DEEP WATER SKATES OF MADAGASCAR. PART 3. RAJIDAE (PISCES, CHONDRICHTHYES, BATOIDEA). *RAJA (DIPTURUS) CROSNIERI* SP. N.

by

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ABSTRACT. - A new species of deep water skate, *Raja (Dipturus) crosnieri*, is described from 23 specimens, juveniles and adults of both sexes, trawled on the continental slopes of the north-western coast (off Nosy Be) and south-western coast (off Tulear) of Madagascar, between 300 and 850 m depth. The taxonomic status of subgenera *Dipturus* Rafinesque, 1810, and *Okamejei* Ishiyama, 1958, is discussed and the new species is compared to its congeners of subgenus *Dipturus*.

RÉSUMÉ. - Une nouvelle espèce de raie bathyale, *Raja (Dipturus) crosnieri*, est décrite à partir de 23 spécimens, juvéniles et adultes des deux sexes, chalutés sur les pentes continentales des côtes nord-ouest (au large de Nosy Be) et sud-ouest (au large de Tulear) de Madagascar, entre 300 et 850 m de profondeur. Le statut taxinomique des sous-genres *Dipturus* Rafinesque, 1810 et *Okamejei* Ishiyama, 1958, est discuté et la nouvelle espèce est comparée à ses congénères du sous-genre *Dipturus*.

Key-words : Rajidae, *Raja (Dipturus) crosnieri*, ISW, Malagasy Rep., Taxonomy, New species.

Seret (1986 a) recorded three juvenile specimens of a new skate of the subgenus *Dipturus* of genus *Raja*, and two other specimens referable to *Raja (Dipturus) johannisdavisi* Alcock, 1899, all trawled off the north-western coast of Madagascar during the shrimp stock surveying operated by the ORSTOM Center of Nosy Be between 1971 and 1975 (Crosnier and Jouannic, 1973 ; Crosnier, 1978). Two similar surveys recently performed by ORSTOM off the south-western coast of Madagascar, off Toliara (Cléva, 1986 ; Von Cosel, 1987) brought additionnal specimens of the new species.

This new species is herein described according to the modern taxonomic standards used for the Rajoidei. The type specimens are deposited to Muséum National d'Histoire Naturelle, Paris (MNHN), British Museum of Natural History, London (BMNH), Smithsonian Institution, Washington (USNM), and J.L.B. Smith Institute, Grahamstown (RUSI).

The present paper is the third of a series on the deep water skates of Madagascar (Seret 1986 b ; Seret, 1989).

Methods : External and skeletal measurements were taken according to the methods proposed by Hubbs and Ishiyama (1968) and McEachran and Compagno (1979, 1982). A paratype, MNHN 1988. 1091 (adult male 582 mm TL) was dissected to reveal the structure of the neurocranium, left scapulocoracoid and right clasper. Terminology of neurocranium follows Hulley (1972), McEachran and Compagno (1979) ; that of scapulocoracoid follows McEachran and Compagno (1979) and that of clasper follows Stehmann (1970) and Hulley (1972). Anatomy of the pelvic girdle was observed from radiographs. Meristics counts of vertebrae and pectoral radials were enumerated from radiographs. Tooth counts were taken from specimens and radiographs.

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Cybium 1989, 13(2) : 115-130.

RAJA (DIPTURUS) CROSNIERI SP. N.
(Figs 1, 2)

Raja (Dipturus) sp. : Seret, 1986 : 258 - 259.

Holotype : MNHN 1988. 1089, adult male 573 mm TL, shrimp stock survey of trawler «Mascareignes III» off the south-western coast of Madagascar, 22° 05' S - 22° 30' S, 43° 00' E - 43° 09' E, 300 - 850 m depths, 8 September 1986 - 5 December 1986, col. R. Von Cosel-ORSTOM, shrimp trawl 48 m head line, sea bottom predominantly mud.

Paratypes : MNHN 1988. 1090, adult male 597 mm TL ; MNHN 1988. 1091, adult male 582 mm TL (dissected) ; MNHN 1988. 1092, adult male 554 mm TL ; MNHN 1988. 1093, adult female 610 mm TL, MNHN 1988. 1094, adult female 575 mm TL, MNHN 1988. 1095, juvenile male 474 mm TL ; MNHN 1988. 1096, juvenile male 436 mm TL ; MNHN 1988. 1097, juvenile female 414 mm TL ; MNHN 1988. 1098, juvenile female 404 mm TL ; capture data as for the holotype. MNHN 1988. 1099, juvenile male 474 mm TL ; MNHN 1988. 1100, juvenile male mm TL ; MNHN 1988. 1101, juvenile male 269 mm TL ; shrimp stock survey of trawler «Mascareignes III» off the south-western coast of Madasgascar (Toliara) 22° S, 43° E, 425 - 500 m depths, 17 December 1985 - 25 January 1986, col. R. Cléva - ORSTOM, shrimp trawl, sea bottom muddy. MNHN 1988. 1102, juvenile male 317 mm TL ; MNHN 1988. 1103, juvenile male 265 mm TL ; MNHN 1988. 1104, juvenile female 189 mm TL ; MNHN 1988. 1105, juvenile female 161 mm TL ; shrimp stock survey of trawler «Mascareignes III» st. 6, 22° 27' S, 43° 06, 3' E, 425 - 500 m depth, 21 December 1985, col R. Cléva - ORSTOM, shrimp trawl, sea bottom muddy. MNHN 1988. 1106, juvenile female 233 mm TL, shrimp stock survey of trawler «Mascareignes III», st. 19, 22° 18, 7' S, 43° 04, 5' E 400 m depth, 7 January 1986, col. R. Von Cosel - ORSTOM, shrimp trawl, sea bottom muddy. MNHN 1988. 1107 juvenile male 481 mm TL, R.V. «Vauban», CH 33, 12° 28, 1' S, 48° 12, 2' E, 600 - 605 m depths, 13 September 1972, col. A. Crosnier - ORSTOM, shrimp beam trawl. MNHN 1988. 1108, juvenile male 264 mm TL, R.V. «Vauban», CH 49, 15° 18' S, 48° 10' E 500 - 550 m depths, 8 November 1974, col. A. Crosnier - ORSTOM, shrimp beam trawl. RUSI 28021, juvenile male 463 mm TL, capture data as for the holotype. BMHN 1988. 7. 25 : 1, juvenile male 461mm TL, capture data as for the holotype. USNM 297040, juvénile male 454 mm TL, capture data as for the holotype.

