, 1985; Williams, 1987). Included in this material are specimens of houndsharks (Carcharhiniformes: Triakidae) that represent the first Australian records of the genus *Hemitriakis* Herre, 1923 as defined by Compagno (1970).

Compagno (1984) noted an undescribed species of *Hemitriakis* from Western Australia while Compagno (1988) cited two specimens of this species (WAM P26271-001 and WAM P26724-007) and deferred their description to the present paper. While preparing the description of this species we discovered that additional specimens of *Hemitriakis* deposited in the CSIRO

collections fell into two non-overlapping groups on vertebral counts, with an average difference of 27 centra in total counts between the groups. The higher vertebral count group is represented by five specimens from the upper slope on the Coral Sea Plateau off north-eastern Queensland while the lower count group includes eight specimens from Western Australia along with the material cited by Compagno (1988). As the two groups included individuals of both sexes that are very similar in morphology and are clearly separable from the western North Pacific *H. japanica* (Müller & Henle, 1839) and *H. leucoperiptera* Herre, 1923, they are regarded as a pair of undescribed sibling species.

Terminology and Abbreviations

The terminology for external structures, chondrocrania, vertebrae and dentition follows Compagno (1970, 1988). The abbreviations for tooth row groups include: AL – anterolaterals; AP – anteroposteriors; M – medials; P – posteriors. For tooth counts (Table 3 [Appendix]), the abbreviations include: TT – total number of tooth rows in both jaws; UT – number of upper tooth rows; LT – number of lower tooth rows. For vertebrae, the abbreviations include: MP – monospondylous precaudal centra; DP – diplospondylous precaudal central; DC – diplospondylous caudal centra; TC – total vertebral counts (MP + DP + DC counts). An additional abbreviation is: PC – precaudal (MP + DP) vertebral counts.

The abbreviations and methods of measuring follow the FAO system of Compagno (1984), except that the measurement MOL (mouth length) was incorrectly shown in the diagram (Compagno, 1984: 12) as extending from the lower symphysis to the mouth corners; it should be from the *upper* symphysis to the mouth corners. Also, TL is used for total length and PCL for precaudal length (following general usage in ichthyology) instead of TOT and PRC. The abbreviations for measurements in this account include: TL (TOT) – total length; PCL (PRC) – precaudal length; PRN – prenarial length; POR – preoral length; POB – preorbital length; PSP – prespiracle length; PGI – pregill (prebranchial) length; HDL – head length; PP1 – prepectoral length; PP2 – prepelvic length; SVL – snout-vent length; PAL – preanal length; PD1 – pre-first dorsal length; PD2 – pre-second dorsal length; IDS – interdorsal space; DCS – dorso-caudal space; PPS – pectoral-pelvic space; PAS – preanal space; ACS – anal-caudal space; EYL – eye length; EYH – eye height; INO – interorbital width; NOW – nostril width; INW – internarial width; ANF – anterior nasal flap length; SPL – spiracle length; ESL – eye-spiracle length; MOL – mouth length; MOW – mouth width; ULA – upper labial furrow length; LLA – lower labial furrow length; GS1 – first gill opening height; GS2 – second gill opening height; GS3 – third gill opening height; GS4 – fourth gill opening height; GS5 – fifth gill opening height; HDH – head height; HDW – head width; TRH – trunk height; TRW – trunk width; CPH – caudal peduncle height; CPW – caudal peduncle width; GIR – girth; P1L – pectoral length; P1A – pectoral anterior margin; P1B – pectoral base; P1H – pectoral height; P1I – pectoral inner margin; P1P – pectoral posterior margin; P2L – pelvic length; P2A – pelvic anterior margin; P2B – pelvic base; P2H – pelvic height; P2I – pelvic inner margin; P2P – pelvic posterior margin; CLO – clasper outer length; CLI – clasper inner length; CLB – clasper base width; D1L – first dorsal length; D1A – first dorsal anterior margin; D1B – first dorsal base; D1H – first dorsal height; D1I – first dorsal inner margin; D1P – first dorsal posterior margin; D2L – second dorsal length; D2A – second dorsal anterior margin; D2B – second dorsal base; D2H – second dorsal height; D2I – second dorsal inner margin; D2P – second dorsal posterior margin; ANL – anal length; ANA – anal anterior margin; ANB – anal base; ANH – anal height; ANI – anal inner margin; ANP – anal posterior margin; CDM – dorsal caudal margin; CPV – preventral caudal margin; CPL – lower postventral caudal margin; CPU – upper postventral caudal margin; CST – subterminal caudal margin; CTR – terminal caudal margin; CTL – terminal caudal lobe; DPI – first dorsal midbase-pectoral insertion; DPO – first dorsal midbase-pelvic origin; PDI – pelvic midbase-first dorsal insertion; PDO – pelvic midbase-first dorsal origin; DAO – second dorsal-anal origin; DAI – second dorsal-anal insertion; FOR – fork length (snout tip to caudal fork).

NBL is the abbreviation for nasobasal length, the distance from the base of the medial rostral cartilage to the occipital centrum of the chondrocranium. WT is the abbreviation for weight in g. Abbreviations for sex and maturity are after Compagno (1988) and include: SEX/M – sex and maturity stages: F – female; M – male; 1 – fetus; 2 – immature; 3 – adolescent; 4 – adult. Abbreviations for statistics include: CV – coefficient of variation; N – number of specimens; SD – standard deviation; SE – standard error.

Abbreviations and prefixes for field, accession, and catalog numbers follow Leviton *et al.* (1986) and Compagno (1988) in part: CAS – CAS-Acc., California Academy of Sciences, San Francisco; CSIRO CA and H – CSIRO Marine Laboratories, Hobart, Tasmania; LACM-F – Los Angeles County Museum of Natural History, uncatalogued Applegate specimens; LJVC – L.J.V. Compagno collection; SO – CSIRO RV *Soela* station number; SU – Stanford University fish collection, now housed at CAS; UMMZ – University of Michigan Museum of Zoology, Ann Arbor; USNM – United States National Museum of Natural History, Washington, D.C.; WAM – Western Australian Museum, Perth.

All tables are listed in the Appendix.

Triakidae Gray, 1851

Comments. For definitions of this family see Compagno (1973a, 1973b, 1979, 1984, 1988).

Hemitriakis Herre, 1923

Hemitriakis Herre, 1923: 70. Type species *Hemitriakis leucoperiptera* Herre, 1923, by original designation.

Comments. For detailed definitions and discussions of the scope of this genus see Compagno (1970, 1979, 1984, 1988). *Hemitriakis* was proposed by Herre (1923) as a monotypic genus for *H. leucoperiptera* Herre, 1923, from the Philippine Islands. *Hemitriakis leucoperiptera* was included in *Triakis* Müller & Henle, 1838 by Fowler (1941), Bigelow & Schroeder (1948), Garrick (1954), Kato (1968), Springer (1968), and Pinchuk (1972), but was revived by Compagno (1970) for Herre's species and *Galeus japanicus* Müller & Henle, 1839. *Hemitriakis japanica*, from off China, Korea, Taiwan and Japan, had been placed in the genus *Galeorhinus* or its synonyms by previous writers. The genus *Hemitriakis* was recognised by Compagno (1973a, 1973b, 1979, 1984, 1988), Steuben & Krefft (1978, 1989), Cadenat & Blache (1981), and Masuda *et al.* (1984).

There is probably a second species of *Hemitriakis* in Philippine waters, differing from *H. leucoperiptera* in colouration and fin proportions (Compagno, 1970, 1979, 1988: fig.17.11C) and also vertebral counts (see discussion below). The smaller paratypes of *Hemitriakis falcata* n.sp. and *H. abdita* n.sp. have a similar spotted colour pattern to this species (Fig.2), except that their dark spots and saddles lack light centres.

Fowler (1941) cited a record of *Hemitriakis japanica* from Ambon, while Fourmanoir & Rancurel (1972) reported *H. japanica* from New Caledonia. We have not been able to verify the Ambon record, but a large New Caledonian *Hemitriakis* was deposited by P. Fourmanoir in the Museum National d'Histoire Naturelle, Paris, as *Galeorhinus japanicus*. We have examined photographs, measurements and radiographs of this specimen that were prepared for us through the kind agency of Drs B. Seret and M.-L. Bauchot. This specimen has a much higher vertebral count than all other *Hemitriakis* except *H. abdita* and may represent another undescribed species of *Hemitriakis* (see discussion below) or possibly may be an adult of *H. abdita*.

Comparative Material

Hemitraikis japanica. JAPAN: LACM F-420, 350 mm immature male; LACM F-421, 582 mm immature female; SU 12677, 682 mm immature female, Nagasaki; UMMZ 179060, 650 mm immature male, Auraji (Osaki Market, Osaki); UMMZ 179061, 560 mm immature female, Ainoshima (Fukuoka Market, Fukuoka); UMMZ 179062, 505 mm immature male, Ezumi (Ezumi Market); LJVC-0419, 898 mm adult male; LJVC-0420, 886 mm adult male; LJVC-0421, 833 mm adolescent male (heads only); East China Sea. TAIWAN: USNM 191193, 685 mm eviscerated female, 651 mm immature male, 675 mm adult male, Taipei-hsien; CAS Acc. 1971-VII: 16, 235 mm immature female, Taiwan Straits, about 26°N 121°E; CAS Acc. 1971-VII: 22, 220 mm immature female, Taiwan Straits, 27.5°N 121°E; CAS 28576, 2 immature males, 252-307 mm, 353 mm immature female, Taiwan Straits.

Hemitriakis leucoperiptera. SU 27118, 169 mm male and 170 mm female fetuses, Dumaguete, Negros Island, Philippine Islands.

Hemitriakis sp. SU 40097, 171 mm male fetus and 3 female fetuses, 161-180 mm, Dumaguete, Negros Island, Philippine Islands.

Hemitriakis sp. near *abdita*. MNHN 1986-720, 860 mm adult male, New Caledonia.

Key to the Species of *Hemitriakis*

1. Eyes relatively low and slitlike. First dorsal origin over or behind pectoral free rear tips. Fins not strongly falcate in adults ..... *Hemitriakis japanica* (Müller & Henle, 1839)

—— Eyes relatively high and horizontally oval. First dorsal origin anterior to pectoral free rear tips. Fins strongly falcate in adults 2

2. Total vertebral counts 133-146, MP counts 34-35. Young without dark bars and spots on precaudal fins and body ..... *Hemitriakis leucoperiptera* Herre, 1923

—— Total vertebral counts 158-193, MP counts 37-53. Young with prominent dark bars and spots on precaudal fins and body 3

3. No dusky bar on the ventral surface of the snout. Total vertebral counts 158-165, MP counts 37-41, DP counts 55-60 ..... *Hemitriakis falcata* n.sp.

—— A dusky bar on the ventral surface of the snout. Total vertebral counts 186-193, MP counts 48-53, DP counts 77-78 ..... *Hemitriakis abdita* n.sp.

Hemitriakis falcata n.sp.

Sicklefin houndshark

Figs 1-5, 6A,C,E

Type material. HOLOTYPE, WAM P26271-001 (Fig.1), 770 mm adult male, RV *Courageous* stn CR-78-755, 29 June, 1978, bottom trawl, 16°54'S 120°50'E, Western Australia, outer continental shelf at 150 m depth.

PARATYPES, WAM P26274-007 (Fig.2), 258 mm immature female, RV *Courageous* 30 May 1978, 18°11'S 118°57'E, 215 km north to north-north-east off Port Hedland, WA, 160 m depth, bottom trawl; CSIRO H1094-01, SO7/87/133, 380 mm immature male, 13 Oct. 1987, 18°58'S 117°34'E, 146 m, silt bottom; CSIRO CA4056, SO1/83/23, 251 mm immature male, 25 Jan. 1983, 19°09'S 116°59'E, 180 m, silt bottom; CSIRO H1036-26, SO7/87/129, 773 mm adult male, 12 Oct. 1987, 19°06'S 117°08'E, 181 m, silt bottom, North West Shelf, WA; CSIRO H1035-17, SO6/86/84, 724 mm adult male, 24 Oct. 1986, 19°09'S 116°53'E, 197 m, shelly sand bottom, North West Shelf, WA (head and claspers dissected); CSIRO H977-01, SO6/86/109, 744 mm adult male, 28 Oct. 1986, 19°34'S 115°52'E, 147 m; CSIRO H1035-16, SO6/86/84, 740 mm adult male, 24 Oct. 1986, 19°09'S 116°53'E, 197 m, shelly sand bottom, North West Shelf, WA; CSIRO H1036-27, SO7/87/129, 760 mm adult male, 12 Oct. 1987, 19°06'S 117°08'E, 181 m, silt bottom, North West Shelf, WA; CSIRO H1035-18, SO6/86/84, 695 mm adult male, 24 Oct. 1986, 19°09'S 116°53'E, 197 m, shelly sand bottom, North West Shelf, WA.

Diagnosis. *Hemitriakis* with eyes horizontally oval. Tooth rows 55-66 in both jaws. Dorsal, pectoral and anal fins strongly falcate in adults. First dorsal-fin origin anterior of free rear tips of pectoral fin, over pectoral-fin insertions. Total vertebral counts 158-165, precaudal counts 101-109, monospondylous precaudal counts 37-41. Newborn young and subadults below 500 mm with bold to faint colour pattern of saddles and large spots on body and fins; spots with solid centers. Males fully mature at 695-773 mm TL.

Etymology. From Latin *falcata*, sickle-shaped, in reference to the highly curved fins of adults.

Description. Proportional dimensions as percentage of total length (see terminology) for type series, listed in Table 1.

Head short, length 0.8-1.1 in pectoral-pelvic space; fairly narrow, flattened, and roughly trapezodial in cross-section at eyes. Outline of head in lateral view slightly

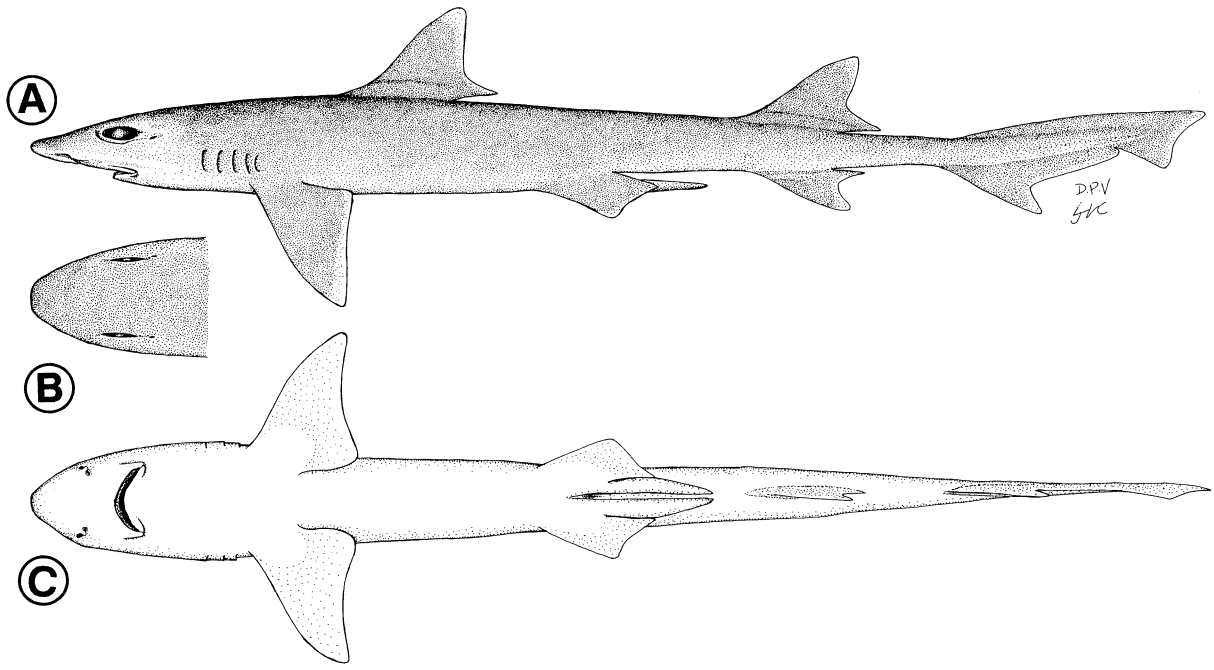

Fig.1. *Hemitriakis falcata* n.sp., holotype, WAM P26271-001, 770 mm adult male; A, lateral and C, ventral views; B, dorsal view of head. Illustration by D.P. Voorfelt and L.J.V. Compagno.

convex or nearly straight dorsally, slightly convex ventrally along lower jaws and nearly flat beneath gills; in dorsoventral view head anteriorly parabolic and posteriorly tapering along branchial region. Preoral snout long, 1.1-1.3 in mouth width. Snout tip narrowly rounded in dorsoventral view, with shallow indentations anterior to nostrils; snout bluntly pointed in lateral view, convex above and below.

