

A hermaphroditic Port Jackson shark, *Heterodontus portusjacksoni*, with complete and separate female and male reproductive tracts

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One of 353 Port Jackson sharks, *Heterodontus portusjacksoni*, caught off the southern coast of Western Australia, was a hermaphrodite. The female reproductive tract consisted of a large (functional) right ovary with three large yolked ova, a small non-functional left ovary and two well-developed uteri and oviducal glands. The male tract comprised two conspicuous but undeveloped testes, two vas deferens and two calcified claspers with grooves. This individual represents the first published example of hermaphroditism in the order Heterodontiformes and is a rare example of an elasmobranch with a complete suite of both male and female reproductive structures.

Hermaphroditism, i.e. the possession by an individual of recognizable ovarian and testicular tissue, is rare among elasmobranchs (Atz, 1964). However, there have been different expressions of the hermaphrodite theme in elasmobranchs and this has sometimes been accompanied by the use of different terminologies for comparable conditions in different taxa. Recently, Iglésias et al. (2005) reported that, among 82 specimens of the catshark *Apristurus longicephalus*, 95% possessed a pair of claspers and were thus recorded as males. However, when these authors dissected 80 of these individuals, they found that 85% possessed 'simultaneously both the female and male genital apparatus' and they thus regarded this species as hermaphroditic. The adults with developed claspers and thin oviducts always contained developed testes and were thus designated as functional males. In contrast, individuals with small claspers and developed oviducts always had one developed ovary, but, from their descriptions, photographs and figures, apparently no testes. These were termed functional females. Such individuals, which have been found in the lantern shark *Etmopterus unicolor*, were termed abnormal females by Yano & Tanaka (1989). Following the same approach, Yano (1995) regarded, as abnormal males, those individuals of the black dogfish *Centroscyllium fabricii*, which possessed claspers and both ovarian and testicular tissues within the same gonad.

Recently, an individual of the Portuguese dogfish *Centroscymnus coelolepis* was found with a single ovary, oviduct, oviducal gland and uterus on its right side and a single testis on its left side, but no claspers externally (Verissimo et al., 2003). An individual of both the blue shark *Prionace glauca* and the southern lantern shark *Etmopterus baxteri* were discovered to possess separate male and female reproductive tracts internally and two claspers externally (Pratt, 1979; Irvine, 2004). However, the female and male gonads of the blue shark were immature, while the single ovary and two testes in the southern lantern shark were located on the left and right sides of the body cavity, respectively.

The Port Jackson shark *Heterodontus portusjacksoni* (Meyer) is endemic to Australian waters, south of latitude 28°30'S (Last & Stevens, 1994). This short communication describes a Port Jackson shark, which possessed complete female and male reproductive systems internally and claspers externally and is one of the very few recorded examples of an elasmobranch with these particular hermaphroditic characteristics. It is also the first record of hermaphroditism in the order Heterodontiformes.

A total of 353 *Heterodontus portusjacksoni* was obtained from the by-catches of commercial prawn trawl and demersal gill-net and longline vessels, operating in depths of 12 to 75 m off the south-western Australian coast. One of the individuals caught in November 2003 at a depth of 70 m at 35°07'S 118°05'E was a hermaphrodite.

The total length, total body weight and lengths of left and right claspers (i.e. distance between their distal tip and point of insertion in the pelvic fin) of the hermaphrodite were recorded. Lengths and weights were recorded to the nearest 1 mm and 10 g respectively.

The internal reproductive tracts of the hermaphrodite were removed and the weights, number and size of their components recorded (Table 1). For comparisons, the same

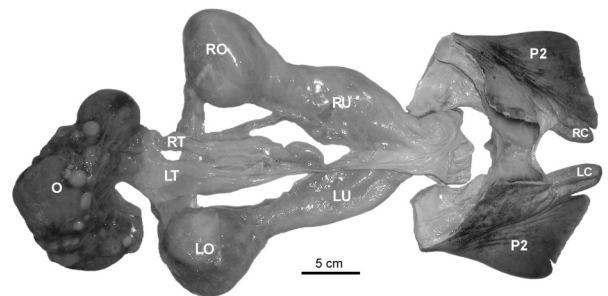


Figure 1. Dorsal view of reproductive organs of the hermaphrodite of *Heterodontus portusjacksoni*. LC, left clasper; LO, left oviducal gland; LT, left testes; LU, left uterus; O, largest ova in the ovary; P2, pelvic fin; RC, right clasper; RO, right oviducal gland; RT, right testes; RU, right uterus.

Table 1. Comparisons between measurements and weights recorded for the hermaphrodite and six mature females and five mature males of *Heterodontus portusjacksoni*, all of which were caught in November 2003. Note that widths of the left and right uteri of mature females were measured on two other individuals that were 982 and 992 mm long and thus of similar size to the hermaphrodite.

