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Title: Table of ray identification schemes for nonluidiid Asteroidea

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Many schemes for numbering and lettering of asteroid rays have been used. This diversity makes comparison of research findings on the behavior of starfish difficult and subject to mistakes. To assist in this matter I offer the following table. I have tried to include reference to the leading proponent of the various numbering schemes, but this is of course a matter of personal judgment. Because this table was collated in connection with examining the literature on leading rays in starfish, the cited literature is partly relevant to that topic. Luidiid asteroids are excluded because the madreporite in luidiidids is not in homologous location compared with non-luidiidids (see Hotchkiss 1998). I use a personal communication from Dr. E.W. Knight-Jones (June 1999), and also the M.Sc. thesis of Thorpe (1964), to inform me that Smith (1950) employed the numbering scheme of embryologists (i.e. Gemmill 1914, Chadwick 1923).

Literature cited:

- Bather, F.A. 1900. General description of the Echinoderma. Pp. 1-37 in E. R. Lankester, ed. A treatise on zoology, part III, the Echinodermata. Adam & Charles Black.
- Chadwick, H.C. 1923. Asterias. Liverpool Marine Biology Committee Memoirs on Typical British Marine Plants and Animals 25:1-63 + pls. 1-9.
- Coe, W.R. 1912. Echinoderms of Connecticut. Connecticut State Geol. Nat. Hist. Survey Bulletin No. 19, 152 pp.
- Cole, L.J. 1913. Direction of locomotion of the starfish (*Asterias forbesi*). The Journal of Experimental Zoölogy 14:1-32.
- Cuénnot, L. 1912. Contributions à la faune du bassin d'Arcachon. V. Échinodermes. Bulletin de la Station Biologique d'Arcachon, 14th year [1911-12]:17-116.
- Delage, Y. and E. Hérouard. 1903. Traité de Zoologie Concrète. Tome III. Les Échinodermes. Schleicher Frères, Paris.
- Gemmill, J. F. 1914. The development and certain points in the adult structure of the starfish *Asterias rubens* L. Philosophical Transactions of the Royal Society of London, series B, 205:213-294, pls. 18-24.
- Hotchkiss, F. H. C. 1979. Case studies in the teratology of starfish. Proceedings of the Academy of Natural Sciences of Philadelphia 131:139-157.

	Clockwise → → oral view						Clockwise → → aboral view						
	BIVIUM			TRIVIUM			R/P	TRIVIUM			BIVIUM		
Coe 1912; Schuchert 1915							R/P						
Preyer 1886-7; Schuchert 1915	1	M	5	4	3	2	R/P	2	3	4	5	M	1
Ludwig 1899; Kjerschow-Agersborg 1922; Rodenhouse & Guberlet 1946	I	M	V	IV	III	II	R/P	II	III	IV	V	M	I
Jennings 1907; Cole 1913	a	M	e	d	c	b	R/P	b	c	d	e	M	a
Polis & Goner 1975; Zirpolo 1928	A	M	E	D	C	B	R/P	B	C	D	E	M	A
Gemmill 1914; Chadwick 1923; Reid 1950; Smith 1950	I	M	II	III	IV	V	R/P	V	IV	III	II	M	I
Knight-Jones (pers. comm); Jones et al. 1968	1	M	2	3	4	5	R/P	5	4	3	2	M	1
Lovén 1874 Delage & Hérouard 1903	II	M	III	IV	V	I	R/P	I	V	IV	III	M	II
Bather 1900; Cuénot 1912; Hyman 1955	C	M	D	E	A	B	R/P	B	A	E	D	M	C
Moore & Fell 1966 Hotchkiss 1979, 1995, 1998	D	M	E	A	B	C	R/P	C	B	A	E	M	D
O'Donoghue 1926	R.1	M	A	L.1	L.2	R.2	R/P	R2	L2	L1	A	M	R.1