External eye opening with prominent posterior notch but no anterior one; eyes large and elongate-oval in shape, eye length 4.1-6.5 in head length, eye length 1.9-3.0 times eye height. Eyes dorsolateral on head, with lower edges well medial to horizontal head rim in dorsal view, subocular ridges prominent. Nictitating lower eyelids external in young and adults, with deep but entirely scaled subocular pouches and secondary lower eyelids.

Spiracles small, length 4.6-11.5 in eye length, spiracles 0.1-0.3 eye lengths behind and below posterior eye notch. First four gill openings about equally high or first slightly lower than others; fifth shorter than third, height of fifth 0.6-0.8 of third; third 7.2-11.8 in head and 0.4-0.8 of eye length. All gill openings slightly concave, gill filaments not visible from outside. Upper ends of gill openings slightly below lower edges of eyes. Gill-raker papillae absent from gill arches.

Nostrils with large oval incurrent apertures lacking posterolateral keels, rounded anterior nasal flaps with round or bluntly pointed tips, prominent mesonarial flaps, small oval excurrent apertures, and small posterior nasal flaps. Nostrils well in front of mouth, 2.0–3.3 times farther from snout tip than from eyes. Nostril width 2.0-3.0 in internarial space, 1.8-3.0 in eye length, 0.8-1.7 in third gill opening height.

Mouth broadly arched, moderately large, short, mouth width about 0.7 of head width at mouth corners, 2.7-3.5 in head length; mouth length 2.2-2.7 in mouth width. Tongue large, flat and broadly rounded, filling floor of mouth. Maxillary valve narrow, width slightly more than five in eye diameter; valve covered with small papillae. No buccal papillae on floor of mouth and palate behind maxillary valve, this smooth and covered with buccopharyngeal denticles. Labial furrows long, upper 1.3-2.0 times lower furrows, anterior ends of uppers under first third of eye length and reaching virtually to symphysis of upper jaw. Labial cartilages large.

Teeth relatively few, in 29-35/26-33 rows (see Table 3 for detailed counts and statistics). Teeth not arranged in diagonal files, no toothless spaces at symphysis. Teeth weakly differentiated in upper and lower jaws and along jaws, with well-defined medials and weakly differentiated anterolaterals and posteriors. Tooth formulae (count ranges combined for both sides of jaw) are:

$$\frac{\text{M3-5 AL8-14 P1-5}}{\text{M3-5 AL5-10 P3-9}} \quad \text{or} \quad \frac{\text{M3-5 AP12-15}}{\text{M3-5 AP11-14}}$$

Upper anterolateral teeth higher-crowned than lowers (Fig.3), both with well-developed distal cusplets and oblique cusps, cusps somewhat higher and more erect on upper teeth than lowers; small juveniles have anterolateral teeth with blade only and no cusplets, but later juveniles, subadults and adults acquire 1-3 cusplets on successive generations of teeth (compare Fig.3B,C,E with G,H). Medial teeth smaller than anterolaterals, with more erect cusps, higher crowns, and both mesial and distal cusplets (Fig.3A). Anterolaterals gradually become lower crowned and lower-cusped along the dental band, grade into keel-like posterior teeth which are very low-crowned, lack cusps,

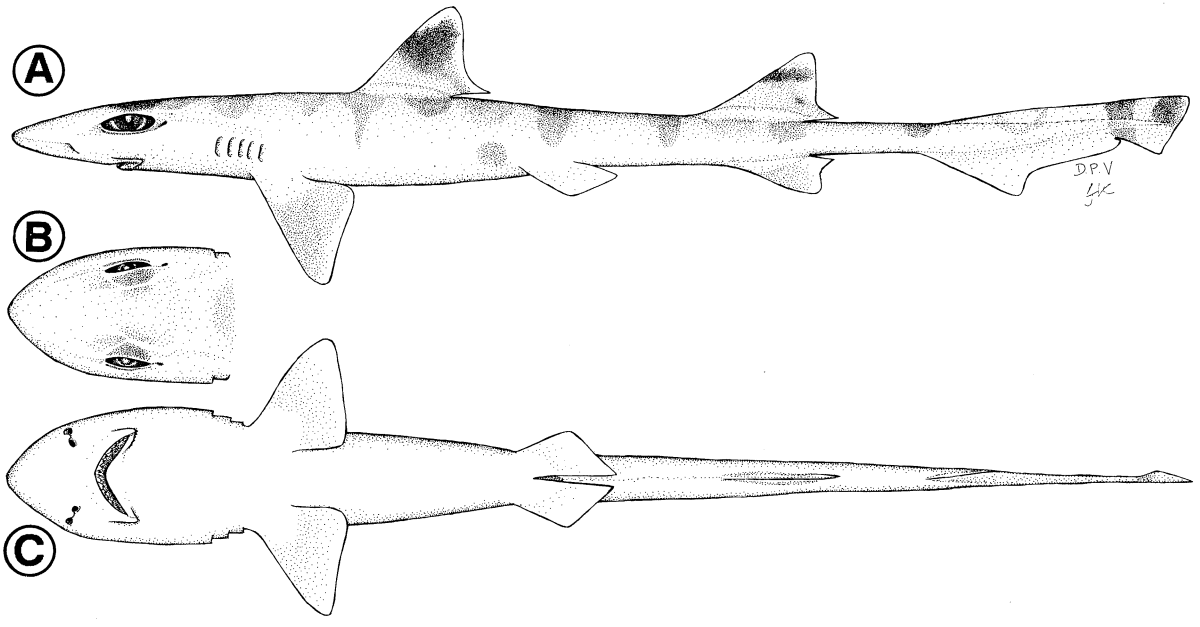

Fig.2. *Hemitriakis falcata* n.sp., paratype, WAM P26274-007, 258 mm immature female, A, lateral and C, ventral views; B, dorsal view of head. Illustration by D.P. Voorfelt and L.J.V. Compagno.

have a broad convex edge (Fig.3D). All teeth have broad basal ledges, strong basal grooves, large mesial and distal root lobes separated by broad transverse grooves and prominent centrolingual foramen on linguobasal attachment surface of roots, medial teeth with lateral foramina. Transverse ridges obsolete on teeth of specimens examined, perhaps represented by irregular notching on basal ledge. Tooth histological type orthodont as observed with transmitted light through teeth in water, with a definite pulp cavity, crown formed of orthodentine and enameloid, osteodentine confined to roots.

Body elongate, slender, trunk vertically oval to circular in section at first dorsal-fin base, length of trunk from fifth gill openings to vent 1.0-1.5 times head length. A low interdorsal ridge on midline of back between dorsal fins, and a low postdorsal ridge, but without predorsal ridges; lateral ridges absent from body. Caudal peduncle slender, cylindrical-tapering and without lateral keels, caudal peduncle height at upper caudal-fin origin 0.9-1.5 of width there, 4.2-5.0 in dorsal-caudal space. Precaudal pits absent.

Lateral trunk denticles with elongated, teardrop-shaped crowns about 1.5 times as long as wide in adults (Fig.4A) but up to twice as long as wide in young (Fig.4B). Interspaces between ridges, including that between medial ridges, covered with reticulated depressions which are better developed in young than adults. Crown with a single medial ridge along the entire crown length in the smallest denticles of newborn young, but larger denticles in young and all denticles in larger juveniles and in adults have prominent paired longitudinal ridges that diverge and then converge posteriorly to end at the medial cusps. Medial cusps relatively long and strong, a third to half length of crown but relatively longer in young than adults. Pair of strong lateral ridges on crown, terminating in strong but short lateral cusps. Denticle crowns closely imbricated in adults and larger juveniles

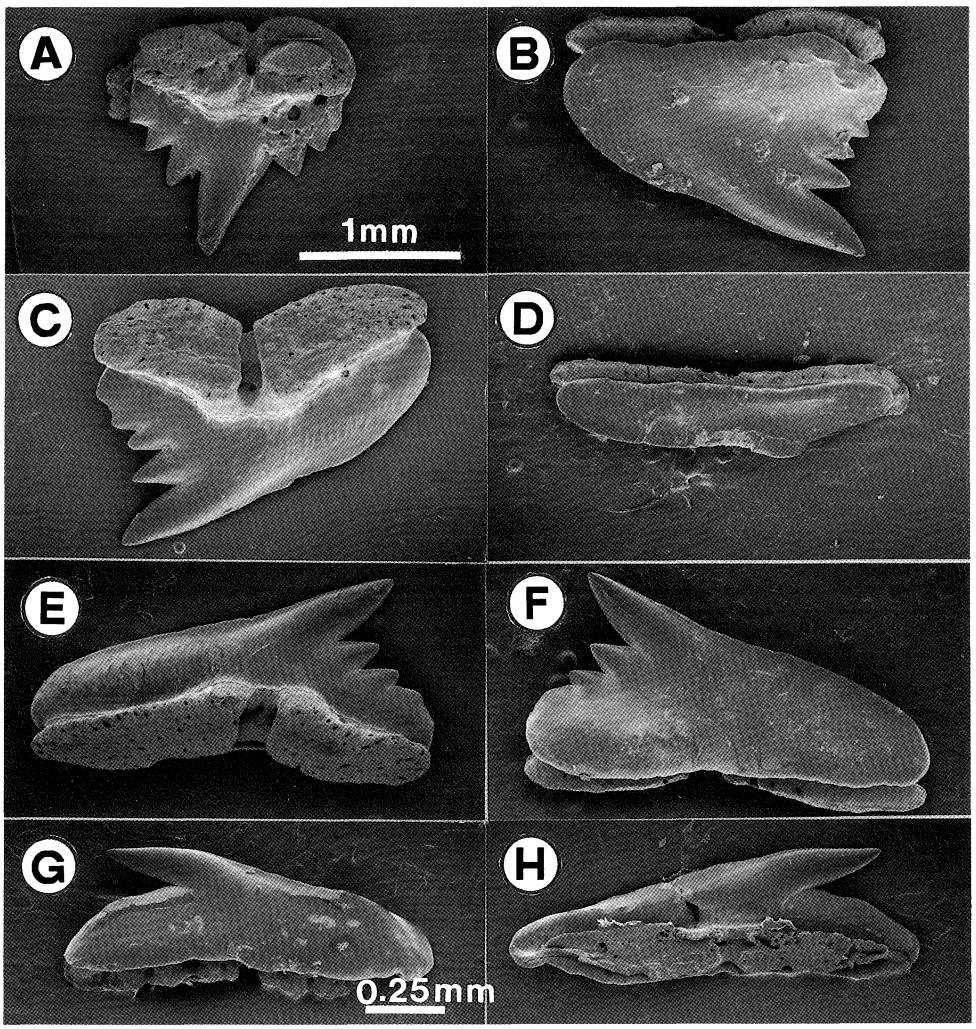

Fig.3. *Hemitriakis falcata*, scanning electron micrographs of representative teeth. A-F, CSIRO H1035-17, 724 mm adult male. A, upper medial tooth, lingual view; B, first upper anterolateral tooth, labial view; C, 2nd upper anterolateral tooth, lingual view; D, 2nd upper posterior tooth, labial view; E, second lower anterolateral tooth, lingual view; F, third lower anterolateral tooth, labial view. G-H, CA4056, 251 mm immature male, lower anterolateral teeth from near symphysis. G, labial view; H, lingual view. A-F, scale bar = 1 mm; G-H, scale bar = 0.25 mm. Photos by A.J. Rees.

but wide spaced in smallest young.

Pectoral fins narrow and semifalcate, with broadly convex anterior margins, bluntly to acutely pointed apices, nearly straight (young) to broadly concave (adults) posterior margins, broadly rounded free rear tips, convex inner margins, narrow bases. Pectoral-fin anterior margin 1.2-1.6 times pectoral-fin length. Pectoral fins subequal in area to first dorsal fin. Origins of pectoral fins under fourth gill openings. Apex of pectoral fin posterior to its free rear tip when fin is elevated and adpressed to body.

Pectoral fin skeleton with radials extending about 0.6 of pectoral anterior margin length into fin. Radials mostly divided into 3 segments except for bisegmental propterygial radial and last 2 metapterygial radials. Longest distal radial segment 1.3 times length of its proximal segment. Distal pectoral-fin radials with parallel edges and truncated tips, not pointed and tapering. No fusion of proximal radial segments. Pectoral-fin skeleton tribasal, propterygium with a single radial, mesopterygium with 3 radials, metapterygium with 10 radials on basal segment and 4 on metapterygial axis; total radial count 18 in one adult counted. Propterygium short, narrow and slightly elongated in the axis of its radial. Mesopterygium short, subquadrate, and slightly expanded distally in the axes of its radials. Metapterygial basal segment triangular, elongated diagonal to the axes of its radials; metapterygial axis short, trisegmental, and with length about two-thirds of metapterygial basal segment.

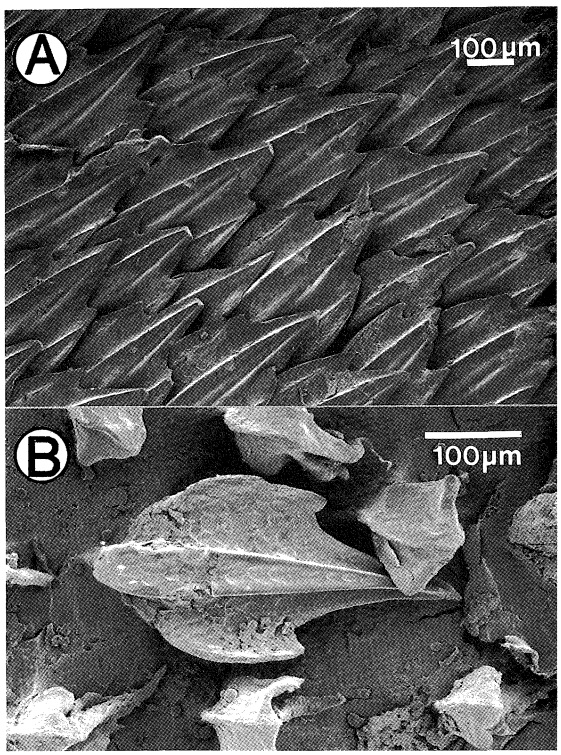

Fig.4. *Hemitriakis falcata*, scanning electron micrographs of lateral trunk denticles. A, denticles in three-quarters anteriolateral view from CSIRO H977-01, 744 mm adult male; B, crown of denticle from CA4056, 251 mm immature male, surrounded by broken pedicels. Photos by A.J. Rees.