	Hermaphrodite	Mature females	
		Mean	Range
Total length (mm)	924	952	918–990
Total weight (g)	6500	7835	7120–8560
Weight of right (functional) ovary (g)	188	220	170–313
Number of large yolked ova in the right functional ovary	3	3	1–4
Maximum ovum diameter (mm)	47	44	42–47
Mean width of oviducal glands (mm)	63	71	60–85
Width of left uterus (mm)	36	35	35 and 35
Width of right uterus (mm)	44	34	34 and 34

	Hermaphrodite	Mature males	
		Mean	Range
Total length (mm)	924	687	627–720
Total weight (g)	6500	2277	1666–2734
Weight of left testis (g)	11	12	11–16
Weight of right testis (g)	5	13	11–17
Left clasper length (mm)	29	78	71–84
Right clasper length (mm)	10	78	71–84

data were recorded for six normal mature females and five normal mature males in the same catch. The females were considered mature because they contained large yolked ova, enlarged uteri and, in four individuals, also *in utero* egg cases, while the males were regarded as mature because they possessed well-developed calcified claspers, lobular testes and a tightly coiled vas deferens. Weights and dimensions were recorded to the nearest 0.1 g and 0.1 mm, respectively and their means were corrected to the nearest 1 g and 1 mm.

The total length of the hermaphrodite, 924 mm, lies within the length-range of the six mature females taken in the same catch, but is substantially greater than both the 720 mm recorded for the largest of the five mature males in that catch and the maximum length of 785 mm recorded for any of the 153 males collected throughout the study.

The hermaphrodite possessed a large and well-developed right ovary, a small and undeveloped left ovary and left and right oviducts, oviducal glands and enlarged uteri (Figure 1), all of which are typical of normal mature females of *H. portusjacksoni*. The weight of the right (functional) ovary, the number of large yolked ova, the maximum ovum diameter and the mean width of the pair of oviducal glands all lie within the range of values recorded for the corresponding variables in the six normal mature females caught in the same month (Table 1). The widths of the left and right uteri of the hermaphrodite were similar to, or greater than, those of two normal mature females of similar length (Table 1).

From the above comparisons, it is concluded that the female reproductive tract of this hermaphrodite is mature.

The hermaphrodite contained two small and immature testes, poorly-developed and strand-like vas deferens and two calcified claspers with prominent grooves (Figure 1). These typical male reproductive structures were far better developed in the five normal mature males. The left testis of the hermaphrodite was heavier than its right testis and they collectively weighed far less than the collective weights of the two similarly sized testes of the five normal mature males (Table 1). Furthermore, the length of the longest clasper of the hermaphrodite was less than half that of the minimum length of those of the normal mature males (Table 1). It is thus evident that, in the hermaphrodite of *H. portusjacksoni*, the male reproductive structures are not as well developed as the female reproductive structures.

The presence of separate male and female gonads internally and claspers externally in the hermaphroditic *H. portusjacksoni* parallels the situations recorded for *P. glauca* by Pratt (1979), for *E. baxteri* by Irvine (2004) and for *A. longicephalus* by Iglésias et al. (2005). However, unlike the hermaphrodite of *P. glauca*, that of *H. portusjacksoni* possessed mature female organs and, unlike the hermaphrodite of *E. baxteri* and the hermaphrodites of *A. longicephalus*, it contained a full and separate complement of both female and male reproductive organs. Despite the diversity and abundance of elasmobranch fauna in Australian waters, our hermaphroditic *H. portusjacksoni*, together with the individuals of *E. baxteri* and *A. longicephalus*, represent the only three recorded examples of hermaphroditism in elasmobranchs in these waters.

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REFERENCES

- Atz, J.W., 1964. Intersexuality in fishes. In *Intersexuality in vertebrates including man* (ed. C.N. Armstrong and A.J. Marshall), pp. 145–232. London: Academic Press.
- Iglésias, S.P., Sellos, D.Y. & Nakaya, K., 2005. Discovery of a normal hermaphroditic chondrichthyan species: *Apristurus longicephalus*. *Journal of Fish Biology*, **66**, 417–428.
- Irvine, S.B., 2004. *Age, growth and reproduction of deepwater dogfishes from southeastern Australia*. PhD thesis, Deacon University, Warrnambool, Australia.
- Last, P.R. & Stevens, J.D., 1994. *Sharks and rays of Australia*. Hobart: CSIRO Division of Fisheries.
- Pratt, H.L., 1979. Reproduction in the blue shark, *Prionace glauca*. *Fisheries Bulletin*, **77**, 445–470.
- Verissimo, A., Gordo, L. & Figueiredo, I., 2003. Reproductive biology and embryonic development of *Centroscymnus coelolepis* in Portuguese mainland waters. *ICES Journal of Marine Science*, **60**, 1335–1341.
- Yano, K., 1995. Reproductive biology of the black dogfish, *Centroscyllium fabricii*, collected from waters off western Greenland. *Journal of the Marine Biological Association of the United Kingdom*, **75**, 285–310.
- Yano, K. & Tanaka, S., 1989. Hermaphroditism in the lantern shark *Etmopterus unicolor* (Squalidae, Chondrichthyes). *Japanese Journal of Ichthyology*, **36**, 338–345.

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