- Hotchkiss, F.H.C. 1995. Lovén's law and adult ray homologies in echinoids, ophiuroids, edrioasteroids and an ophiocistiid (Echinodermata: Eleutherozoa). Proceedings of the Biological Society of Washington 108:401-435.
- Hotchkiss, F.H.C. 1998. A "rays-as-appendages" model for the origin of pentamerism in echinoderms. *Paleobiology* 24:200–214.
- Hyman, L. H. 1955. The invertebrates: Echinodermata. Volume IV. McGraw-Hill, New York, 763 pp.
- Jennings, H.S. 1907. Behavior of the starfish, *Asterias forneri* de Loriol. University of Calif. Publications in Zoology 4(2):53-185.
- Jones, D.A., E.W. Knight-Jones, J. Moyse, P.C. Babbage, and A.R.D. Stebbing. 1968. Some biological problems in the Aegean. Underwater Association Report, Malta 1968:73-78
- Kjerschow-Agersborg, H. P. 1922. The relation of the madreporite to the physio-logical anterior end in the twenty-rayed starfish *Pycnopodia helianthoides* (Stimpson). *Biol. Bulletin* 42:202 216.
- Knight-Jones, E. W. And D. H. Thorpe. 1964. Orientation of locomotion in echinoderms. Challenger Society, London, Annual Report and Proceedings 3(16):27.
- Lovén, S. 1874. Études sur les échinoidées. Kongelige Svenska Vetenskaps-Akademiens Handlingar, new series, 11(7):1-91 + pls. 1-53.
- Ludwig, H. 1899. Klasse Asteroidea, Seesterne. Pp. 461-744 + 12 plates in H. G. Bronn (ed.) Klassen und Ordnungen des Thierreiches, Buch 2, Die Seesterne,. Leipzig.
- Moore, R. C. and H. B. Fell. 1966. Homology of echinozoan rays. Pp. U119-U131 in R. C. Moore, ed., Treatise on Invertebrate Paleontology, Part U, Echinodermata 3, volume 1. The Geological Society of America and The University of Kansas Press, Lawrence, Kans.
- O'Donoghue, C.H. 1926. On the summer migration of certain starfish in Departure Bay, B.C. Fisheries Res. Board of Canada, Contrib. to Canadian Biology 1:455-472.
- Polls, I. And J. Gonor. 1975. Behavioral aspects of righting in two asteroids from the Pacific coast of North America. *Biological Bulletin* 148:68-84.
- Preyer, W. 1886-7. Über die Bewegungen der Seesterne. Zweite Hälfte. Mitth. A. D. Zool. Station z. Neapol. 7:191-233 + pl. 7.
- Reid, W. M. 1950. *Asterias forbesi*. Pp. 515-523 in F. A. Brown, ed. Selected invertebrate types. John Wiley and Sons, New York.
- Rodenhouse, I. Z. and J. E. Guberlet. 1946. The morphology and behavior of the cushion star *Pteraster tesselatus* Ives. University of Washington Publ. in Biology 12:21-48.
- Schuchert, C. 1915. Revision of Paleozoic Stelleroidea with special reference to North American Asteroidea. United States National Museum Bull. 88:1-311, pls. 1-38.
- Smith, J. E. 1950. Some observations on the nervous mechanisms underlying the behaviour of starfishes. Pp. 196-220 in J. F. Danielli and R. Brown (eds.) Physiological mechanisms in animal behaviour. Symposia of the Society for Experimental Biology No. IV. Academic Press, New York. 482 pp.
- Thorpe, D.H. 1964. Orientation of locomotion in echinoderms. Unpublished M.Sc. thesis, Department of Zoology, University College of Swansea, University of Wales, April 1964, 54pp.
- Zirpolo, G. 1928. Caso di eteromorfosi in un *Astropecten aurantiacus* L. Bollettino della Società dei Naturalisti in Napoli. 39(ser. 2, vol. 19): 195-206 + pl. 17

EXPLANATORY POSTSCRIPT TO TABLE (13 April 2014): M = madreporic interradius. R = interradius of hydrocoel closure (hydrocoel crescent forms the ring canal). P = interradius of periproct/anus.