Pelvic fins broadly triangular and weakly falcate in adults but not falcate in young; pelvic-fin anterior margins 0.4-0.6 of pectoral-fin anterior margins; area subequal to anal-fin area. Pelvic-fin anterior margins slightly convex, apices bluntly pointed (adults) or narrowly rounded (young), posterior margin straight (young) or broadly concave (adults), free rear tips pointed, inner margins straight.

Claspers relatively long and basally stout, convex and strongly tapering on lateral edge, with a convex, blunt-tipped clasper glans (Fig.5A). Claspers extending well behind pelvic-fin free rear tips, by distance about 1.3 times pelvic-fin inner margin, but falling in front of anal-fin origin by about length of anal-fin base. Most of clasper except dorsal surface of glans covered with small clasper denticles with blunt, rounded crowns and no cusps. Exorhipidion, envelope and pseudopera absent, clasper groove open. Rhipidion present, very large, extending over most of length of clasper glans, formed as a flat, convex-edged blade with posterior end far behind cover rhipidion. Cover rhipidion very low, hardly differentiated from medial edge of clasper groove, extending from apopyle to apex of rhipidion. Pseudosiphon very short, slitlike, extending opposite the posteriormost third of the cover rhipidion. Clasper siphons very long and narrow, extending anteriorly along the entire abdomen and terminating about opposite the last third of the pectoral-fin bases; width of siphons at pelvic-fin origins about two-thirds of distance from midline of body to pelvic-fin origin.

Clasper skeleton simple (Fig.5B-D). Axial cartilage or appendix-stem connected proximally by a single very short basal segment (B1) and a moderately long, posteriorly tapering, wedge-shaped dorsal beta cartilage (ß) to pelvic basipterygium. Clasper shaft, formed from axial cartilage and tightly rolled dorsal and ventral marginal cartilages, is slender, tapers and then expands slightly posteriorly in an elongated hourglass-shape. Clasper glans skeleton comprises a large, narrow, subrectangular, slightly curved, blunt-tipped dorsal terminal and a more proximally expanded, blade shaped ventral terminal, articulating with and separated along their proximomesial nine-tenths to the tapering, fairly narrow, cylindrical-flattened end-style (terminal extension of axial cartilage); very short free posterior ends of terminal cartilages separated by a narrow gap and are nearly straight. Accessory dorsal marginal cartilage (RD2) a long, elongate-oval, proximodistally tapering cartilage that supports the weak cover rhipidion. Accessory dorsal terminal cartilage (TD2) a large, elongated, bladelike, distally tapering cartilage that extends along proximal two-thirds of clasper glans from dorsal marginal to midlength on ventral terminal, supports the rhipidion. No ventral covering piece, unlike some other triakids, nor accessory ventral terminal cartilages. Very long, narrow, broad-tipped, bladelike accessory terminal cartilage (T3) present, extends from hypopyle just anterior to RD2 end to midlength of TD2 and just posterior to RV-TV junction.

First dorsal fin high, apically narrow and falcate, with basally concave and distally convex anterior margin, narrowly rounded apex, broadly concave posterior margin, acutely pointed free rear tip, and nearly straight inner margin. First dorsal-fin origin slightly anterior to free rear tips of pectoral fins, midpoint of base varies from 1.1 times closer to pelvic-fin origins than pectoral-fin insertions to 1.8 times closer to pectoral-fin insertions than pelvic-fin origins. First dorsal-fin insertion and free rear tip well anterior to pelvic-fin origins. Posterior margin slanting ventrally (young) or anteroventrally (adults) from apex, then abruptly posteriorly towards free rear tip, insertion slightly anterior (adults) to posterior (young) to level of dorsal apex. First dorsal-fin base 2.2-2.8 in interdorsal space, 2.0-2.4 in dorsal caudal-fin margin; first dorsal-fin height 1.1-1.6 in first dorsal-fin base; first dorsal-fin inner margin 1.5-2.1 in first dorsal-fin height, 2.1-2.6 in first dorsal-fin base.

Second dorsal fin high, apically narrow and falcate, nearly as large as first dorsal fin, second dorsal-fin height 0.7-1.0 in first dorsal-fin height, second dorsal-fin base 0.8-1.0 of first dorsal-fin base. Second dorsal fin with basally concave and apically convex anterior margin, narrowly rounded apex, deeply concave posterior margin, acutely pointed free rear tip, and straight or slightly concave inner margin. Second dorsal-fin origin separated from pelvic-fin insertions by a space about 1.8-2.6 times pelvic-fin base; free rear tip extending slightly behind anal-fin free rear tip but far in front of upper caudal-fin origin. Posterior margin extending ventrally (young) or anteroventrally (adults) from apex, then abruptly posteroventrally towards free rear tip, insertion slightly anterior (adults) to about opposite (young) to dorsal apex. Second dorsal-fin base 1.1-1.3 in dorsocaudal space, second dorsal-fin height 1.3-1.8 in second dorsal-fin base, second dorsal-fin inner margin 1.6-2.0 in second dorsal-fin height and 2.2-3.0 in second dorsal-fin base.

Anal fin low, apically narrow, semifalcate, much smaller than second dorsal fin, anal-fin height 0.5-0.6 in second dorsal-fin height, anal-fin base 0.7-1.0 in second dorsal-fin base. Anterior margin concave basally and distally convex, apex bluntly rounded (young) to sharply pointed (adults), posterior margin deeply concave (young) to broadly notched (adults), free rear tip acutely pointed, inner margin nearly straight. Anal-fin base with short preanal ridges less than one-third of rest of

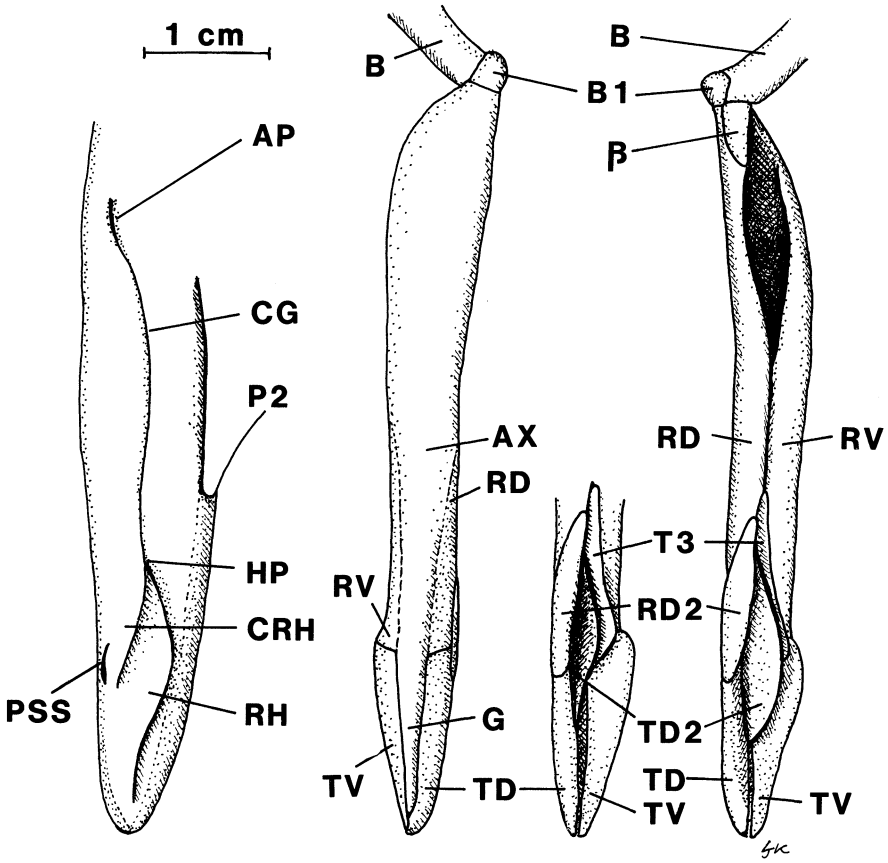

Fig.5. *Hemitriakis falcata*, morphology of right clasper, CSIRO H1035-17, 724 mm adult male. A, dorsal view of entire clasper. B-D, clasper skeleton. B, ventral view; C, dorsal view of entire clasper skeleton, terminal elements not dilated; D, clasper glans with elements spread. Abbreviations: AP – apopyle; AX – axial cartilage; ß – beta cartilage; B – basipterygium; B1 – intermediate segment; CG – clasper groove; CRH – cover rhipidion; G – end-style; HP – hypopyle; P2 – pelvic fin; PSS – pseudosiphon; RD – dorsal marginal cartilage; RD2 – accessory dorsal marginal cartilage; RH – rhipidion; RV – ventral marginal cartilage; T3 – accessory terminal cartilage; TD – dorsal terminal cartilage; TD2 – dorsal terminal 2 cartilage; TV – ventral terminal cartilage. Illustration by L.J.V. Compagno.

base, anal-fin origin slightly behind second dorsal-fin origin by 0.1-0.3 of second dorsal-fin base, anal-fin insertion slightly behind, approximately below, or slightly in front of second dorsal-fin insertion. Anal-fin free rear tip well in front of lower caudal-fin origin. Anal-fin posterior margin slanting dorsally (young) or anterodorsally (adults) from apex, then abruptly posterodorsally towards free rear tip, anal-fin insertion in front of apex. Anal-fin base 1.0-1.9 in anal-caudal space, anal-fin height 1.7-2.6 in anal-fin base, anal-fin inner margin 1.0-1.6 in anal-fin height and 2.1-3.2 in anal-fin base.

Caudal fin narrow-lobed and asymmetrical, with short terminal lobe and prominent ventral lobe at all stages, bluntly angular in young but strongly falcate in adults. Caudal fin short, dorsal caudal-fin margin 3.6-3.9 in precaudal length. Preventral caudal-fin margin 1.9-2.4 and terminal lobe length 2.6-3.1 in dorsal caudal-fin

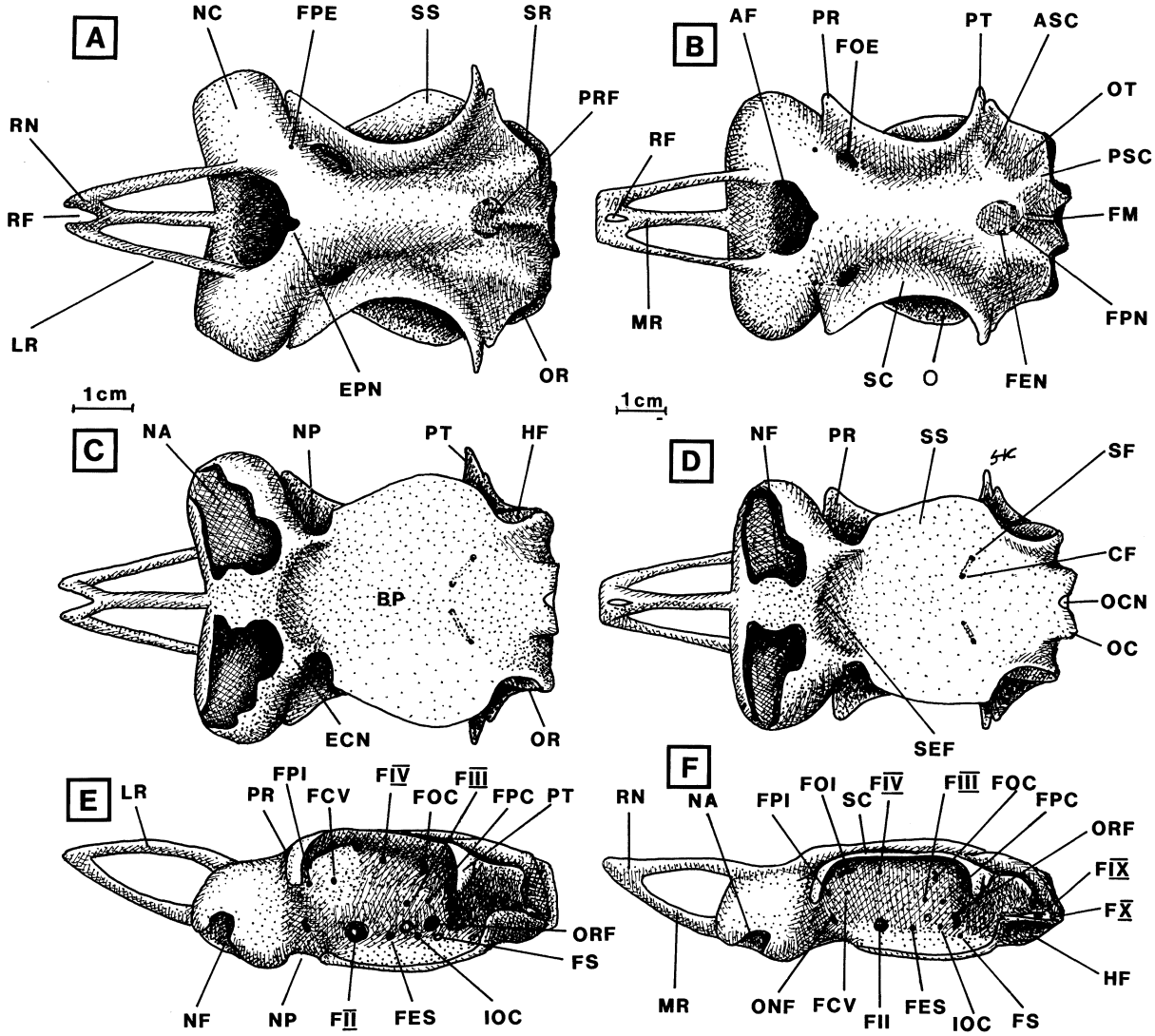

Fig.6. *Hemitriakis* spp., chondrocrania. A,C,E – *H. falcata*, CSIRO H1035-17, 724 mm adult male, cranium. A, dorsal view; C, ventral view; E, lateral view. B,D,F – *H. japanica*, LJVC-0420, 886 mm adult male, cranium. B, dorsal view; D, ventral view; F, lateral view. Abbreviations: AF – anterior fontanelle; ASC – anterior semicircular canal; BP – basal plate; CF – internal carotid foramen; ECN – ectethmoid condyle; EPN – epiphysial notch; FCV – foramen for anterior cerebral vein; FEN – endolymphatic foramen; FES – foramen for efferent spiracular artery; FM – foramen magnum; FOC – foramen for superficial opthalmic nerve; FPC, FPE and FPI – cranial, external and orbital foramina of deep ophthalmic nerve; FPN – perilymphatic foramen; FII – optic nerve foramen; FIII – oculomotor nerve foramen; FIV – trochlear nerve foramen; FIX – glossopharyngeal nerve foramen; FX – vagus nerve foramen; HF – hyomandibular facet; IOC – interorbital canal; LR – lateral rostral cartilage; MR – medial rostral cartilage; NA – nasal aperture; NF – nasal fontanelle; NC – nasal capsule; NP – orbital notch; O – orbit; OC – occipital condyle; OCN – occipital centrum; ONF – orbitonasal foramen; OR – opisthotic ridge; ORF – orbital fissure; OT – otic capsule; PR – preorbital process; PRF – parietal fossa; PSC – posterior semicircular canal; PT – postorbital process; RF – rostral fenestra; RN – rostral node; SC – supraorbital crest; SEF – subethmoid fossa; SF – stapedial foramen; SR – sphenopterotic ridge; SS – suborbital shelf. Illustration by L.J.V. Compagno.

margin, subterminal margin 2.1-2.4 in terminal margin. Dorsal caudal-fin margin proximally and distally convex, and mesially concave, without lateral undulations. Preventral margin basally straight or concave and apically convex, tip of ventral caudal-fin lobe narrowly rounded (young) or acutely pointed (adults), lower postventral margin concave, upper convex, notch between postventral margins forming angle of 80° (adults) to 125° (young), subterminal notch a narrow, deep slot, subterminal margin slightly concave, terminal margin slightly to strongly concave, lobe formed by these margins bluntly angular, and tip of tail narrowly rounded (young) to pointed (adults).