Diagnosis : A relatively small *Raja (Dipturus)* species with a maximum total length of about 600 mm, and with the combination of the following characters : disc distinctly rhombic with sharply rounded outer pectoral corner ; tail long and slender, its length about equal to precloacal distance, and only slightly expanded at level of dorsal fins. Upper surface of disc with prickles or asperities, at least along anterior margins and on snout ; ventral surface with prickles along anterior margins and snout, and asperities scattered sometimes on head and abdomen. Orbital thorns present, up to 13 in adults ; a constant median nuchal thorn ; and only a mediodorsal row of 14 - 31 thorns on tail ; adult females with an irregular lateral row on each side of tail. Dorsal side plain brown to greyish brown ; ventral side plain brown, mottled with white in early juveniles. Rostral cartilage long, its length more than 60 % of cranial length ; rostral appendices flat, long and attached to rostral shaft. Anterior fontanelle with distinct anterior margin. Clasper glans external components sentinel and spike present, but funnel absent ; inner dorsal lobe with two clefts separated by terminal bridge ; shield and rhipidion well developed ; no dermal denticles. Clasper glans skeleton with seven cartilages : large ventral terminal (Vt), accessory terminal one (atr 1) Y - shaped with only one developed arm ; accessory terminal two (atr 2) J - shaped, three dorsal terminal cartilages (dtr 1, dtr 2 and dtr 3), and a terminal bridge cartilage. Ventral lobe cartilages covered by a piece of fibrous tissue (ft). Scapulocoracoid with elevated rear corner, large anterior and postdorsal fenestrae, small postventral fenestra and a postventral foramen, mesocondyle greatly depressed and laterally expended. Tooth rows in upper jaw : 31 - 37. Trunk vertebrae (Vtr) : 28 - 31. Predorsal tail vertebrae (Vprd) : 51 - 60. pectoral radials : 84 - 91.

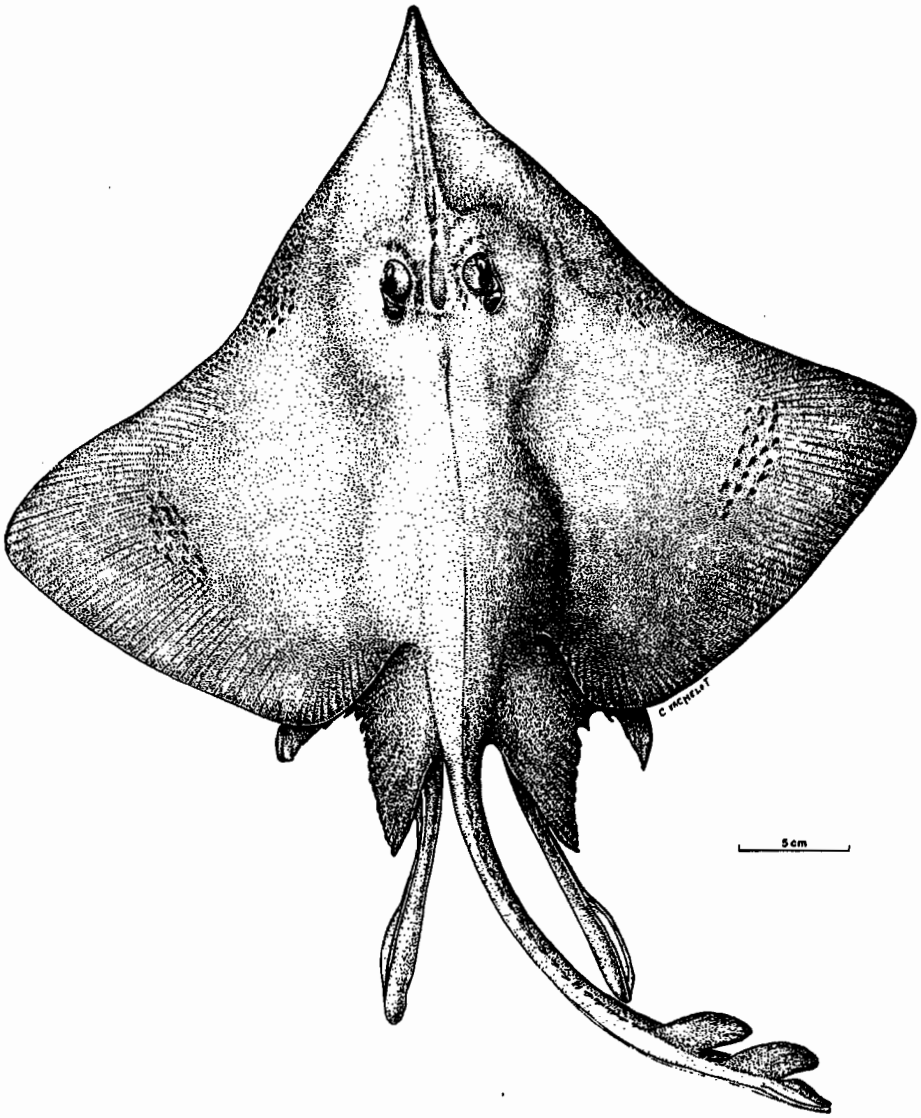

Fig. 1 : *Raja (Dipturus) crosnieri* sp. n., holotype, MNHN 1988. 1089, adult male 573 mm TL, in dorsal view.

Etymology : The new species is named in honour to Mr Alain Crosnier (ORSTOM) who initiated the deep trawling surveys off Madagascar in the seventies, and who entrusted the present author with his valuable collection of skates from Madagascar.

Description :

Morphology : Detailed morphometric proportional measurements based on 23 specimens (4 adult males, 2 adult females and 17 juveniles) are presented in Table I.