Vertebral counts and ratios listed for holotype and 9 paratypes in Table 4 and summarised as follows: total counts (TC) 158-167, precaudal (PC) counts 101-109, monospondylous precaudal (MP) centra 37-41, diplospondylous precaudal (DP) centra 63-69, diplospondylous caudal (DC) centra 55-60. MP counts 23.4-25.2%, DP counts 38.7-41.8%, and DC counts 34.7-36.6% of TC counts. Ratios of DP/MP counts 1.5-1.8, DC/MP counts 1.4-1.5, 'A' ratio 114.8-155.6, 'B' ratio 66.7-95.5. Transition between MP and DP centra over pelvic-fin bases and 1 or 2 centra behind pelvic-fin girdle. Last few MP centra before MP-DP transition moderately enlarged, not forming a 'stutter zone' of alternating long and short centra. Vertebra examined just behind cranium with strong wedge-shaped intermedialia and long diagonal calcified lamellae extending well into the basalia spaces.

Chondrocranium studied by dissection of an adult paratype (Fig.6A,C,E) and checked on radiographs of other specimens. Rostral cartilages elongated, slender, cylindrical, and not hypercalcified in adults. Medial rostral cartilage length 46% of nasobasal length (NBL), distance between bases of lateral rostral cartilages 1.9 in medial rostral cartilage. Medial rostral cartilage narrow-based, arched dorsally, lateral rostrals arched ventrally. Rostral node formed as a broad yoke with a large, anteriorly perforated rostral fenestra, separating the anterior end of the medial rostral cartilage from the lateral rostrals. Nasal capsules large, high, diagonally elliptical and somewhat wider than long, width across them 82% NBL, length of capsule 1.1 in its width. Anterior margins of nasal capsules nearly straight, slightly oblique to the cranial axis. Nasal apertures on ventrolateral faces of capsules, separated from large nasal fontanelles by a broad channel. Ectethmoid chambers inside nasal cavities, at posterior edges of nasal fontanelles and not visible ventrally. Subnasal plate in the form of irregular medial extensions of the lateral capsule wall, and broad lateral extensions of the narrow, high internasal septum bordering the wide nasal fontanelles. Strong ectethmoid condyles on posteroventral edges of nasal capsules, separated by a broad arcuate subnasal fenestra. Anterior fontanelle transversely oval, length about 1.2 times in its width and about 23% NBL. Dorsal lip of fontanelle not flared but with a prominent epiphysial notch. Cranial roof broadly arched, about level with supraorbital crests but not domelike. Parietal fossa deep. Orbital notches deep. Basal plate nearly flat from orbital notches to occipital centrum, without keels. Internal carotid foramina slightly closer to each other than to the stapedial foramina. Edge of supraorbital crests deeply arcuate in dorsal view, with short, prominent triangular Preorbital processes and laterally directed, ventrally hooked, bifurcated postorbital processes. Width across preorbital processes 71% NBL, width across postorbital processes 82% NBL, least width across supraorbital crests 2.0 in width across postorbital processes. Orbits horizontally subrectangular in lateral view, with contents indicated in Figure 6E. No ledge between suborbital shelves and nasal capsules. Suborbital shelves broadly convex, extending well lateral to the supraorbital crests in dorsal view. Width across suborbital shelves 69% NBL. Otic capsules not greatly expanded or inflated, their lengths about 25% NBL and greatest width across them 51% NBL. Sphenopterotic ridges diagonally arched in dorsal view, without a distinct Pterotic horn in lateral view. Opisthotic ridges high, extending laterally to edges of sphenopterotic ridges. Hyomandibular facets large, wedge-shaped, extending across rear half length of otic capsules and slightly exserted posteriorly. Occipital condyles broad and slightly exserted from occiput, with a single occipital centrum between them.

Intestinal valve with 7 (2 specimens) or 8 turns (3 specimens).

Colour. In alcohol adults are greyish brown above, lighter below, with prominent white-tipped dorsal, pectoral, pelvic and caudal fins (Fig.1). The tip of the terminal lobe of the caudal fin is dusky and the dorsal fins are abruptly dusky below their white tips, highlighting them. Young specimens below 400 mm TL have a series of solid dusky saddles on the back over the gills, pectoral-fin bases, first dorsal-fin base, interdorsal space, second dorsal-fin base, and caudal-fin base; also dark spots or bars over the eyes, on the flank just in front of the pelvic fin, and on the caudal-fin epichordal and terminal lobes. The dorsal-fin webs just below the white tips are more strikingly highlighted with blackish spots in juveniles than in adults.

Size. The largest known specimen of *H. falcata* is a 773 mm adult male. Of the ten specimens examined, one is an immature female, 258 mm, two are immature males, 251 to 380 mm, while seven are adult males, 695 to 773 mm. Weights of our specimens are given in Table 1.

Hemitriakis abdita n.sp.

Deepwater sicklefin houndshark

Fig.7

Type material. HOLOTYPE, CSIRO H1365-03, SO6/85/66, 596 mm adolescent male, 4 Dec. 1985, 17°38'S 150°11'E, Coral Sea Plateau off north-eastern Queensland, 225 m.

PARATYPES, CSIRO H1366-01, SO6/85/63, 360 mm immature male, 3 Dec. 1985, 17°30'S 149°41'E, Coral Sea Plateau off north-eastern Queensland, 401 m; CSIRO H1365-02, 536 mm immature female and CSIRO H1365-01, 465 mm immature male, SO6/85/66, 4 Dec. 1985, 17°38'S 150°11'E, Coral Sea Plateau off north-eastern Queensland, 225 m; CSIRO H1368-01, SO6/85/64, 561 mm immature female, 3 Dec. 1985, 17°30'S 149°46'E, Coral Sea Plateau off north-eastern Queensland, 343 m.

Diagnosis. *Hemitriakis* with eyes horizontally oval. Tooth rows 63-70 in both jaws. First dorsal-fin origin anterior to pectoral-fin free rear tips, over pectoral-fin insertions. First dorsal-fin length about 0.8-1.2 in distance from pectoral-fin free rear tips to pelvic-fin origins. Total vertebral counts 186-193, precaudal counts 126-130, monospondylous precaudal counts 48-53. Late juveniles and adolescents with prominent colour pattern of dark bars and saddles on body and fins. Males adolescent at 596 mm.

Etymology. From Latin *abditus*, hidden, in reference to the close external similarity of this sibling species to *H. falcata*.

Description. Proportional dimensions as percentage of total length (see terminology) for type series, listed in Table 2.

Head short, length 0.8-1.0 in pectoral-pelvic space; fairly narrow, flattened, roughly trapezodial in cross-section at eyes. Outline of head in lateral view nearly straight dorsally, slightly convex ventrally along lower jaws and nearly flat beneath gills; in dorsoventral view head anteriorly rounded and posteriorly tapering along branchial region. Preoral snout long, 1.2-1.3 in mouth width. Snout tip narrowly rounded in dorsoventral view, slightly indented anterior to nostrils; snout bluntly pointed in lateral view, nearly straight above and convex below.

External eye opening with prominent posterior notch but no anterior one; eyes large, elongate-oval in shape, eye length 5.1-6.5 in head length and 2.0-2.5 times eye height. Eyes dorsolateral on head, with lower edges well medial to horizontal head rim in dorsal view, subocular ridges prominent. Nictitating lower eyelids external, with deep but entirely scaled subocular pouches and secondary lower eyelids free from upper eyelids in young and adolescents.

Spiracles small, length 4.5-6.7 in eye length, spiracles 0.2 eye lengths behind and below posterior eye notch. First 4 gill openings about equally high or first slightly narrower than others; fifth shorter than third, height of fifth 0.6-0.7 of third; third 10.6-12.2 in head and 0.5-0.6 of eye length. All gill openings slightly concave, gill filaments not visible from outside. Upper ends of gill openings slightly below lower edges of eyes. Gill-raker papillae absent from gill arches.

Nostrils with large oval incurrent apertures lacking posterolateral keels, rounded anterior nasal flaps with

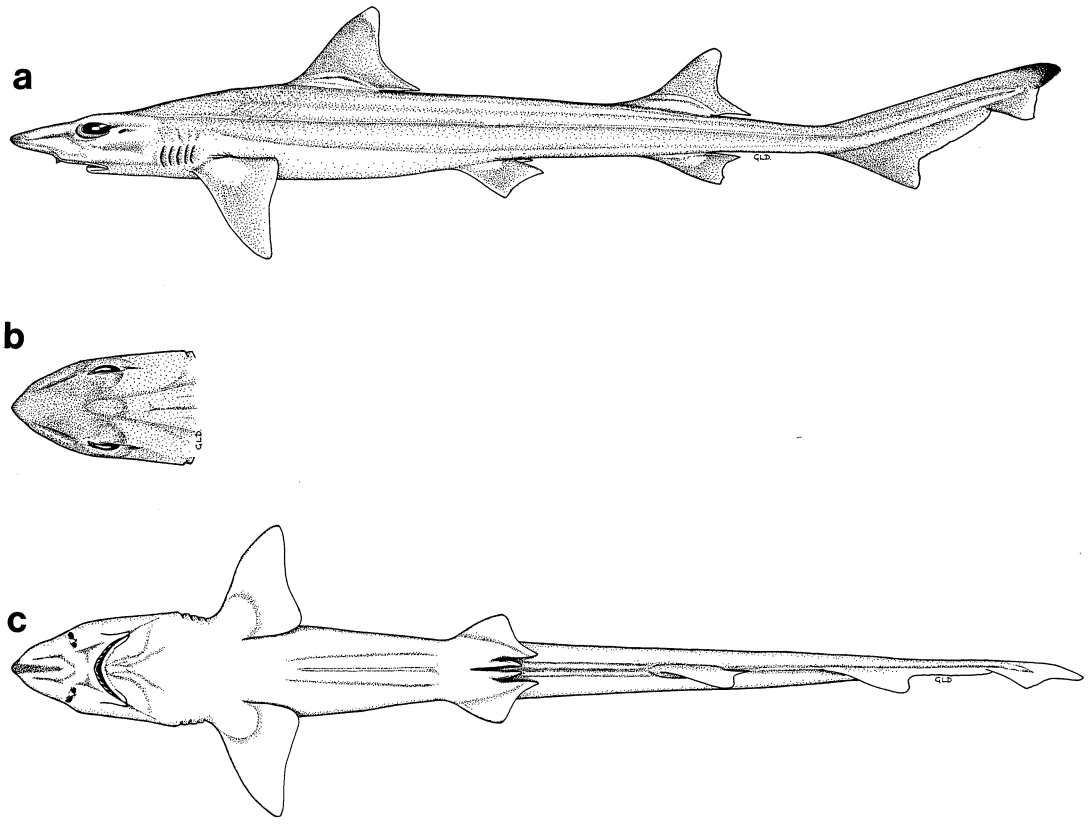

Fig.7. *Hemitriakis abdita* n.sp., holotype, H1365-03, 596 mm adolescent male, A, lateral and C, ventral views; B, dorsal view of head. Illustration by G. Davis.

round tips, elongated mesonarial flaps that prominently protrude from above the anterior nasal flaps, small oval excurrent apertures, and fairly large posterior nasal flaps. Nostrils well in front of mouth, about 3.1-3.5 times farther from snout tip than from eyes. Nostril width 1.9-2.4 in internarial space, 1.6-2.1 in eye length, 0.9-1.0 in third gill opening height.

Mouth broadly arched, moderately large, short, mouth width about 0.7 of head width at mouth corners, 2.9-3.3 in head length; mouth length 2.4-2.9 in mouth width. Tongue large, flat, broadly rounded, filling floor of mouth. Maxillary valve narrow, papillose. Palate and floor of mouth with tiny papillae, covered with buccopharyngeal denticles. Labial furrows long, upper 1.3-1.7 times lower furrows, anterior ends of uppers under first third of eye length and reaching virtually to symphysis of upper jaw. Labial cartilages large.

Teeth relatively few, in 34-37/28-33 rows (see Table 4 for detailed counts and statistics), 1-2/1-4 series functional. Teeth not arranged in diagonal files, no toothless spaces at symphysis. Tooth formulae:

$$\frac{\text{M5-6 AL11-13 P3-4}}{\text{M5 AL8-11 P3-5}} \quad \text{or} \quad \frac{\text{M5-6 AP14-17}}{\text{M5 AP11-14}}$$

Upper anterolateral teeth higher-crowned than lowers, both with well-developed distal cusplets and oblique cusps, cusps somewhat higher and more erect on upper teeth than lowers. Upper anterolateral teeth of immature and adolescent specimens examined with a strongly oblique cusp, a single cusplet, and a short blade. Medial teeth smaller than anterolaterals, with more erect cusps, higher crowns, and both mesial and distal cusplets. Anterolaterals gradually become lower crowned and lower-cusped along the dental band, grade into keel-like posterior teeth which are very low-crowned, lack cusps, and have a broad convex edge. All teeth have broad basal ledges, strong basal grooves, large mesial and distal root lobes separated by broad transverse grooves and prominent centrolingual foramen on linguobasal attachment surface of roots, medial teeth with lateral foramina. Transverse ridges obsolete on teeth of specimens examined, perhaps represented by irregular notching on basal ledge.

Body elongate, slender, trunk vertically oval to circular in section at first dorsal-fin base, length of trunk from fifth gill openings to vent 1.1-1.2 times head length. A low interdorsal ridge on midline of back between dorsal fins, and a low postdorsal ridge, but without predorsal ridges; lateral ridges absent from body. Caudal peduncle slender, cylindrical-tapering, without lateral keels or precaudal pits.

Lateral trunk denticles with elongated, teardrop-shaped crowns about 1.5 times as long as wide. Interspaces between ridges, including that between medial ridges, covered with reticulated depressions. Crown with prominent paired longitudinal ridges that diverge and then converge posteriorly to end at the medial cusps. Medial cusps relatively long and strong, a third to half length of crown. A pair of strong lateral ridges on crown, terminating in strong but short lateral cusps. Denticle crowns closely imbricated.

Pectoral fins narrow with broadly convex anterior margins, bluntly to acutely pointed apices, nearly straight (young) posterior margins, broadly rounded free rear tips, undulated to straight inner margins, narrow bases. Pectoral-fin anterior margin 1.3-1.5 times pectoral-fin length. Pectoral fins subequal in area to first dorsal fin. Origin of pectoral fins under fourth gill openings. Apex of pectoral fin posterior to its free rear tip when fin is elevated and adpressed to body.

Pectoral fin skeleton examined from radiographs, essentially similar to that of *H. falcata*. About 17-18 radials in 2 specimens that were countable, with 1 radial on propterygium, 5 on mesopterygium, approximately 11 on metapterygium (CSIRO H1365-01). Distal pectoral-fin radials with parallel edges and truncated tips, not pointed and tapering. Propterygium short, narrow, slightly elongated in the axis of its radial. Mesopterygium short, subangular, slightly expanded distally in the axes of its radials. Metapterygial basal segment triangular, elongated diagonal to the axes of its radials.

Pelvic fins broadly triangular. Pelvic-fin anterior margins 0.4-0.5 of pectoral-fin anterior margins; area subequal to anal-fin area. Pelvic-fin anterior margins slightly convex, apices narrowly rounded, posterior margin slightly concave, free rear tips pointed, inner margins straight. Claspers not examined in detail as there were no adult males in our sample.

First dorsal fin high, apically narrow and falcate, with basally concave and distally convex anterior margin, narrowly rounded apex, broadly concave posterior margin, acutely pointed free rear tip, nearly straight inner margin. First dorsal-fin origin slightly anterior to free rear tips of pectoral fins, midpoint of base varies from about equidistant between pectoral-fin insertions and pelvic-fin origins to 1.4 times closer to pectoral-fin insertions than pelvic-fin origins. First dorsal-fin insertion and free rear tip well anterior to pelvic-fin origins. Posterior margin slanting ventrally from apex, then abruptly posteriorly towards free rear tip, insertion about under level of dorsal apex. First dorsal-fin base 2.3-2.6 in interdorsal space, 2.2-2.5 in dorsal caudal-fin margin; first dorsal-fin height 1.1-1.3 in first dorsal-fin base; first dorsal-fin inner margin 2.0-2.3 in first dorsal-fin height, 2.1-2.9 in first dorsal-fin base.

Second dorsal fin high, apically narrow and falcate, nearly as large as first dorsal fin, second dorsal-fin height 0.7-0.8 in first dorsal-fin height, second dorsal-fin base 1.0-1.1 of first dorsal-fin base. Second dorsal fin with basally concave and apically nearly straight anterior margin, narrowly rounded apex, deeply concave posterior margin, acutely pointed free rear tip, straight or slightly concave inner margin. Second dorsal-fin origin separated from pelvic-fin insertions by a space about twice pelvic-fin base; free rear tip extending about level with anal-fin free rear tip but far in front of upper caudal-fin origin. Posterior margin extending ventrally from apex, then abruptly posteroventrally towards free rear tip, insertion about under dorsal apex. Second dorsal-fin

base 1.1-1.2 in dorsocaudal space, second dorsal-fin height 1.3-1.6 in second dorsal-fin base, second dorsal-fin inner margin 2.1-2.9 in second dorsal-fin height and 3.2-4.5 in second dorsal-fin base.

Anal fin low, apically narrow, semifalcate, much smaller than second dorsal fin, anal-fin height about 0.5 in second dorsal-fin height, anal-fin base 0.6-0.7 in second dorsal-fin base. Anterior margin concave basally and distally convex, apex bluntly rounded or sharply pointed, posterior margin deeply concave, free rear tip acutely pointed, and inner margin nearly straight. Anal-fin base with short preanal ridges, anal-fin origin behind second dorsal-fin origin by 0.2-0.3 of second dorsal-fin base, anal-fin insertion slightly behind or slightly in front of second dorsal-fin insertion. Anal-fin free rear tip well in front of lower caudal-fin origin. Anal-fin posterior margin slanting dorsally from apex, then abruptly posterodorsally towards free rear tip, anal-fin insertion about under apex. Anal-fin base 1.4-1.6 in anal-caudal space, anal-fin height 1.9-2.2 in anal-fin base, anal-fin inner margin 1.4-1.6 in anal-fin height and 2.7-3.4 in anal-fin base.

Caudal fin narrow-lobed, asymmetrical, with short terminal lobe and short but prominent ventral lobe. Caudal fin short, dorsal caudal-fin margin 3.6-3.8 in precaudal length. Preventral caudal-fin margin 2.3-2.4 and terminal lobe length 2.7-2.8 in dorsal caudal-fin margin, subterminal margin 1.5-2.4 in terminal margin. Dorsal caudal-fin margin proximally and distally convex, mesially concave, without lateral undulations. Preventral margin basally straight or concave, apically convex, tip of ventral caudal-fin lobe narrowly rounded or acutely pointed, lower postventral margin concave, upper convex, subterminal notch a narrow, deep slot, subterminal margin slightly concave, terminal margin slightly to strongly concave, lobe formed by these margins bluntly angular, tip of tail narrowly rounded or pointed.

Vertebral counts and ratios listed for holotype and 4 paratypes in Table 3 and summarised as follows: total counts (TC) 186-193, precaudal (PC) counts 126-130, monospondylous precaudal (MP) centra 48-53, diplospondylous precaudal (DP) centra 77-78, diplospondylous caudal (DC) centra 58-63. MP counts 25.8-27.5%, DP counts 39.9-41.9%, DC counts 31.0-32.8% of TC counts. Ratios of DP/MP counts 1.45-1.63, DC/MP counts 1.14, 1.27, 'A' ratio 115.0-133.3, 'B' ratio 53.5-70.5. Transition between MP and DP centra over pelvic-fin bases and 1-3 centra behind pelvic-fin girdle. Last few MP centra before MP-DP transition slightly enlarged, not forming a 'stutter zone' of alternating long and short centra.

Chondrocranium examined from radiographs of the type series, but these cannot be described in detail because of insufficient calcification of many cranial structures. Rostral cartilages elongated, slender, cylindrical, not hypercalcified in juveniles and adolescents. Medial rostral cartilage length about 59-63% of nasobasal length (NBL), distance between bases of lateral rostral cartilages 2.0-2.2 in medial rostral cartilage. Medial rostral cartilage narrow-based, arched dorsally. Rostral node formed as a broad yoke with a large, anteriorly perforated rostral fenestra. Nasal capsules large, high, diagonally elliptical, somewhat wider than long. Anterior margins of nasal capsules nearly straight, slightly oblique to cranial axis. Anterior fontanelle transversely oval, width about 29% NBL. Dorsal lip of fontanelle with a prominent epiphysial notch. Otic capsules not greatly expanded or inflated. Hyomandibular facets large, wedge-shaped, extending across rear half length of otic capsules and slightly exserted posteriorly. Occipital condyles broad and slightly exserted from occiput, with a single occipital centrum between them.

Intestinal valve with 7 (3 specimens) or 8 turns (2 specimens).

Colour. In alcohol juveniles and adolescents are greyish brown above, lighter below, with prominent white tips and posterior edging on the dorsal, pectoral and pelvic fins, and a white margin on the caudal fin below its terminal tip. There are a series of solid dusky saddles on the back over the gills, pectoral-fin bases, first dorsal-fin base, interdorsal space, second dorsal-fin base, and caudal-fin base; and dark spots or bars on the snout tip, on the underside of the snout, over and below the eyes, on the flank between the pectoral and pelvic-fin bases, and on the caudal-fin epichordal and hypochordal lobes. The base of the caudal-fin terminal lobe and the terminal tip is black. The dorsal-fin webs just below the white tips are strikingly marked with a pair of blackish bars.

Size. Of the five specimens of *H. abdita* examined, two are immature females, 536 and 561 mm, two are immature males, 360 to 465 mm, and the largest known specimen is a 596 mm adolescent male. Weights of our specimens are given in Table 2.

Distribution of *Hemitriakis abdita* and *H. falcata*. *Hemitriakis falcata* and *H. abdita* are allopatric as presently known (Fig.8). *Hemitriakis falcata* is known from the outer continental shelf of Western Australia from north-west of Dampier to north-west of Broome, at depths of 146 to 197 m. *Hemitriakis abdita* is only known from the southern Coral Sea Plateau south-east of Cairns on the north-eastern coast of Queensland, at depths of 225 to 401 m. At present there are no known records of the genus from intermediate localities. The known records are few but suggest that these two species may have depth habitat differences.

Comparisons between the Species of *Hemitraikis*

Compagno (1970, 1979, 1984, 1988) noted that *Hemitriakis* is readily distinguished from other triakid genera, but that the species of *Hemitriakis* are morphologically very similar in external appearance. Subtle differences in external morphology between these species are masked by inadequate series of specimens, by considerable growth changes in proportions and fin

and body shape between juveniles and adults (compare Figs 1 and 2), and by considerable variation within individuals of the same maturity class. There are few morphometric and external morphological characters that separate the species in our limited sample. Comparative morphometrics of *H. falcata*, *H. abdita*, *H. japanica*, and the New Caledonian *Hemitriakis* are presented in Tables 1 and 2.

Hemitriakis species have similar pectoral-fin radial counts with slight differences between species, but these differences are suspect with the small sample size presently available: *H. abdita* has about 17 to 18 radials, *H. falcata* 18 radials, *H. japanica* 19 radials, and *H. leucoperiptera* 17 radials. Intestinal valve counts are similar in *Hemitriakis* species and are probably not diagnostic: *H. abdita* and *H. falcata* have seven to eight intestinal valve turns, while *H. leucoperiptera* has seven turns and *H. japanica* six to eight turns (Compagno, 1988).

Hemitriakis species are most clearly separable by vertebral counts (Fig.9, Table 3), as are certain other triakids and some carcharhinids which are externally similar but differ sharply in numbers of vertebrae and in ratios of vertebral groups. Examples include sibling species of *Mustelus* in the Gulf of Mexico and the Gulf of California (Heemstra, 1973), sympatric species pairs within *Carcharhinus* such as *C. amboinensis* + *C. leucas* and *C. dussumieri* + *C. sealei* (Garrick, 1982), some allopatric species of *Rhizoprionodon* (Springer, 1964), and allopatric species of *Negaprion* (Compagno, 1988). There are also differences in colouration, in head and fin shapes, and in a few proportional dimensions between *Hemitriakis* species.

Hemitriakis falcata and *H. abdita* strongly differ from each other in precaudal vertebral counts (Fig.9), with no overlap between these taxa in MP, DP, PC and TC counts. There is an average difference in TC counts of about 27 centra between these species, and a separation of 19 centra between the highest *H. falcata* and lowest *H. abdita*. *Hemitriakis abdita* has the highest TC counts of any known *Hemitriakis*, but is approached by the New Caledonian *Hemitriakis* in total centra and is exceeded by it in PC and MP counts (see also Table 4). *Hemitriakis falcata* has MP, PC and TC counts broadly overlapping our sample of *H. japanica*, but averaging slightly higher TC counts and lower MP counts. *Hemitriakis leucoperiptera* in contrast has the lowest vertebral counts of any *Hemitriakis* and does not overlap any known species in precaudal counts. An undescribed species of *Hemitriakis* from the Philippine Islands was noted by Compagno (1970, 1979, 1984, 1988) to differ from the sympatric *H. leucoperiptera* in external morphology and colouration. This is represented by four fetal specimens in the Stanford University collections (SU-40097) which were left unnamed by Compagno (1988) because their vertebrae could not be counted and their teeth had not yet erupted. Re-examination of a radiograph of these specimens with high illumination and magnification revealed faint but barely countable precaudal centra on one of them. This has a count of MP 44, DP 72, and PC 116, which is much greater than comparable counts of *H. leucoperiptera* (Table 4) and is intermediate between *H. falcata* and *H. japonica* with lower MP and PC counts and *H. abdita* and the New Caledonian *Hemitriakis* with higher MP and PC counts (Fig.9).

Hemitriakis abdita differs from *H. falcata* in having a dusky bar on the ventral surface of the snout, and in narrower white tips to the dorsal fins.

Juvenile and early adolescent *H. abdita* and the New

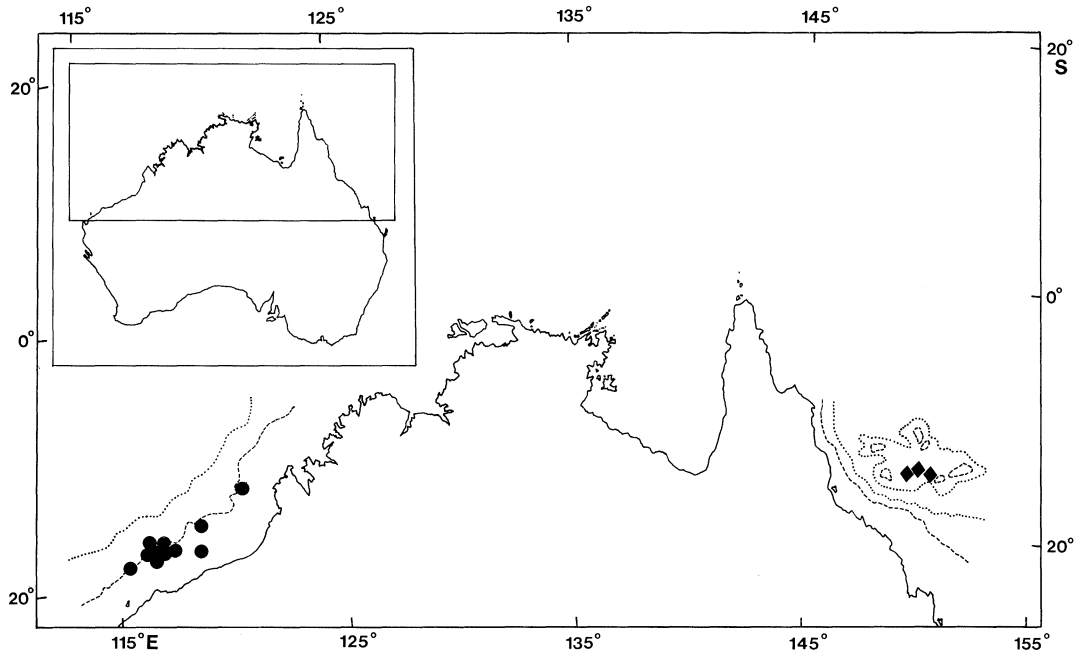

Fig.8. Map of northern Australia showing records of *Hemitriakis* spp. Inset map shows Australian continent with rectangle indicating area of main map. Diamonds – *H. abdita*; circles – *H. falcata*.

Caledonian *Hemitriakis* differ from *H. falcata* and *H. japanica* in having a slightly longer prenarial snout (PRN, Fig.10A, compare PRN in Tables 1 and 2). The greater PRN of *H. abdita* versus *H. falcata* is reflected in its longer rostral cartilages (see below). An adult female *H. leucoperiptera* as illustrated by Herre (1923: pl.1) agrees with large *H. japanica* males in having a broader head and more bluntly pointed snout than any of our (smaller) adult male *H. falcata.*

Similar-sized *H. falcata* and *H. japanica* differ in the flatter, more wedge-shaped head and slightly lower, more elongated, slitlike eyes of the latter species, which is also indicated by a plot of the ratio of eye length to eye height (EYL/EYH) versus total length for *Hemitriakis* species (Fig.10B). There is, however, considerable variation in EYL/EYH ratio for *H. japanica* and overlap with other species; the New Caledonian *Hemitriakis* has eyes which are as narrow as large *H. japanica.* The smaller eyes (and cranial orbits) of *H. japanica* may reflect its more inshore habitat compared to *H. falcata.*

Hemitriakis leucoperiptera agrees with *H. falcata*, *H. abdita* and the New Caledonian *Hemitriakis* in having falcate dorsal fins in adults or subadults and its first dorsal-fin origin in front of the free rear tips of the pectoral fin. *Hemitriakis japanica* has a more broadly angular dorsal, pectoral and anal fins, and the first dorsal-fin origin over or behind the free rear tips of the pectoral fin.