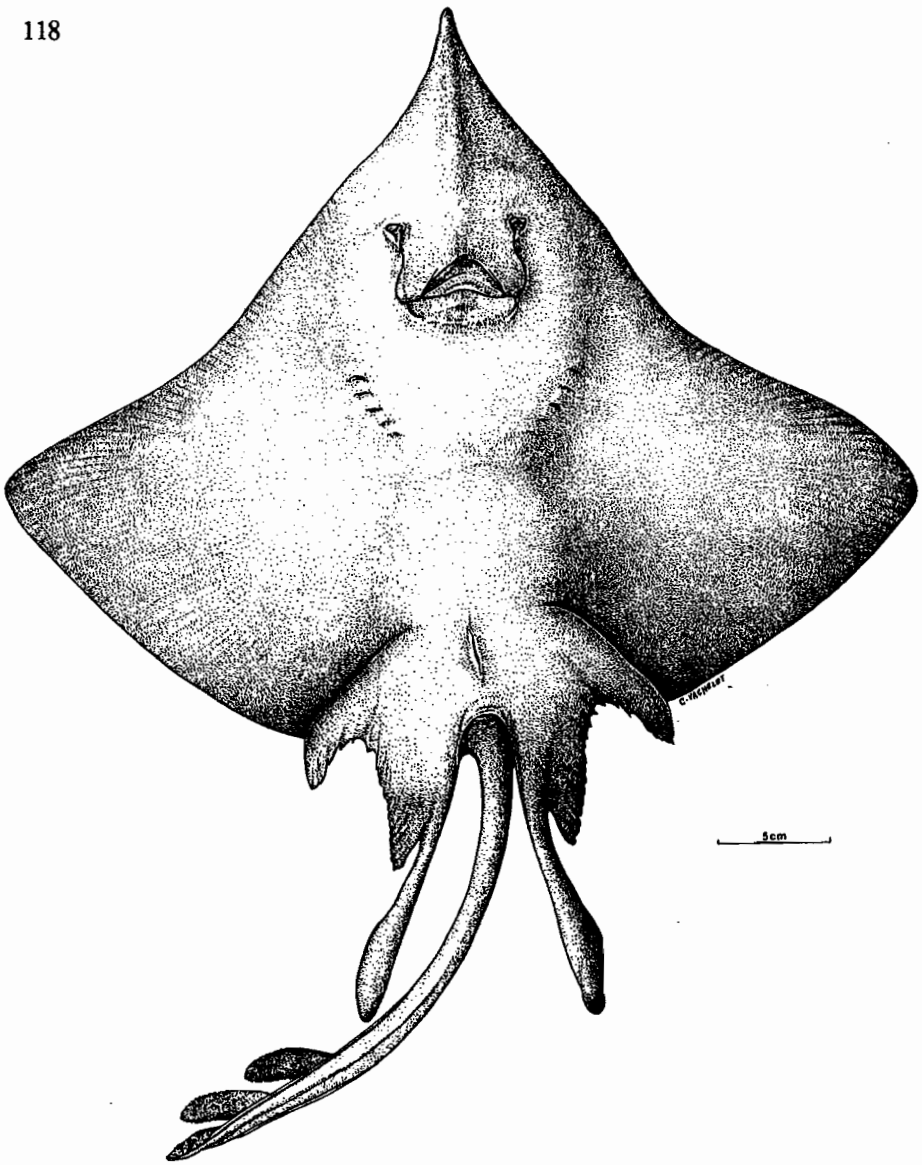

Fig. 2 : *Raja (Dipturus) crosnieri* sp. n., holotype, MNHN 1988. 1089, adult male 573 mm TL, in ventral view.

Disc broadly rhombic, 1.3 times as broad as long ; its width 1.3 - 1.5 times in total length. Axis of maximum disc width 63.5 - 65.5 % of disc length, behind level of shoulder girdle. Anterior margins undulated from snout to outer pectoral corner ; slightly concave immediately behind snout tip, convex at level of nostrils, then markedly concave at level of spiracle. Outer pectoral corners sharply rounded. Posterior pectoral margin regularly and gently convex from outer corner to inner corner ; the latter broadly rounded. Snout long, its preorbital length 4.3 - 5.0 times the interorbital width ; produced and pointed, its maximum angle in front of spiracles

71 - 87° (early juveniles : 90 - 95°). Orbits large, their horizontal diameter about equal to interorbital width, and about 5 times in the preorbital snout length. Spiracles about half as long as the orbits ; interspace between them 1.2 - 1.4 times the interorbital width. Each spiracle with 9.11 pseudobranchial folds. Pelvic fins deeply incised ; anterior lobe slender, its length from pelvic girdle 0. 8 times as long as the posterior lobe, to 1.1 times longer than the latter ; both lobes separated by a deep notch.

Claspers of adult males very long and slender, their postcloacal length 45 - 52 % of the tail length ; their tip somewhat expanded and falling short in front of level of first dorsal fin origin. Tail long and slender, its length from middle of cloaca 45 - 54 % of total length of body ; a depressed oval in cross-section at level of pelvic axils ; cross-section semicircular with a flat ventral side at level of dorsal fins. Distal part of tail little expanded at level of dorsal fins.Lateral tail folds mainly developed in the posterior third of tail, and running forward as a low keel ; fold-keel length 48 - 70 % of tail length. Dorsal fins about similar in size and shape, triangular with a broadly rounded apex and posterior margin ; separated by a short interspace of one-fifth one-third of first dorsal fin base length. Postdorsal section of tail long, its length 1.1 - 1.9 times as long as second dorsal fin base length. Caudal fin a long and low fold, continued ventrally as a very low fold to below the third posterior tip of postdorsal section of tail. Preoral snout length about 2. 5 times mouth width, the latter somewhat smaller than the internasal width. Distance between fifth gill slits 60 - 68 % ($\bar{x}$ = 63) of that between first gill slits. Mouth slightly arched. Nostrils with an anterior cornet-like fleshy flap, slightly and finely fringed on its posterior margin ; nasal curtain subrectangular with undulated outer margin, posterior margin transverse and set with relatively long lobelets, some of them bifid or trifid. No oronasal pits. Upper jaw with 31 - 37 (mean = 33.7) tooth rows. Teeth of adult males with a large pointed cusp on a rounded crown, arranged in quincunx to jaw corners and in more or less regular parallel rows to symphysis ; shape also changing along the jaws, cusp becoming almost indistinct at jaw corners.

Spinulation : The upper surface of a early juvenile of 161 mm TL is totally smooth. Juveniles longer than 182 mm TL are partially to totally set with asperities. Adults exhibit spinules mainly on anterior disc margins, tip of snout, head, trunk and tail, and asperities scattered all over the disc. The ventral surface of early juveniles is predominantly smooth with a few asperities along anterior margins of disc and tip of snout. Juveniles also predominantly smooth with spinules along anterior disc margins, tip of snout and rostrum ; some specimens exhibit scattered asperities around mouth, on branchial region and anterior abdomen ; lower surface of tail smooth. Adults have close-set coarse spinules on anterior disc margins and snout, and asperities on head (around mouth, on branchial region), anterior pectoral and abdomen ; lower surface of tail smooth.

Thorn pattern : Early juveniles with only 1 preorbital thorn and 2 widely separated supraorbital thorns ; 1 single median nuchal thorn ; 14 mediodorsal thorns more or less embedded in skin of tail and 1 inter-dorsal thornlet. Orbital thorn number increases with growth : 4 - 9 (juveniles) to 8 - 13 (adults). No interspiracular thorn, 1 - 2 median nuchal, no scapular thorns, and a mediodorsal row of 14 - 26 (juveniles) to 20 - 31 (adults) of hooked thorns on tail from level of pectoral axils to first dorsal fin origin ; 1 interdorsal thornlet (sometimes lacking). Adult females with an irregular lateral row of spinules (female 575 mm TL) or 13 - 14 lateral thorns (female 612 mm TL). Adult males with strong malar thorns and 14 - 34 alar thorns in 2 - 4 longitudinal rows.

Colouration : (after fixation in formalin and preservation in alcohol) : Dorsal surface of juveniles and adults plain medium brown to grey brownish, some specimens darker. Lateral areas of rostrum translucent yellowish. Orbits, tip of tail, dorsal and caudal fins blackish. Ventral surface of early juveniles ligth, «dingy whitish» with wide dark brown pectoral margins toning down to center of pectoral . Posterior margins of anterior and posterior pelvic lobes dark brown. Tail brownish, tip blackish. Pores on head dark pigmented. Ventral surface of larger juveniles

Table I : Morphometric measurements expressed as percentage of total length of *Raja (Dipturus) crosnieri* sp. n. ; means, standard deviations (s.d.), minimums and maximums calculated for the type series (6 adults and 17 juveniles).