Hemitriakis abdita differs from *H. falcata* in having slightly higher tooth row counts, as shown on a plot of upper versus lower tooth row counts (Fig.10C). *Hemitriakis japanica* broadly overlaps these two species in tooth row counts (Table 3).

Young *Hemitriakis* are more boldly patterned than adults, as in many other carcharhinoid sharks (Compagno, 1988), but juvenile colour patterns differ between species. *Hemitriakis leucoperiptera* and *H. japanica* lack the bold spots and saddles of young *H. falcata*, *H. abdita* and the Philippine intermediate-count form. Young *H. japanica* have a dark upper caudal-fin terminal tip and young *H. leucoperiptera* have obscure saddles on their caudal peduncles and dusky epichordal caudal-fin lobes and terminal lobe bases (Compagno, 1988: fig.17.11A,B). Juvenile *H. abdita* differ from juvenile *H. falcata* in having a black snout tip and black bar on the underside of the snout and a dark bar beneath the eye. Late fetuses of the Philippine intermediate-count form have a dark spot on the snout tip and spots below the eyes as in *H. abdita*, but they differ from *H. abdita* and *H. falcata* in having light centers on their dark saddles and spots and a light rather than dark terminal caudal-fin tip (Compagno, 1988: fig.17.11C). The New

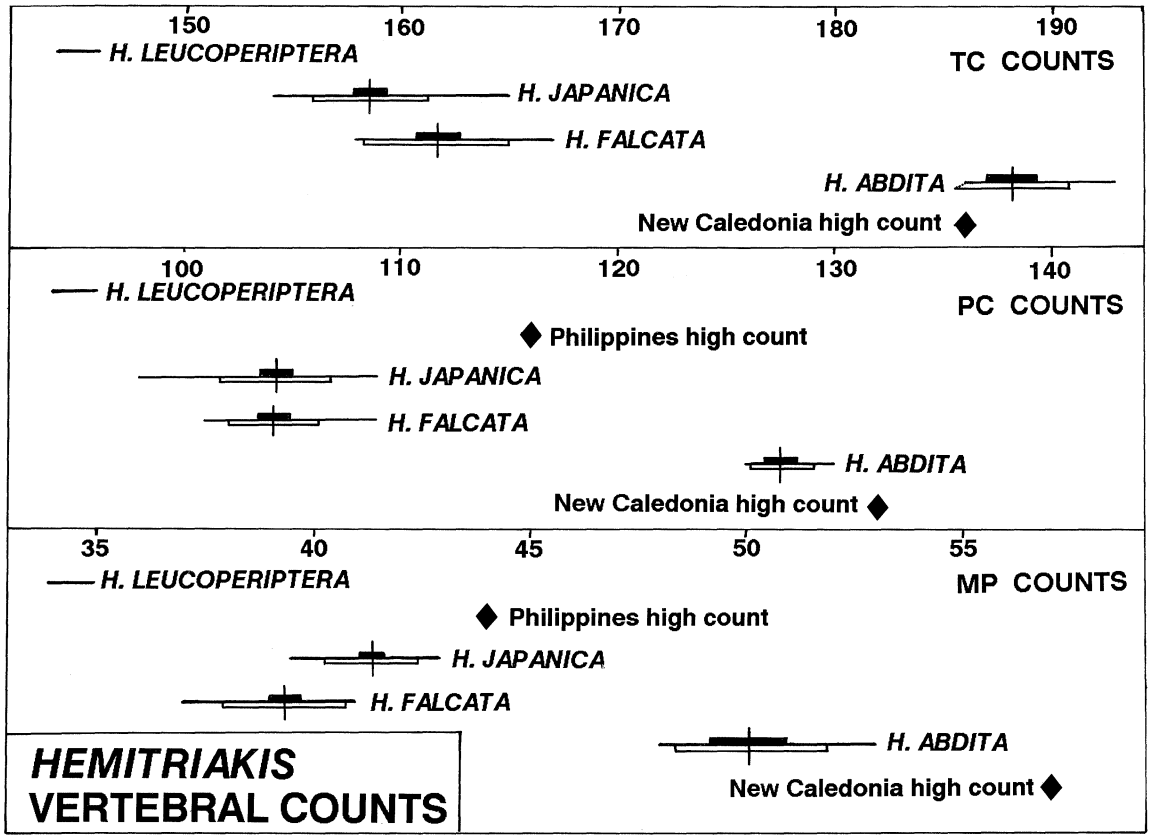

Fig.9. Horizontal line graphs of vertebral counts of *Hemitriakis* spp., including *abdita*, *falcata*, *japanica*, *leucoperiptera*, the undescribed Philippine high-count form, and the New Caledonian *Hemitriakis* near *abdita*. Horizontal line is range of counts, vertical line indicates arithmetic mean, solid bar above line is one standard error to either side of mean, hollow bar below line of mean is one standard deviation to either side of mean, diamonds indicate single counts. For detailed counts and statistics see Table 4.

Caledonian *Hemitriakis* (adult male) lacks dark bars and spots but has prominent white fin margins as in adults of *H falcata*, *H. japanica* and *H. leucoperiptera*.

The chondrocrania of *Hemitriakis falcata* (Fig.6A,C,E) and *H. japanica* (Fig.6B,D,F) are generally similar but differ in various details. The cranium of *H. japanica* has smaller, narrower, transverse nasal capsules with transverse anterior edges and smaller nasal fontanelles; smaller anterior fontanelle; cranial roof elevated above level of supraorbital crests in lateral view; less deeply

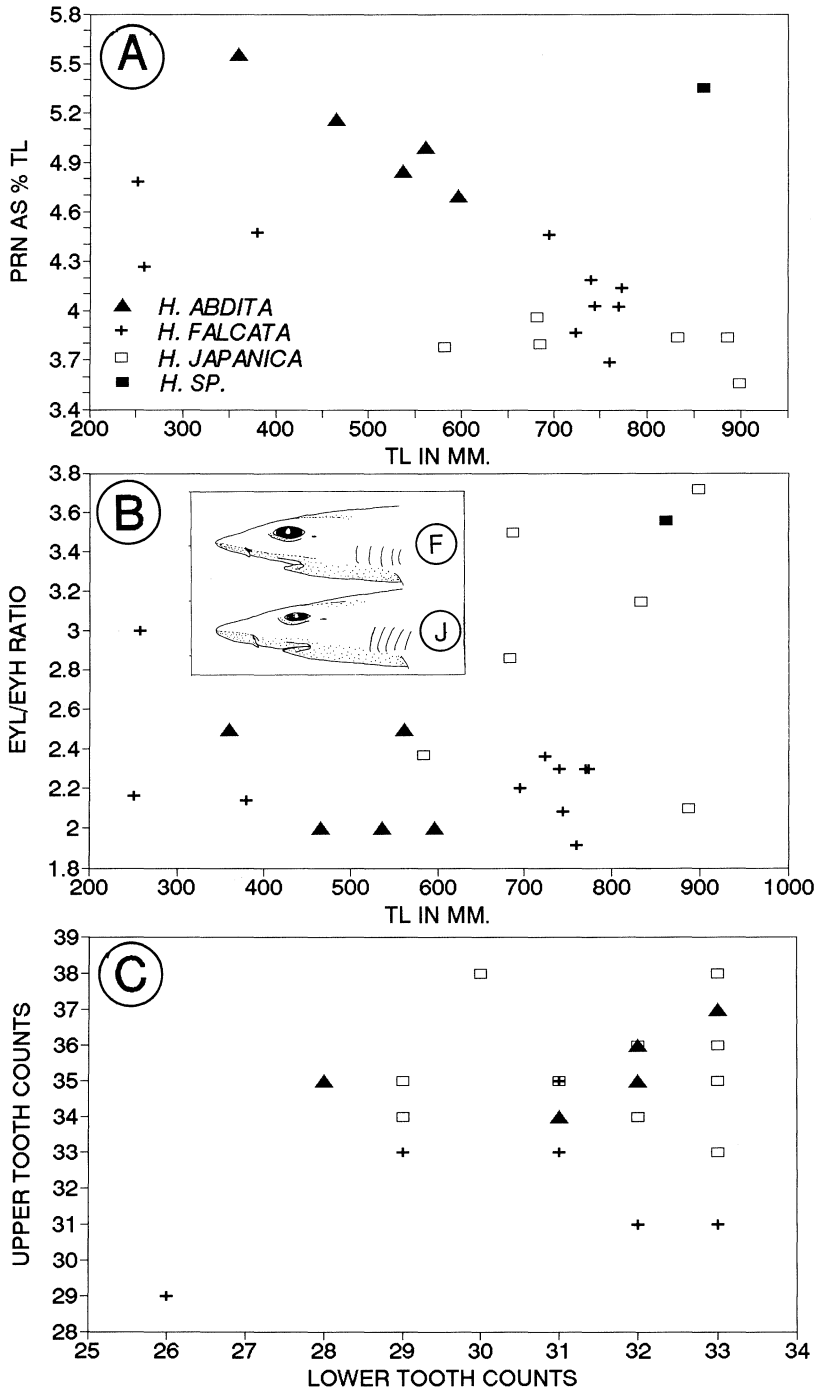

Fig.10. A = X-Y plot of prenarial length (PRN) as a percentage of total length versus total length (x-axis) for A – *Hemitriakis abdita*, F – *H. falcata*, J – *H. japanica*, N – *H. sp.* near *abdita* from New Caledonia. B = X-Y plot of eye length/height ratio (EYL/EYH) versus total length (x-axis) for A – *Hemitriakis abdita*, F – *H. falcata*, J – *H. japanica*, N – *H. sp.* near *abdita* from New Caledonia. Inset sketches of head in F – *H. falcata* (WAM P26271-001, 770 mm adult male holotype), J – *H. japanica* (LJVC-0421, 833 mm adolescent male), drawn to same scale, to show flatter head and lower, more slitlike eye of latter. C = X-Y plot of upper tooth row counts (y-axis) versus lower tooth row counts (x-axis) for A – *Hemitriakis abdita*, F – *H. falcata*. For detailed tooth row counts and statistics see Table 3.

concave supraorbital crest; lower, less ventrally-arching postorbital processes; more longitudinal sphenopterotic ridges; less laterally expanded suborbital shelves; narrower otic capsules. Differences between the crania of these two species mostly reflect the larger orbits of *H. falcata*. Comparison of the crania of *H. abdita* and *H. falcata* from radiographs suggest that the former species has a longer rostrum (medial rostral cartilage 59-63% of nasobasal length in 2 late juvenile specimens versus 45% in a dissected cranium of an adult *H. falcata*).

Male *Hemitriakis japanica* apparently mature at a larger size than *H. falcata* and may possibly grow larger. According to Chen & Mizue (1973) male *H. japanica* mature at about 850 mm and reach 1100 mm TL. However, a specimen of *H. japanica* from Taiwan was adult (or nearly so) at 675 mm (USNM 191193). Adults of *H. leucoperiptera* (adult female at 960 mm TL) and the New Caledonian *Hemitriakis* (adult male 860 mm TL) also attain a larger size than known *H. falcata* but maximum size is not known for any of these taxa and size at maturity is unknown for *H. leucoperiptera* and the New Caledonian *Hemitriakis*.

The taxonomic status of the New Caledonian *Hemitriakis* is somewhat problematical, but it is probably not conspecific with *H. leucoperiptera*, *H. japanica* and *H. falcata*. It is most similar to the geographically close *H. abdita* in general morphology and vertebral counts except for its slightly higher PC and MP counts and possibly narrower eyes. It may be conspecific with *H. abdita* and the few differences between it and *H. abdita* might be size-related and a result of our small sample. The largest *H. abdita* from the Coral Sea Plateau is a 596 mm adolescent male while the New Caledonian specimen is an 860 mm adult male. Until a wider series of *H. abdita* becomes available and direct comparison of *H. abdita* and New Caledonian material is possible we refer the New Caledonian specimen to *H.* sp. near *abdita* as a temporary expedient.

The Philippine high vertebral count *Hemitriakis* is still problematical because of its inadequate sample of four fetuses (SU 40097). The precaudal vertebral counts recorded here for one of these fetuses strengthens Compagno's (1988) suggestion that they represent an undescribed species of *Hemitriakis*.

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APPENDIX

Table 1. *Hemitriakis falcata* n.sp. Total lengths, weights and proportions as percent of total length for holotype and nine paratypes.

	Holotype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype
Coll. No.	WAM P 26271 -001	CSIRO CA 4056	WAM P 26274 -007	CSIRO H1094 -01	CSIRO H1035 -18	CSIRO H1035 -17	CSIRO H1035 -16	CSIRO H977 -9	CSIRO H1036 -27	CSIRO H1036 -26
SEX/M	M 4	M 2	F 2	M 2	M 4	M 4	M 4	M 4	M 4	M 4
WTgm	1024	44	36	141	1150	1260	1100	1300	1350	1450
TL mm	770	251	258	380	695	724	740	744	760	773
PCL	77.9	77.7	77.5	78.7	78.6	79.1	78.5	78.4	78.9	79.0
PRN	4.0	4.8	4.3	4.5	4.5	3.9	4.2	4.0	3.7	4.1
POR	6.6	8.8	7.8	7.6	7.3	6.8	6.6	6.6	6.4	6.7
POB	6.1	8.0	7.0	8.7	7.8	6.4	6.5	6.3	6.7	6.9
PSP	10.4	13.5	11.2	11.8	11.9	10.5	10.0	10.3	10.5	10.9
PGI	15.1	17.9	16.3	16.3	17.3	15.6	14.3	15.1	15.7	15.7
HDL	19.5	23.5	19.0	19.7	20.6	18.9	17.7	18.3	18.9	18.8
PP1	18.8	20.7	18.6	19.2	20.3	18.2	16.2	17.5	18.7	18.0
PP2	42.5	44.2	41.9	42.9	45.3	42.8	40.5	41.3	43.2	42.7
SVL	44.4	45.8	43.8	44.7	46.9	44.9	42.7	43.4	44.7	46.2
PAL	60.6	61.8	58.9	62.9	63.5	61.6	60.0	58.9	61.8	62.9
PD1	26.0	29.1	27.9	27.9	28.1	26.9	25.7	25.5	27.0	29.1
PD2	59.7	59.4	57.4	60.5	61.2	59.3	60.3	59.5	60.3	60.8
IDS	24.4	21.5	19.8	24.2	23.0	23.6	25.8	24.5	24.5	23.8
DCS	9.9	10.0	10.5	11.3	9.8	10.2	10.8	10.6	10.8	11.0
PPS	21.0	19.5	17.8	20.0	21.2	20.0	18.6	20.2	20.3	21.0
PAS	14.3	13.1	12.0	15.5	12.7	14.2	13.8	13.2	13.4	13.7
ACS	8.8	8.8	8.5	10.5	8.5	8.6	9.3	8.9	9.9	9.1
EYL	3.0	5.2	4.7	3.9	3.2	3.6	3.1	3.4	3.0	3.0
EYH	1.3	2.4	1.6	1.8	1.4	1.5	1.4	1.6	1.6	1.3
INO	6.8	8.8	7.4	7.4	6.9	7.3	6.8	7.5	6.1	6.1
NOW	1.4	2.4	1.6	1.8	1.7	1.7	1.4	1.6	1.7	1.6
INW	3.5	4.8	4.7	4.2	4.0	3.9	3.6	3.6	3.7	3.8
ANF	0.6	0.6	0.4	0.8	0.6	0.6	0.7	0.7	0.7	0.5
SPL	0.4	0.6	0.5	0.5	0.5	0.6	0.3	0.5	0.7	0.5
ESL	0.6	0.8	0.6	0.9	0.9	0.8	0.7	0.7	0.7	0.8
MOL	2.3	2.8	3.1	2.1	2.4	2.6	2.2	2.6	2.2	2.2
MOW	5.6	6.8	7.0	5.8	5.9	5.8	5.9	5.9	5.8	5.6
ULA	2.2	3.2	3.1	2.4	2.6	2.3	2.4	2.6	2.5	2.5
LLA	1.4	1.6	1.6	1.8	1.3	1.4	1.5	1.5	1.3	1.4
GS1	1.8	2.0	1.7	2.1	1.9	2.3	2.0	1.9	2.0	2.1
GS2	1.8	2.4	1.9	2.1	1.9	2.6	2.0	2.0	2.1	2.3
GS3	1.8	2.0	1.9	2.1	2.0	2.6	2.3	2.3	2.1	2.3
GS4	1.9	1.6	1.6	1.8	1.9	2.2	2.0	2.2	2.0	1.9
GS5	1.4	1.2	1.1	1.3	1.3	1.5	1.5	1.5	1.3	1.3
HDH	7.8	–	6.2	–	8.3	8.6	7.8	8.6	8.7	7.9
HDW	9.5	–	10.9	–	11.1	10.6	10.5	11.3	9.3	10.2
TRH	8.2	8.4	8.5	8.7	10.6	10.1	8.4	9.3	8.9	8.9
TRW	6.8	8.8	7.0	8.4	9.9	9.0	7.8	9.1	8.9	8.9
CPH	2.3	–	2.3	–	2.3	2.3	2.2	2.2	2.2	2.5
CPW	1.7	–	1.6	–	1.9	1.9	1.6	2.4	2.0	2.1
GIR	23.6	29.5	19.8	27.6	30.2	30.4	27.0	29.8	28.9	28.5
P1L	9.5	8.8	10.1	8.7	8.6	8.6	9.1	8.5	8.3	8.5
P1A	13.6	11.6	12.0	11.8	13.5	13.1	14.1	12.9	13.4	13.5
P1B	4.4	4.0	3.9	3.2	4.0	4.7	4.1	3.8	3.8	4.3
P1H	10.1	9.6	9.7	10.0	10.1	11.0	12.2	11.3	9.3	10.3
P1I	4.3	5.2	6.6	6.3	3.9	4.7	5.4	4.7	3.9	4.1
P1P	10.1	8.0	8.1	8.7	10.2	10.1	10.9	10.1	10.4	10.7
P2L	9.0	8.8	8.9	9.2	9.2	8.7	9.2	8.9	8.6	8.7
P2A	6.6	5.6	7.0	6.6	5.9	6.1	7.2	5.9	5.8	6.0
P2B	6.2	4.0	4.3	4.7	5.5	4.7	5.4	5.1	5.1	5.3