Raja crosnieri	Adults					Juveniles					Total				
	mean	s.d.	mini.	maxi.	N	mean	s.d.	mini	maxi	N	mean	s.d.	mini	maxi	N
Disc length	55.2	1.6	52.9	57.5	6	54.0	1.7	51.1	57.9	17	54.3	1.7	51.1	57.9	23
Disc width	72.9	1.1	71.1	74.3	6	70.4	3.5	65.0	75.4	17	71.0	3.3	65.0	75.4	23
Snout tip to max disc width	35.4	1.5	33.3	37.7	6	34.8	1.1	32.6	36.9	17	35.0	1.3	32.6	37.7	23
Preorbital length	19.3	0.7	18.4	20.2	6	19.2	1.0	16.8	21.3	17	19.2	0.9	16.8	21.3	23
Prenasal length	16.8	0.8	15.7	17.8	6	16.8	1.0	14.3	18.8	17	16.8	0.9	14.3	18.8	23
Preoral length	19.9	1.0	18.9	21.6	6	20.3	1.0	18.6	22.3	17	20.2	1.0	18.6	22.3	23
Snout to middle of cloaca	51.7	2.2	49.8	55.9	6	48.9	1.7	45.3	52.0	17	49.6	2.2	45.3	55.9	23
Head length ventrally	32.9	1.0	32.0	34.0	6	31.8	1.1	29.8	34.2	17	32.1	1.1	29.8	34.2	23
Middle of cloaca to D1	32.6	1.5	29.7	34.2	6	32.5	1.1	30.4	34.6	17	32.5	1.2	29.7	34.6	23
Middle of cloaca to D2	38.6	1.5	35.8	40.3	6	39.0	0.9	36.6	40.5	17	38.9	1.1	35.8	40.5	23
Middle of cloaca to tail tip	48.5	1.7	45.3	49.6	6	50.8	1.3	49.2	54.0	17	50.3	1.7	45.3	54.0	23
Orbit diameter	3.6	0.2	3.4	4.0	6	3.9	0.2	3.6	4.3	17	3.8	0.2	3.4	4.3	23
Spiracle	2.3	0.2	2.1	2.5	6	2.1	0.2	1.7	2.4	17	2.2	0.2	1.7	2.5	23
Orbit + spiracle	4.8	0.2	4.7	5.1	6	4.8	0.2	4.5	5.3	17	4.8	0.2	4.5	5.3	23
Interorbital width	4.1	0.1	4.0	4.3	6	4.1	0.1	3.9	4.3	17	4.1	0.1	3.9	4.3	23
Interspiracular width	6.1	0.2	5.9	6.4	6	5.9	0.2	5.6	6.3	17	6.0	0.2	5.6	6.4	23
Internasal width	8.4	0.3	8.0	8.8	6	8.6	0.3	8.1	9.0	17	8.5	0.3	8.0	9.0	23
Mouth width	8.2	0.4	7.7	8.6	6	7.9	0.4	7.3	8.6	17	8.0	0.4	7.3	8.6	23
Nasal curtain length	4.8	0.3	4.4	5.2	6	4.7	0.3	4.2	5.2	17	4.7	0.3	4.2	5.2	23
Width of nasal lobes	2.1	0.2	1.9	2.3	6	2.0	0.2	1.8	2.5	17	2.1	0.2	1.8	2.5	23
Distance between lobes	6.1	0.4	5.6	6.7	6	5.3	0.4	4.4	6.0	17	5.5	0.6	4.4	6.7	23
1 st gill slit length	1.3	0.2	1.0	1.6	6	1.1	0.1	0.8	1.2	17	1.1	0.2	0.8	1.6	23
3rd gill slit length	1.4	0.2	1.2	1.7	6	1.3	0.2	1.0	1.5	17	1.3	0.2	1.0	1.7	23
5th gill slit length	0.9	0.1	0.8	1.1	6	0.8	0.1	0.6	1.0	17	0.8	0.1	0.6	1.1	23
Interbranchial width, 1st	13.9	0.6	13.2	15.0	6	13.8	0.4	13.0	14.4	17	13.8	0.5	13.0	15.0	23
Interbranchial width, 5th	8.7	0.8	7.8	10.1	6	8.7	0.3	8.2	9.2	17	8.7	0.5	7.8	10.1	23
Ant. pelvic lobe from axil	12.9	0.4	12.2	13.4	6	12.6	0.7	11.5	13.9	17	12.6	0.6	11.5	13.9	23
Ant. pelvic lobe from girdle	14.4	0.6	13.7	15.2	6	14.4	0.6	13.4	15.8	17	14.4	0.6	13.4	15.8	23
Post. pelv. lobe from girdle	16.7	2.0	14.3	19.5	6	13.9	1.1	12.4	15.8	17	14.7	1.9	12.4	19.5	23
D1, height	3.1	0.3	2.6	3.5	6	2.7	0.5	1.6	3.5	17	2.8	0.5	1.6	3.5	23
D1, base length	4.9	0.4	4.3	5.2	6	5.1	0.3	4.7	5.8	17	5.1	0.3	4.3	5.8	23
Distance D1/D2	1.1	0.2	0.9	1.3	6	1.4	0.3	1.0	1.9	17	1.3	0.3	0.9	1.9	23
D2, height	2.9	0.5	2.3	3.6	6	2.7	0.5	1.6	3.5	17	2.7	0.5	1.6	3.6	23
D2, base length	4.4	0.5	3.8	5.2	6	4.9	0.4	4.2	5.6	17	4.8	0.5	3.8	5.6	23
Post-D2 length	5.4	0.8	4.0	6.3	6	7.1	1.4	5.3	10.6	17	6.7	1.5	4.0	10.6	23
Caudal, height	0.9	0.1	0.8	1.1	6	0.8	0.1	0.6	1.0	17	0.8	0.1	0.6	1.1	23
Caudal, base length	5.1	0.7	4.0	6.3	6	7.0	1.3	5.3	10.6	17	6.6	1.5	4.0	10.6	23
Tail, height at pelvic axils	1.9	0.2	1.6	2.1	6	1.7	0.1	1.5	2.0	17	1.8	0.2	1.5	2.1	23
Tail, width at pelvic axils	3.3	0.2	3.0	3.6	6	3.1	0.3	2.7	3.7	17	3.2	0.3	2.7	3.7	23
Tail, height in front of D1	1.0	0.1	0.9	1.2	6	1.1	0.1	1.0	1.2	17	1.1	0.1	0.9	1.2	23
Tail, width in front of D1	2.2	0.2	1.9	2.6	6	1.9	0.3	1.5	2.3	17	2.0	0.3	1.5	2.6	23
Lateral tail fold length	27.6	3.3	21.7	30.9	6	32.3	3.9	24.5	37.9	17	31.2	4.3	21.7	37.9	23

becoming predominantly brown with light, greyish to dingy whistish areas : pectoral axils, anterior part of pelvic lobes, cloaca, branchial area. Tail brown, tip blackish. Pores on head dark pigmented. Subadults and adults plain dark brown, darker than the dorsal surface ; tip of tail blackish ; pores in head dark pigmented.

Meristics (Table II) : trunk vertebrae (Vtr) : 28 - 31 (mean = 29.6). Predorsal tail vertebrae (Vprd) : 51 - 60 (mean = 53.8). Pectoral radials : 84 - 91 (mean = 87.6).

Clasper morphology (Fig. 3) : Claspers of adult males long and slender ; ventral lobe of clasper glans only little expanded. Outer surface of dorsal lobe with neither dermal denticles, nor pseudosiphon. Two deep clefts (cf.) on the inner dorsal lobe ; the proximal cleft is formed between the axial cartilage and the dorsal terminal 2 cartilage ; the distal cleft is formed between the axial cartilage and the dorsal terminal 3 cartilage ; the clefts are separated by the terminal bridge cartilage. The dominant component of the inner ventral lobe is the elongate, plate-like shield (sh) extending from level of hypopyle to distal tip of the clasper ; its outer lateral margin is free and sharp-edged. The component rhidipion (rh) composed of porous tissue is situated medially, along the inner border of the shield. The tip of the accessory terminal 1 cartilage, covered with integument, appears as a finger-like sentinel (st), medially situated in the inner ventral lobe. The hooked tip of the accessory terminal 2 cartilage, also covered by integument, appears as a spike (sp) in the medio-distal region of the glans. Skin of clasper brown, inner surfaces of the glans white with the component rhipidion ligth pink.

Clasper skeleton (Figs 4, 5,6) : the basic shaft of the clasper consists of 3 cartilages ; an elongate axial cartilage (Ax) extending form the pelvic basipterygium to tip of glans ; an elongate plate-like, distally expanded ventral marginal cartilage (vmg) and a gutter-shaped dorsal marginal cartilage (dmg) ; dmg and vmg are tightly attached to the axial to form the clasper groove open on the outer lateral surface of the clasper. The skeleton of the clasper glans consists of 7 terminal cartilages. The dorsal terminal one cartilage (dtr 1) is a curved nail-shaped piece covering the proximal dorsal region of the glans ; it is tightly attached to the axial and to the dorsal marginal. The ventral terminal cartilage (vt) is a complex piece with a large flat cutlass-shaped, sharp-edged outer margin (forming the component shield), a inner ridge evently running distally and somewhat twisted, with a distomedial process wrapping around the axial and a short, finger-like, proximo-medial process connected to the accessory terminal 1 cartilage (art 1). The latter cartilage is Y-shaped with the medial arm reduced to a short process ; it is proximally attached to vmg and its distal finger-like extension forms the component sentinel. The accessory terminal 2 cartilage (art 2) is a J-shaped rod with its hooked distal extension forming the component spike ; it is proximally articulated to atr 1 and vmg. A large piece of fibrous connective tissue (ft) extends from the inner surface of the atr 1 and atr 2, and attaches to the outer distal expanded end of the vmg. The dorsal terminal 2 cartilage (dtr 2) is a depressed rod, proximally attached

Table II : Meristics of *Raja (Dipturus) crosnieri* sp. n. ; means, standard deviations (s.d.), minimums and maximums, numbers of specimens (N).

Raja (Dipturus) crosnieri	mean	s.d.	mini.	maxi.	N
Trunkal vertebrae	29.6	0.8	28	31	20
Predorsal vertebrae	53.8	2.1	51	60	19
Total number of vertebrae	142.4	5.2	128	149	16
Pectoral radials	87.6	1.6	84	91	20
Tooth rows, upper jaw	33.6	1.3	31	37	23
Tooth rows, lower jaw	32.2	2.0	29	36	19
Pseudobranchial folds	9.5	0.5	9	11	23
Snout angle	80.8°	5.7	71°	95°	23

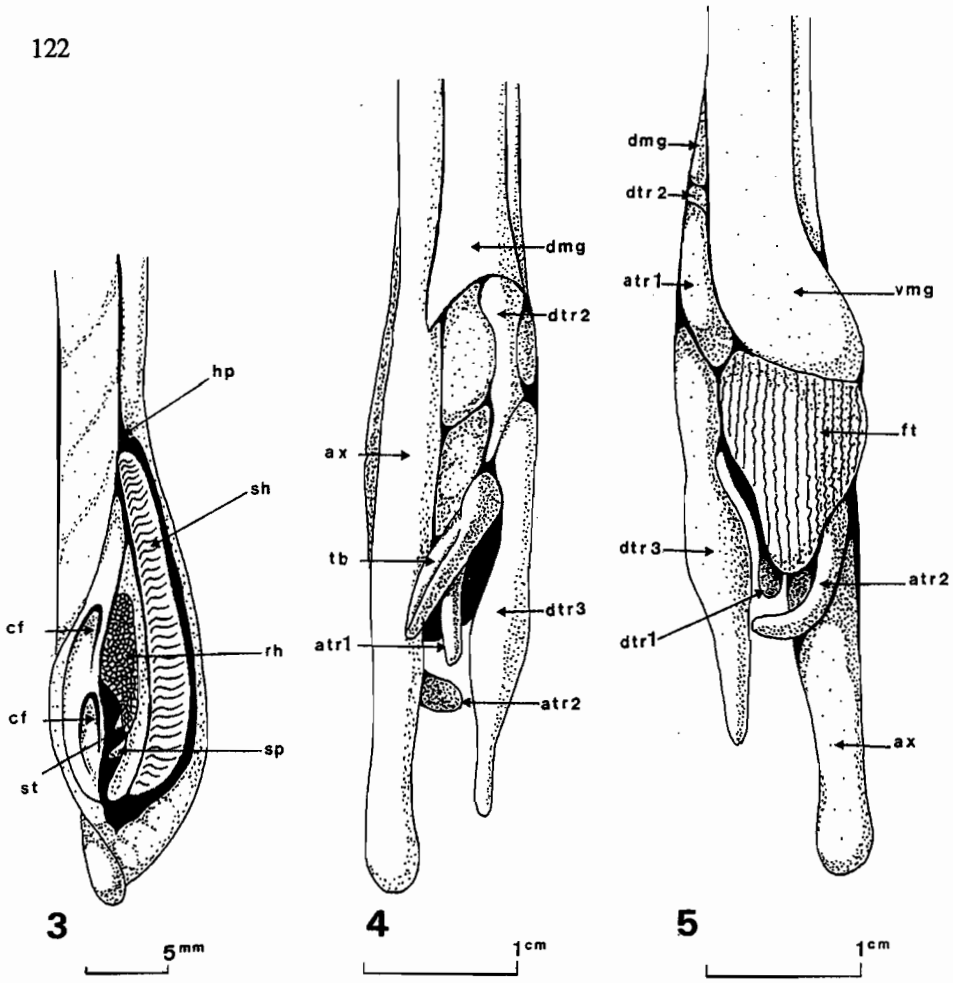

Fig. 3 : *Raja (Dipturus) crosnieri* sp. n., lateral view of right clasper glans of paratype MNHN 1988. 1091, adult male 582 mm TL. cf : cleft ; hp : hypopyle ; rh : rhipidion ; sh : shield ; sp : spike ; st : sentinel.
Fig. 4 : *Raja (Dipturus) crosnieri* sp. n., dorsal view of right clasper cartilages of paratype MNHN 1988. 1091, adult male 582 mm TL. ax : axial ; atr1 : accessory terminal one ; atr2 : accessory terminal two ; dmg : dorsal marginal ; dtr2 : dorsal terminal two ; tb : terminal bridge (Vt removed).
Fig. 5 : *Raja (Dipturus) crosnieri* sp. n., ventral view of right clasper cartilages of paratype MNHN 1988.1091 adult male 582 mm TL. ax : axial ; atr1 and atr 2 : accessory terminal one and two ; dmg : dorsal marginal ; dtr 1, dtr 2 and dtr 3 : dorsal terminal one, two and three ; ft : fibrous tissue ; vmg : ventral marginal (Vt removed).

to the dorsal region of dmg and distally to proximal region of the dorsal terminal 3 (dtr 3) cartilage. The latter cartilage is an elongate flat bar distally joined to tip of axial by connective tissue. Dtr 2 and dtr 3 form the frame of the dorsal lobe. The terminal bridge (tb) is a linking bar-like cartilage, proximally attached to dtr 2 and dtr 3 and distally to the axial, it separates the two clefts of the dorsal lobe.