Table 1 (cont'd).

	Holotype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype	Paratype
Coll. No.	WAM P 26271 -001	CSIRO CA 4056	WAM P 26274 -007	CSIRO H1094 -01	CSIRO H1035 -18	CSIRO H1035 -17	CSIRO H1035 -16	CSIRO H977 -9	CSIRO H1036 -27	CSIRO H1036 -26
P2H	3.6	2.8	3.9	3.2	4.9	4.1	3.5	4.0	3.8	4.1
P2I	2.7	4.8	3.9	4.2	4.0	3.3	3.0	2.6	3.7	3.5
P2P	4.7	4.8	3.9	4.2	5.0	5.1	4.5	5.4	4.5	4.9
CLO	6.5	1.6	–	2.4	6.0	7.3	7.4	7.3	7.1	6.6
CLI	10.1	5.6	–	5.3	10.5	10.9	11.2	10.9	10.9	10.9
CLB	1.4	0.8	–	0.8	1.4	1.4	1.4	1.2	1.2	1.3
D1L	14.2	12.4	12.4	13.4	14.7	13.8	13.4	14.0	13.9	14.4
D1A	13.0	10.4	11.6	11.8	13.4	13.0	13.0	13.2	12.4	13.3
D1B	10.0	9.2	8.9	9.5	10.4	10.1	9.2	10.2	10.0	10.5
D1H	6.1	6.4	7.0	8.4	7.8	8.1	7.7	8.5	8.4	8.3
D1I	4.2	4.0	3.9	4.2	4.7	3.9	4.3	3.9	4.6	4.1
D1P	7.1	6.0	8.5	7.1	7.8	9.5	9.5	9.4	9.1	9.4
D2L	12.9	12.4	12.0	11.3	12.8	13.1	12.3	12.5	11.7	12.2
D2A	12.1	10.0	10.9	10.3	11.4	11.7	11.4	11.6	10.4	10.9
D2B	9.2	8.4	8.9	8.4	9.2	9.5	8.8	9.3	8.2	8.9
D2H	6.4	4.8	5.4	6.3	6.2	6.4	6.4	6.5	5.9	6.0
D2I	3.5	2.8	3.1	3.7	3.6	3.6	3.9	3.2	3.6	3.2
D2P	6.0	4.8	5.8	5.8	6.9	7.2	6.2	7.1	6.6	6.2
ANL	10.3	9.2	9.7	7.9	9.4	9.3	9.9	10.5	8.8	9.3
ANA	8.8	8.4	8.1	6.3	8.3	8.1	8.6	–	7.8	7.5
ANB	7.1	7.2	7.0	5.5	6.8	6.5	8.5	8.9	6.3	6.7
ANH	3.9	2.8	2.7	3.2	3.5	3.7	3.4	3.8	3.7	3.4
ANI	2.5	2.8	2.7	2.6	2.9	2.6	2.7	–	2.5	2.5
ANP	6.0	3.2	3.5	2.9	3.7	3.6	3.9	–	3.2	3.8
CDM	21.4	20.3	21.3	21.6	21.3	20.9	21.2	21.5	20.5	20.6
CPV	11.2	9.2	9.3	9.5	10.2	9.8	10.7	9.1	10.1	10.1
CPL	2.5	1.2	1.9	2.1	2.7	2.6	2.2	3.1	2.8	2.6
CPU	2.1	7.6	7.8	9.5	8.1	8.1	7.8	8.2	8.8	8.0
CST	4.0	4.0	4.3	3.7	3.7	3.9	3.8	3.8	3.3	3.5
CTR	5.7	4.8	5.0	5.8	6.6	6.5	5.7	6.2	6.3	6.2
CTL	7.7	6.8	7.0	7.4	7.8	8.0	8.0	7.8	7.8	8.0
CFL	8.8	7.6	8.9	8.7	8.3	8.3	8.6	7.4	7.8	8.3
DPI	7.3	9.2	7.4	10.5	9.5	7.7	8.6	8.1	7.9	9.3
DPO	13.1	11.6	10.9	9.5	12.1	12.2	10.4	12.6	12.4	11.5
PDI	9.1	8.8	8.5	9.5	9.6	9.4	10.1	11.6	9.7	9.4
PDO	14.5	12.0	12.4	14.5	13.4	14.4	15.5	13.7	14.5	13.8
DAO	1.0	2.4	1.6	1.1	2.6	2.8	1.4	1.5	2.1	3.0
DAI	0.4	0.4	0.4	–	–	0.7	–	0.9	–	0.5
FOR	86.0	86.1	84.1	86.3	85.8	85.5	85.9	85.5	85.5	86.5

Table 2. *Hemitriakis* spp. Total lengths, weights and proportions as percent of total length for holotype and four paratypes of *H. abdita* n.sp., *Hemitriakis* sp. near *abdita* from New Caledonia (MNHN1986-720), and partial data for *H. japanica*.

	H. abdita					*H. sp*		*H. japanica*				
	Holotype	Paratype	Paratype	Paratype	Paratype							
Coll. No.	CSIRO H1365 -03	CSIRO H1366 -01	CSIRO H1365 -01	CSIRO H1365 -02	CSIRO H1368 -01	MNHN 1986-720	LACM SPA F422	SU 12677	USNM 191193	LJVC 0421	LJVC 0420	LJVC 0419
SEX/M	M 3	M 2	M 2+	F 2	F 2	M 4	F 2	F 2	F ?	M 3	M 4	M 4
WTgm	512	119	244	336	423	–	495	–	–	–	–	–
TL mm	596	360	465	536	561	860	582	682	685	833	886	898
PCL	78.2	78.3	78.3	77.4	78.4	83.7	78.4	–	–	–	–	–
PRN	4.7	5.6	5.2	4.9	5.0	5.3	3.8	4.0	3.8	3.8	3.8	3.6
POR	7.7	8.9	8.2	7.8	7.8	7.1	6.4	6.6	6.7	6.2	6.4	6.3
POB	7.4	8.9	8.0	8.0	7.5	7.7	6.7	–	–	6.4	6.2	6.5
PSP	11.2	13.1	11.8	11.8	11.6	11.6	10.7	–	–	9.6	9.8	10.0
PGI	16.3	17.5	16.6	16.8	16.4	17.8	15.8	–	–	14.8	15.8	14.6
HDL	19.6	21.4	20.9	20.5	20.0	22.2	19.6	19.6	20.0	18.2	19.2	18.7
PP1	19.0	20.8	20.2	20.0	19.4	19.7	17.7	–	–	17.4	18.3	17.8
PP2	41.9	42.2	42.8	42.0	41.2	43.6	42.1	–	–	–	–	–
SVL	43.1	44.4	44.5	44.0	43.7	47.1	44.7	52.1	45.8	–	–	–
PAL	59.1	59.2	60.6	60.1	61.1	66.3	60.7	–	–	–	–	–
PD1	25.5	28.3	27.7	26.1	27.6	29.3	27.0	–	–	–	–	–
PD2	57.2	58.9	58.1	57.1	57.8	56.2	58.6	–	–	–	–	–
IDS	22.5	22.5	22.8	22.0	23.0	24.8	21.8	–	–	–	–	–
DCS	11.2	10.6	10.8	10.8	12.1	10.0	10.5	–	–	–	–	–
PPS	19.8	16.7	17.2	19.4	19.3	18.6	21.1	–	–	–	–	–
PAS	14.8	13.9	13.5	12.7	13.4	15.0	14.1	–	–	–	–	–
ACS	9.9	9.7	9.2	10.1	9.8	8.7	8.2	–	–	–	–	–
EYL	3.0	4.2	3.4	3.4	3.6	3.7	3.3	2.9	3.1	2.6	2.4	2.9
EYH	1.5	1.7	1.7	1.7	1.4	1.0	1.4	1.0	0.9	0.8	1.1	0.8
INO	6.9	8.3	8.0	6.9	7.0	6.7	6.9	6.6	7.6	5.6	6.1	6.0
NOW	1.8	1.9	2.2	1.7	2.0	1.9	1.7	1.6	1.5	1.6	1.5	1.3
INW	3.9	4.7	4.1	3.9	3.7	4.1	3.6	3.8	3.8	3.4	3.6	3.6
ANF	0.7	0.6	0.4	0.4	0.7	0.6	0.5	–	–	0.6	–	0.6
SPL	0.7	0.7	0.6	0.6	0.5	0.4	0.7	0.6	0.6	0.6	0.5	0.7
ESL	0.7	0.8	0.6	0.6	0.7	0.7	0.7	–	–	0.8	–	0.8
MOL	2.3	2.8	2.4	2.4	2.5	3.4	2.6	2.8	2.6	2.3	2.6	2.7
MOW	5.9	7.5	6.9	6.3	6.1	6.9	6.4	6.2	6.0	5.5	5.8	6.9
ULA	2.3	2.8	2.8	2.2	2.5	2.6	2.2	2.5	2.3	2.2	2.3	2.7
LLA	1.5	1.7	1.9	1.7	1.8	2.1	1.4	1.5	1.8	1.4	1.6	1.8
GS1	1.8	2.2	2.2	1.9	1.6	2.1	2.1	2.1	2.3	2.2	2.5	2.3
GS2	1.8	2.2	2.4	1.7	1.6	2.3	2.2	–	–	2.4	2.5	2.4
GS3	1.8	1.9	1.9	1.7	1.8	2.2	2.1	2.1	2.3	2.4	2.5	2.4
GS4	1.8	1.7	1.7	1.5	1.6	1.9	1.9	–	–	2.2	2.1	2.2
GS5	1.2	1.1	1.3	1.1	1.2	1.3	1.9	1.8	2.0	1.7	1.5	1.7
HDH	–	–	–	–	–	6.6	7.4	4.0	3.8	4.7	3.7	5.2
HDW	–	–	–	–	–	10.7	9.8	8.5	8.3	8.6	7.8	9.6
TRH	8.4	8.9	7.5	7.8	9.3	–	8.8	8.2	7.2	8.0	7.1	9.0
TRW	7.9	8.3	8.2	8.0	7.1	–	8.6	10.0	8.5	9.4	9.5	9.8
CPH	–	–	–	–	–	2.9	2.6	–	–	–	–	–
CPW	–	–	–	–	–	1.9	1.9	–	–	–	–	–
GIR	27.2	26.4	24.9	24.3	27.1	–	27.7	–	–	–	–	–
P1L	8.9	8.6	8.6	8.6	8.4	10.6	8.4	10.0	9.9	8.5	8.5	8.5
P1A	11.9	12.2	11.8	12.9	12.3	14.4	10.8	13.2	13.4	13.3	12.0	12.6
P1B	5.0	3.9	4.7	4.7	4.3	4.2	4.0	–	–	4.4	4.1	3.9
P1H	11.2	11.1	11.2	11.6	11.6	14.3	9.1	–	–	10.8	–	10.1
P1I	4.4	5.8	4.9	5.0	5.2	6.4	4.3	–	–	4.3	4.6	4.1
P1P	10.2	10.0	9.9	10.4	10.0	12.6	8.2	–	–	9.2	–	10.5
P2L	8.7	8.9	8.6	8.6	8.6	9.4	8.6	–	–	8.6	–	8.4
P2A	5.9	5.6	6.0	6.2	5.3	6.3	6.2	5.9	6.1	6.5	–	6.0
P2B	5.0	5.0	4.7	4.7	4.5	4.5	5.5	–	–	5.3	–	–

Table 2 (cont'd).