Pelvic girdle (Fig. 7, after radiograph, and Table III) : Pelvic girdle consists of a stout and thick central bar of cartilage with its front edge slightly convex and its rear edge a deep concave arc ; deeper in males than in females. Maximum width is 59 - 62 % in females and 66 -68 % in males of that of pectoral girdle. Prepelvic processes conical, bluntly pointed and slightly

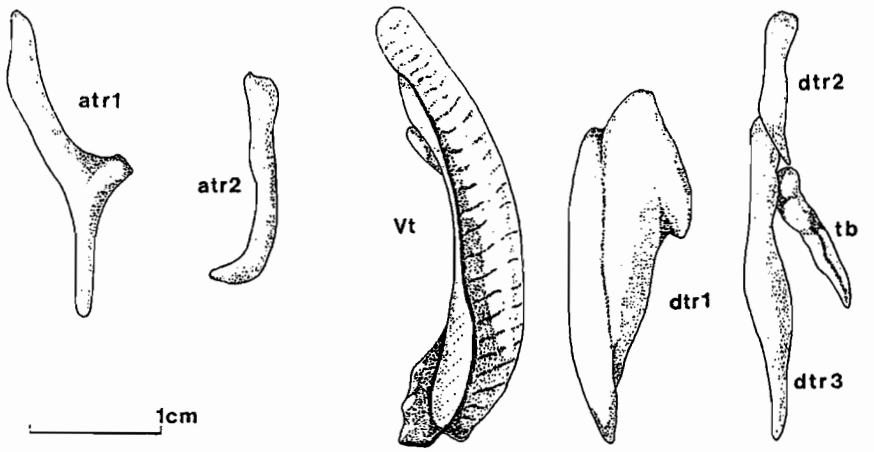

Fig. 6 : *Raja (Dipturus) crosnieri* sp. n. dissected cartilages of right clasper of paratype MNHN 1988. 1091 adult male 582 mm TL. atr 1 and atr 2 : accessory terminal one and two ; dtr 1, dtr 2 and dtr 3 : dorsal terminal one, two and three ; tb : terminal bridge ; vt : ventral terminal.

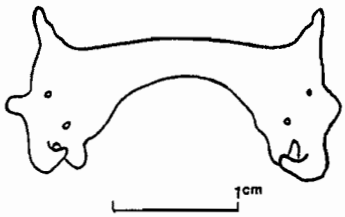

Fig. 7 : *Raja (Dipturus) crosnieri* sp. n., pelvic girdle of holotype, MNHN 1988. 1089, adult male 573 mm TL (after radiograph).

anterolaterally oriented. Iliac processes massive and greatly curved anteromedially. There are two obturator foramina.

Pectoral girdle (after radiograph, scapulocoracoid dissected, Fig. 8, Table III) : Maximum width of pectoral girdle is 1.5 times that of pelvic girdle, and about equal to greatest cranial width. Lateral face of scapulocoracoid is subrectangular, elongate, its length 1.6 times its height. Anterior margin, between procondyle and anterior corner, is almost straight and slightly diagonal. Anterior corner is broadly rounded. Scapular process is little elevated. Dorsal margin, between anterior and rear corners, is gently sloping and slightly concave to rear corner. Rear corner well developed, elevated, and extends to base of metacondyle. Coracoid base is straight. Premesocondyle length is about equal to postmesocondyle length. Procondyle and metacondyle are hemispherical in outline ; mesocondyle greatly expanded and depressed, as an elongate ovoid. Anterior fenestra is large and circular without anterior bridge. Postdorsal fenestra is oval and postventral fenestra is small. There is a postventral foramen below the posterior base of mesocondyle.

Neurocranium (after radiograph and dissection, Fig. 9, Table III) : Rostral shaft is extremely long and moderately slender, its length about 62 % of length of neurocranium. Rostral appendices flat, long and narrow, attached to rostral shaft over entire length. Nasal capsules rhombic and rather narrow, set at about a 18° angle to traverse axis of neurocranium. Preorbital and postorbital processes moderately developed, continuous with the supraorbital crest. Anterior fontanelle, elongate, arrowhead-shaped, and with a distinct anterior margin, not preceded by a rostral groove. Posterior fontanelle long, elliptical and slightly concave or forming a small bottle-neck extension. Jugal arch moderately slender. Basal plate and internasal plate

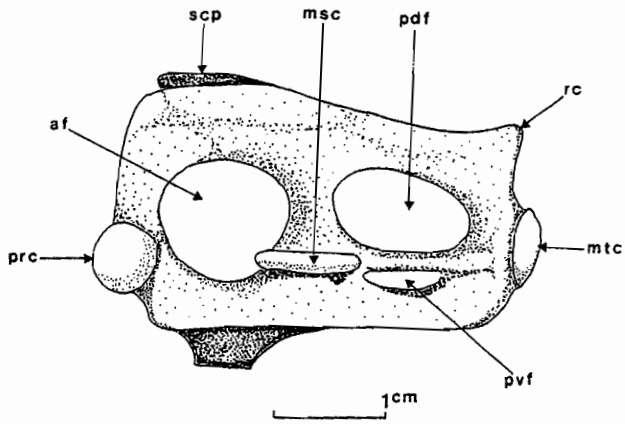

Fig. 8 : *Raja (Dipturus) crosnieri* sp. n., lateral view of left scapulocoracoid of paratype MNHN 1988. 1091, adult male 582 mm TL. af : anterior fenestra ; msc : mesocondyle ; mtc metacondyle ; pdf : postdorsal fenestra ; prc : procondyle ; pvf : postventral fenestra ; rc : rear corner ; scp : scapular process.

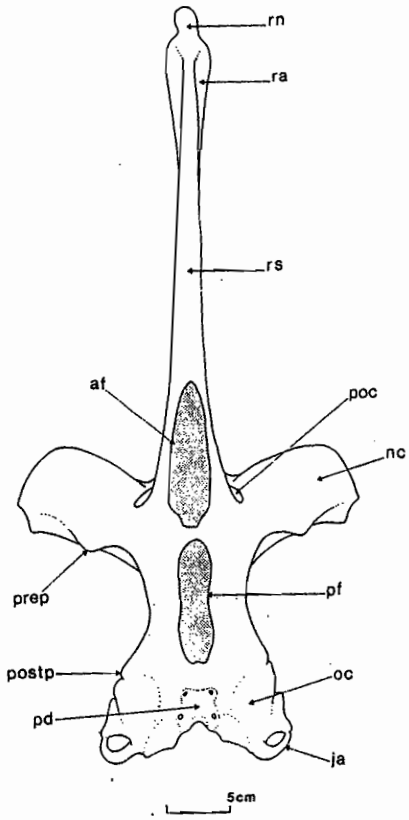

Fig. 9 : *Raja (Dipturus) crosnieri* sp. n., dosal view of neurocranium of paratype MNHN 1988. 1091, adult male 582 mm TL. af : anterior fontanelle ; ja : jugal arch ; nc : nasal capsule ; oc : otic capsule ; pd : parietal depression ; pf : posterior fontanelle ; poc : preorbital canal foramen ; postp : postorbital process ; prep : preorbital appendice ; m : rostral node ; rs : rostral shaft.

Table III

Raja (Dipturus) crosnieri	MNHN 1988.1091 male 582 mm	
	mm	%
Neurocranium		
Nasobasal length	57.0	100.0
Cranial length	152.0	266.7
Rostral cartilage length	95.0	166.7
Prefontanelle length	75.0	131.6
Cranial width	72.0	126.3
Interorbital width	23.3	40.9
Rostral base	13.5	23.7
Anterior fontanelle length	32.4	56.8
Anterior fontanelle width	6.1	10.7
Posterior fontanelle length	23.0	40.4
Posterior fontanelle width	7.5	13.2
Rostral appendice length	26.0	45.6
Rostral appendice width	3.3	5.8
Width across otic capsules	32.2	56.5
Least width of basal plate	18.1	31.8
Greatest width of nasal capsules	30.0	52.6
Internarial width	13.2	23.2
Scapulocoracoid		
Length	39.0	100.0
Height	24.3	62.3
Premesocondyle length	14.4	36.9
Postmesocondyle length	14.6	37.4
Mesocondyle length	10.0	25.6
Anterior fenestra length	11.7	30.0
Anterior fenestra height	11.7	30.0
Postdorsal fenestra length	12.5	32.1
Postdorsal fenestra height	7.6	19.5
Postventral fenestra length	7.1	18.2
Postventral fenestra height	3.4	8.7
Height at rear corner	18.6	47.7
Pelvic girdle		
Maximum width	48.0	100.0
Total length	24.5	51.0
Length of prepelvic process	9.0	18.8
Median depth of anterior arc	6.0	12.5
Median depth of posterior arc	13.0	27.1
Tranverse length of central bar	48.0	10.0

Table III : Neurocranium, scapulocoracoid and pelvic girdle proportional measurements respectively expressed as percentage of nasobasal length, greatest scapulococaroid length and maximum pelvic width, of *Raja (Dipturus) crosnieri* sp. n., paratype MNHN 1988. 1091, adult male 582 mm TL.

broad, 77 and 58 % of interorbital width respectively. No nasobasal fenestra, but the preorbital canal foramen forms a short groove on roof of nasal capsule at base of rostral shaft.

Discussion and interspecific comparisons : The distinction between the subgenera *Dipturus* Rafinesque, 1810, (introduced by Stehmann, 1970) and *Okamejei* Ishiyama, 1958, has long been questionable (McEachran and Fechhelm, 1982 ; Seret, 1986). In their investigation of the North Pacific skates, Ishihara and Ishiyama (1986) recognize the great similarity between these two subgenera, and they state that «problems remain concerning their status». However,

these authors confirm the validity of both subgenera on the basis of clasper anatomy : clasper component «funnel» present in all *Okamejei* species and absent in all *Dipturus* species. They also state that the two subgenera «cannot be distinguished by their scapulocoracoids». The distinction between *Dipturus* and *Okamejei* is also confirmed by McEachran and Miyake (1986) on the basis of neurocranium, scapulocoracoid and clasper structures. These authors consider *Dipturus* as the plesiomorphic sister group of other Rajini, with the shape of scapulocoracoid (mesocondyle greatly depressed and laterally expanded) as the synapomorphic character state shared by *Dipturus* species. Also, the anterior margin of anterior fontanelle is distinct to indistinct and preceded by a more or less deep groove in *Dipturus*, whereas the anterior margin is distinct with or without rostral groove in *Okamejei*. In his revision of the western North Pacific species of genus *Raja*, Ishihara (1987) provides a key to both subgenera distinguishing *Dipturus* from *Okamejei* by length of rostral cartilage, thorn pattern, maximum size of adults, tail expansion, dorsal and ventral spinulation, number of Vtr, shape of anterior fontanelle and that of egg-capsules. The new Malagasy species exhibits character states in accordance with McEachran and Miyake's arrangement of Rajini ; it is in accordance with Ishihara's key except for the anterior fontanelle which is rostrally distinct and lacks a rostral groove and for the number of Vtr (28 - 31 in *R. crosnieri* ; 30 - 35 for *Dipturus* and 25 - 30 for *Okamejei* species). About 30 nominal species have been assigned to the subgenus *Dipturus* and about 10 to the subgenus *Okamejei*, and a worldwide revision is still in need to determine their interrelationships.

However, *Okamejei* species are small to medium sized skates (they do not exceed 66 cm TL) and they occur almost exclusively in coastal waters of the continental shelfs (20 - 240 m depths ; 260 - 457 m for *R. heemstrai*) of the Indo-Pacific region. All exhibit more or less variegated color patterns including reticulations, blotches, spots, dots, rosette-like patches, rings, ocelli and cross-bars (on tail). The Indian Ocean species *R. powelli* and *R. philipi* (probably synonymous of *R. powelli*) have dark pectoral rings ; and *R. heemstrai* has numerous symetrically arranged ocelli.

Detailed descriptions including neurocranium, scapulocoracoid and clasper structures, are available only for about half of the 30 nominal *Dipturus* species. However, *R. crosnieri* can be distinguished from its subcongeners. *Dipturus* species are medium to large sized skates, most exceed 100 cm TL and some reach up to 250 cm TL.

The eastern North Atlantic species *R. batis*, *R. nidarosiensis* and *R. oxyrinchus* have been investigated by Stehmann (1970) ; they are large-sized species (150 to 250 cm TL) with very long and pointed snout. *R. lintea* from Norvegian Sea, assigned to subgenus *Dipturus* (McEachran, pers. com. of unpublished data) differs from *R. crosnieri* mainly by its thorn pattern (a continuous medio-dorsal row of thorns from nape to first dorsal fin ; tail with three rows) and its ventral coloration (white with dark margins).