	H. abdita					*H.* sp		*H. japanica*				
	Holotype	Paratype	Paratype	Paratype	Paratype							
Coll. No.	CSIRO H1365 -03	CSIRO H1366 -01	CSIRO H1365 -01	CSIRO H1365 -02	CSIRO H1368 -01	MNHN 1986- 720	LACM SPA F422	SU 12677	USNM 191193	LJVC 0421	LJVC 0420	LJVC 0419
P2H	3.2	3.3	3.2	3.0	3.6	4.8	3.3	–	–	3.6	–	3.5
P2I	4.0	3.9	4.1	4.1	4.3	5.0	3.3	–	–	2.5	–	2.3
P2P	4.7	5.0	4.9	4.9	4.5	5.8	3.8	–	–	4.4	–	4.6
CLO	2.5	2.2	2.2	–	–	7.6	–	–	–	4.6	–	6.0
CLI	5.4	5.3	4.7	–	–	12.0	–	–	–	8.2	–	–
CLB	0.7	0.8	0.9	–	–	1.9	–	–	–	0.8	–	–
D1L	13.6	13.6	12.5	12.5	13.4	14.2	13.4	–	–	–	–	–
D1A	12.8	12.2	12.3	12.1	12.5	13.8	11.3	–	–	–	–	–
D1B	9.9	9.7	8.8	8.6	9.8	10.1	10.0	12.3	9.3	–	–	–
D1H	8.6	7.8	8.0	8.2	8.6	9.5	7.6	8.1	8.2	–	–	–
D1I	3.9	3.3	3.4	4.1	3.9	4.4	3.6	–	–	–	–	–
D1P	9.6	7.8	8.8	8.4	9.3	11.4	7.9	–	–	–	–	–
D2L	12.9	11.1	11.8	11.9	12.3	11.5	11.2	–	–	–	–	–
D2A	11.4	9.7	10.8	10.8	9.8	11.4	10.0	–	–	–	–	–
D2B	10.2	9.7	9.0	9.5	10.3	8.4	8.6	9.1	7.7	–	–	–
D2H	6.2	5.8	6.0	6.3	6.6	8.1	5.7	6.0	5.5	–	–	–
D2I	2.9	2.8	2.8	2.8	2.3	3.1	2.6	–	–	–	–	–
D2P	6.9	5.6	6.7	6.9	6.8	9.1	5.7	–	–	–	–	–
ANL	8.7	9.4	9.0	8.8	8.9	8.0	9.1	–	–	–	–	–
ANA	7.4	7.5	7.3	7.3	7.5	7.7	7.9	–	–	–	–	–
ANB	6.4	6.7	6.7	6.5	6.8	5.3	7.0	6.2	7.2	–	–	–
ANH	3.4	3.1	3.2	3.0	3.2	4.4	3.1	3.8	3.5	–	–	–
ANI	2.3	1.9	2.2	2.1	2.1	2.4	2.4	–	–	–	–	–
ANP	3.0	3.3	3.0	3.5	3.2	4.3	2.9	–	–	–	–	–
CDM	21.3	21.1	20.6	21.5	21.6	19.8	19.2	16.9	20.4	–	–	–
CPV	9.4	8.9	9.0	9.1	9.3	11.2	9.3	8.7	9.5	–	–	–
CPL	2.5	1.9	1.9	2.1	2.7	4.7	2.4	2.8	2.5	–	–	–
CPU	8.1	6.9	8.4	8.4	8.2	7.4	7.4	6.9	7.6	–	–	–
CST	4.0	4.2	3.7	4.1	4.1	4.1	4.0	3.7	3.8	–	–	–
CTR	5.5	5.8	6.2	6.2	6.4	6.5	5.2	6.5	7.0	–	–	–
CTL	7.7	7.5	7.5	7.8	8.0	7.9	7.6	7.8	8.0	–	–	–
CFL	9.1	8.6	8.2	8.6	8.7	8.8	7.9	–	–	–	–	–
DPI	8.7	6.7	8.4	7.8	10.9	5.8	11.2	10.4	10.7	–	–	–
DPO	12.1	10.3	9.9	12.3	8.6	12.8	10.3	11.3	11.7	–	–	–
PDI	8.2	7.5	8.2	8.8	9.3	9.9	8.9	9.7	9.2	–	–	–
PDO	13.9	13.9	14.6	12.9	13.0	12.8	14.4	12.2	13.0	–	–	–
DAO	3.4	1.9	1.9	2.8	2.5	2.2	2.1	3.2	0.9	–	–	–
DAI	–	–	–	–	1.1	–	0.7	0.7	1.0	–	–	–
FOR	86.1	86.1	85.6	85.1	85.4	–	85.6	–	–	–	–	–

Table 3. *Hemitriakis* spp., tooth row counts.

Hemitriakis japanica, Japan and Taiwan.

						Upper jaw			Lower jaw		
	SEX/M	T L	UT	LT	T T	AP	M	AP	AP	M	AP
USNM 191193	F	685	38	33	71	16	5	17	14	5	14
USNM 191193	M2	651	36	33	69	15	6	15	14	5	14
USNM 191193	M4	675	35	33	68	14	6	15	15	5	13
UMMZ-179060	M2	650	34	29	63	14	5	14	14	4	15
UMMZ-179061	F	560	36	32	68	15	5	16	14	4	14
UMMZ-179062	M2	505	33	33	66	15	1	18	13	1	15
SU-12677	F	682	35	29	64	16	5	15	12	5	12
LACM-F420	M2	350	34	32	66	15	4	15	13	5	14
LACM-F421	F2	582	36	32	68	15	5	16	13	5	14
LJVC-0419	M4	898	35	31	66	15	5	15	14	5	12
LJVC-0420	M4	886	38	30	68	16	5	17	12	5	13
LJVC-0421	M3	833	36	33	69	15	5	16	14	5	14
	range		33	29	63	14	1	14	12	1	12
			38	33	71	16	6	18	15	5	15
	mean		35.5	31.7	67.2	15.1	4.8	15.8	13.5	4.5	13.7
	SD		1.4	1.5	2.2	0.6	1.2	1.1	0.9	1.1	0.9
	SE		0.4	0.4	0.6	0.2	0.4	0.3	0.2	0.3	0.3
	CV		4.1	4.7	3.2	4.2	26.0	6.9	6.4	24.8	6.9
	N		12	12	12	12	12	12	12	12	12

Hemitriakis falcata, Western Australia

						Upper jaw			Lower jaw		
	SEX/M	T L	UT	LT	T T	AP	M	AP	AP	M	AP
WAM P76271-001	M4	770	35	31	66	15	5	15	13	5	13
WAM P76274-007	F2	600	31	33	64	14	5	12	14	5	14
CSIRO H1094-01	M2	380	31	32	63	14	4	13	14	4	14
CSIRO H1036-26	M4	773	29	26	55	13	3	13	12	3	11
CSIRO H977-01	M4	777	33	29	62	15	5	13	12	5	12
CSIRO H1036-27	M4	760	33	31	64	14	5	14	13	5	13
CSIRO H1035-18	M4	695	35	31	66	15	4	15	13	5	13
	range		29	26	55	13	3	12	12	3	11
			35	33	66	15	5	15	14	5	14
	mean		32.4	30.4	62.9	14.3	4.4	13.6	13.0	4.6	12.9
	SD		2.1	2.1	3.5	0.7	0.7	1.0	0.8	0.7	1.0
	SE		0.8	0.8	1.3	0.3	0.3	0.4	0.3	0.3	0.4
	CV		6.4	7.0	5.5	4.9	16.4	7.7	5.8	15.9	7.7
	N		7	7	7	7	7	7	7	7	7

Table 3 (cont'd).

Hemitriakis abdita, Queensland

	Sex/M	T L	UT	LT	T T	Upper jaw AP	Upper jaw M	Upper jaw AP	Lower jaw AP	Lower jaw M	Lower jaw AP
CSIRO H1365-01	M2	465	35	32	67	14	6	15	14	5	12
CSIRO H1365-02	F2	536	37	33	70	17	5	15	14	5	14
CSIRO H1365-03	M3	596	36	32	68	15	6	15	13	5	14
CSIRO H1366-01	M2	360	35	28	63	15	6	14	11	5	12
CSIRO H1368-01	F2	561	34	31	65	14	6	14	13	5	13
	range		34	28	63	14	5	14	11	5	12
			37	33	70	17	6	15	14	5	14
	mean		35.4	31.2	66.6	15.0	5.8	14.6	13.0	5.0	13.0
	SD		1.0	1.7	2.4	1.1	0.4	0.5	1.1	0.0	0.9
	SE		0.5	0.8	1.1	0.5	0.2	0.2	0.5	0.0	0.4
	CV		2.9	5.5	3.6	7.3	6.9	3.4	8.4	0.0	6.9
	N		5	5	5	5	5	5	5	5	5

Hemitriakis sp. near *abdita*, New Caledonia

	Sex/M	T L	UT	LT	T T	Upper jaw AP	Upper jaw M	Upper jaw AP	Lower jaw AP	Lower jaw M	Lower jaw AP
MNHN-1986-720	M4	860	35			17	1	17			

Table 4. *Hemitriakis* spp., vertebral counts and ratios.

Hemitriakis japanica, Japan and Taiwan.

	Sex/M	T L	MP	DP	DC	PC	TC	%MP	%DP	%DC	DP/MP	DC/MP	A	B
SU-12677	F2	682	42	65	52	107	159	26.4	40.9	32.7	1.5	1.2	122.9	66.2
UMMZ-179061	F2	560	43	63	54	106	160	26.9	39.4	33.8	1.5	1.3	132.1	71.2
UMMZ-179062	M2	505	42	62	52	104	156	26.9	39.7	33.3	1.5	1.2	94.6	77.8
UMMZ-179060	M2	650	41	65	53	106	159	25.8	40.9	33.3	1.6	1.3	128.2	75.8
USNM-191113	F2?	685	41	63	56	104	160	25.6	39.4	35.0	1.5	1.4	119.6	84.6
USNM-191113	M2	651	41	66	54	107	161	25.5	41.0	33.5	1.6	1.3	121.6	75.0
USNM-191113	M4	675	41	62	56	103	159	25.8	39.0	35.2	1.5	1.4	107.7	71.2
LACM F-421	F2	582	43	62	52	105	157	27.4	39.5	33.1	1.4	1.2	123.5	91.3
LACM F-422	F2	350	41	63	54	104	158	25.9	39.9	34.2	1.5	1.3	133.3	88.9
CAS-1971:VII-16	F2	231	41	61	56	102	158	25.9	38.6	35.4	1.5	1.4	144.4	76.5
CAS-1971:VII-22	F2	219	43	66	56	109	165	26.1	40.0	33.9	1.5	1.3	162.5	81.3
CAS-28576	F2	353	42	56	56	98	154	27.3	36.4	36.4	1.3	1.3	82.1	76.7
CAS-28576	M2	307	39	63	53	102	155	25.2	40.6	34.2	1.6	1.4	123.5	87.5
CAS-28576	M2	252	40	63	56	103	159	25.2	39.6	35.2	1.6	1.4	125.0	71.4
	range		39	56	52	98	154	25.2	36.4	32.7	1.3	1.2	82.1	66.2
			43	66	56	109	165	27.4	41.0	36.4	1.6	1.4	162.5	91.3
	mean		41.4	62.9	54.3	104.3	158.6	26.1	39.6	34.2	1.5	1.3	122.9	78.2
	S		1.1	2.4	1.6	2.6	2.6	0.7	1.1	1.0	0.1	0.1	18.8	7.2
	SE		0.3	0.6	0.4	0.7	0.7	0.2	0.3	0.3	0.0	0.0	5.0	1.9
	CV		2.7	3.8	3.0	2.5	1.6	2.7	2.9	3.0	4.8	4.3	15.3	9.3
	N		14	14	14	14	14	14	14	14	14	14	14	14

Hemitriakis leucoperiptera, Philippines

	Sex/M	T L	MP	DP	DC	PC	TC	%MP	%DP	%DC	DP/MP	DC/MP	A	B
SU-27118	M2	169	34	62	50	96	146	23.3	42.5	34.2	1.8	1.5	216.7	118.2
SU-27118	F2	170	35	59	50	94	144	24.3	41.0	34.7	1.7	1.4	137.5	100.0

Hemitriakis n.sp., Philippines

	Sex/M	T L	MP	DP	DC	PC	TC	%MP	%DP	%DC	DP/MP	DC/MP	A	B
SU-40097[3]	F1	161	44	72	–	116	–	–	–	–	1.6	–	–	–

Table 4 (cont'd).

Hemitriakis falcata, Western Australia

	SEX/M	T L	MP	DP	DC	PC	TC	%MP	%DP	%DC	DP/MP	DC/MP	A	B
WAM-P26271-001	M4	770	41	64	58	105	163	25.2	39.3	35.6	1.6	1.4	123.9	73.1
WAM-P26724-007	F2	258	41	64	60	105	165	24.8	38.8	36.4	1.6	1.5	146.2	86.4
CSIRO H1036.26	M4	773	38	65	55	103	158	24.1	41.1	34.8	1.7	1.4	150.0	93.5
CSIRO H1035.17	M4	724	37	66	55	103	158	23.4	41.8	34.8	1.8	1.5	114.8	75.6
CSIRO H977.01	M4	744	41	63	59	104	163	25.2	38.7	36.2	1.5	1.4	134.1	80.8
CSIRO H1035.16	M4	740	40	69	58	109	167	24.0	41.3	34.7	1.7	1.5	133.3	95.5
CSIRO H1036.27	M4	760	39	67	57	106	163	23.9	41.1	35.0	1.7	1.5	145.7	93.1
CSIRO H1035.18	M4	695	39	63	56	102	158	24.7	39.9	35.4	1.6	1.4	133.3	83.3
CSIRO H1904.01	M2	380	40	64	60	104	164	24.4	39.0	36.6	1.6	1.5	133.3	66.7
CSIRO CA4056	M2	251	38	63	58	101	159	23.9	39.6	36.5	1.7	1.5	155.6	70.0
	range		37	63	55	101	158	23.4	38.7	34.7	1.5	1.4	114.8	66.7
			41	69	60	109	167	25.2	41.8	36.6	1.8	1.5	155.6	95.5
	mean		39.4	64.8	57.6	104.2	161.8	24.3	40.1	35.6	1.6	1.5	137.0	81.8
	S		1.4	1.9	1.7	2.1	3.1	0.6	1.1	0.7	0.1	0.0	11.8	9.8
	SE		0.4	0.6	0.6	0.7	1.0	0.2	0.4	0.2	0.0	0.0	3.7	3.1
	CV		3.4	2.9	3.0	2.0	1.9	2.3	2.8	2.0	4.9	2.2	8.6	12.0
	N		10	10	10	10	10	10	10	10	10	10	10	10

Hemitriakis abdita, Queensland

	SEX/M	T L	MP	DP	DC	PC	TC	%MP	%DP	%DC	DP/MP	DC/MP	A	B
CSIRO H1365.03	M3	596	51	78	58	129	187	27.3	41.7	31.0	1.5	1.1	124.0	68.9
CSIRO H1368.01	F2	561	53	77	63	130	193	27.5	39.9	32.6	1.5	1.2	115.0	53.5
CSIRO H1365.01	M2	465	49	77	60	126	186	26.3	41.4	32.3	1.6	1.2	133.3	70.6
CSIRO H1366.01	M2	360	48	78	60	126	186	25.8	41.9	32.3	1.6	1.3	125.0	55.6
CSIRO H1365.02	F2	536	49	78	62	127	189	25.9	41.3	32.8	1.6	1.3	127.3	66.7
	range		48	77	58	126	186	25.8	39.9	31.0	1.5	1.1	115.0	53.5
			53	78	63	130	193	27.5	41.9	32.8	1.6	1.3	133.3	70.6
	mean		50.0	77.6	60.6	127.6	188.2	26.6	41.2	32.2	1.6	1.2	124.9	63.0
	S		1.8	0.5	1.7	1.6	2.6	0.7	0.7	0.6	0.1	0.0	5.9	7.1
	SE		0.8	0.2	0.8	0.7	1.2	0.3	0.3	0.3	0.0	0.0	2.7	3.2
	CV		3.6	0.6	2.9	1.3	1.4	2.6	1.7	1.9	3.8	3.8	4.7	11.3
	N		5	5	5	5	5	5	5	5	5	5	5	5

Hemitriakis sp. near *abdita*, New Caledonia

	SEX/M	T L	MP	DP	DC	PC	TC	%MP	%DP	%DC	DP/MP	DC/MP	A	B
MNHN-1986-720	M4	860	57	75	54	132	186	30.6	40.3	29.0	1.3	0.9	121.7	74.7