The western North Atlantic species have been investigated by Bigelow and Schroeder (1953, 1958, 1962). *R. bullisi* resembles *R. crosnieri* in shape and coloration ; the species is probably also a medium-sized skate (greatest immature specimen : 400 cm TL) but it differs from *R. crosnieri* in having only two preorbital thorns, a postorbital one, and smooth dorsal surface of disc. *R. floridana* is a large-sized skate (greatest immature specimen : 772 mm TL), it has a sharp pointed snout, no nuchal thorn and smooth dorsal surface of disc. *R. garricki* reaches 100 cm TL, it has a continuous medio-dorsal row of thorns from nape to first dorsal fin and a scapular thorn on each shoulder. *R. laevis* is a large-sized species (165 cm TL), its tail is armed with three rows of regularly spaced thorns, no nuchal thorn, dorsal surface with dark spots and eye-spot markings, disc white with dark margins ventrally. *R. olseni* is a medium-sized species (about 600 mm TL), it differs from *R. crosnieri* by shape of its disc (rounded outer pectoral corners, tip of snout little produced), dorsal surface of disc predominantly smooth, and with obscure spots. *R. oregoni* is a large-sized species (140 cm TL) with narrowly projecting snout, no nuchal thorn, tail armed with three rows of large close-set thorns, and ventral surface pale bluish-grey. *R. teevani* is probably a large species (greatest immature specimen : 635 mm TL), it has a pointed snout, no nuchal thorn, dorsal fins confluent, tail expanded rearward and

disc creamy below. The west African *R. doutrei* which reaches 115 cm TL, is distinct from *R. crosnieri* in having a produced snout, widened and depressed tail, smooth dorsal and ventral surface, except snout and anterior margins, 43 - 49 Vprd (versus 51 - 60), and 82 - 84 pectoral radials (versus 84 - 91).

The western South Atlantic species, *R. trachyderma* and *R. leptocauda* were described by Krefft and Stehmann (1975). *R. trachyderma* is a large-sized skate (183 cm TL) with long and pointed snout, both sides completely covered with prickles and dark brown, no nuchal thorn, 98 pectoral radials. *R. leptocauda* is probably a medium-sized skate (juvenile : 479 mm TL), it is distinguished by its long and pointed snout, dorsal surface smooth, but scapular thorns present, dark brown above, dark grey below, 98 pectoral radials.

R. chilensis (= *R. flavirostris*, McEachran pers. com.) from the continental shelf of the western South Atlantic and the eastern South Pacific (Chile) is a medium-sized species (880 mmTL) distinguished by its short and wide tail usually armed with lateral thorns, head rugose ventrally, snout yellowish markedly contrasting with the dark brown coloration of both sides of disc.

The South African species have been investigated by Wallace (1967) and Hulley (1970, 1972, 1986). *R. pullopunctata* is distinct from *R. crosnieri* by its much greater size, extremely large nuchal thorn, broadly rounded pectoral corners, high number of tooth rows in upper jaw (53 - 58) and color pattern (dorsally brownish with dark brown and light spots and blotches, irregular dark brown blotch at the base of each pectoral fin, grey below) ; *R. pullopunctata* attains 125 cm TL. *R. lanceorostrata* is markedly distinguished by its extremely acutely pointed snout, narrow tapering tail, dorsal and ventral surface largely smooth, lateral row of thorns on tail in both sexes, and color pattern, (dorsally grey with numerous ligth spots). *R. stenorhynchus* known from a single late immature female (890 mm TL) has a broadly wedge-shaped and markedly produced snout, depressed fleshly tail, dorsal and ventral surfaces largely smooth except for some spinules on tip of snout and anterior margins. *R. springeri* closely resembles *R. crosnieri* in shape, spination and coloration, but it has no nuchal thorn, higher number of pectoral radials (105 - 106) and attains a much greater size (immature holotype male : 620 mm TL. Additional specimens with two adolescent males 1074 and 1253 mm TL, and a larger adult male over about 120 cm long (20 kg) were recently collected by L. J.V. Compagno, (pers. com.). According to L. J. V. Compagno (pers. com.) *R. campbelli* should be a valid species, and distinct from *R. crosnieri* by «snout tip more acutely pointed, pectoral fins more broadly rounded, dorsal and ventral surfaces largely smooth except for prickles on underside of snout, thicker tail base, shorter anterior pelvic lobes, disc gray above with scattered small black spots, graying below, somewhat greater size».

Raja crosnieri resembles *R. johannisdavisi* in shape, but the comparison between the two species has been done with the avaible juvenile females of *R. johannisdavisi* from the John Murray Expedition (BMNH's specimens). The holotype preserved in the collection of the Zoological Survey of India is in a very bad state of conservation (cf. Stehmann, 1976) and could not be examined. However, the new species differs from *R. johannisdavisi* in the following characters : prickles or asperities scattered on dorsal surface of disc, at least along anterior margins, tip of snout and on rostrum versus dorsal surface totally smooth in *R. johannisdavisi*. Also the flesh of *R. crosnieri* is firm while that of *R. johannisdavisi* is soft. Number of pseudobranchial folds somewhat higher in *R. johannisdavisi* (11 - 13 versus 9 - 11). Number of tooth rows in upper jaw also somewhat higher in *R. johannisdavisi* (32 - 42 versus 31- 37). Although most of the proportional measurements have their range of variation overlapping, the following measurements are slightly higher in *R. crosnieri* that in *R. johannisdavisi* : disc length about 55 % TL versus 51 %, disc width about 72 % TL versus 61 %, interorbital width 4.1 % TL versus 3.4 %, internasal width 8.5 % TL versus 7.6%, nasal curtain length 4. 8 % TL versus 3.8 %.

The North Pacific skates have been investigated by Ishiyama (1958, 1967) and Ishihara (1987). Seven skates from this region have been assigned to subgenus *Dipturus*. *R. binoculata*, *R. gigas*, *R. macrocauda*, *R. pulchra*, *R. rhina* and *R. tengu* are large growing skates (100 to 240 cm TL). Moreover, *R. binoculata* has two prominent eyespots on center of pectoral and it is whitish below. *R. rhina* has a extremely long and acute snout, and two dark ocelli on center of pectoral. *R. gigas* is uniformly dark purplish-brown or greyish brown on both surfaces of disc and it has no nuchal thorn. *R. macrocauda* has its tail expanded laterally at midlength, dorsal fins widely separated, prickles limited to snout on both surfaces, and is dark brown dorsally. *R. pulchra* has a dark ring on each pectoral or exhibits reticulate color pattern. *R. tengu* has an extremely pointed snout and tapering tail rearwards. *R. kwangtungensis* is a medium-sized skate (500 - 750 mm TL) ; it is dorsally dark brown mottled with many ligth markings, and ventrally dusky white.

The western South Pacific species have been investigated by Whitley (1939, 1940), Garrick and Paul (1974), and Last *et al.*(1983). *R. nasuta* from Tasmania and New Zealand is a very large skate, reaching 200 cm TL, it is dorsally brownish mottled with numerous small light spots interspaced with dark spots, blotches and marblings, fresh specimens with a pair of dark ocelli, predominantly pale or white below, tail wide and notably depressed, Vtr = 33 - 35. *R. gudgeri* from south-western Australia, Tasmania and New Zealand, attains at least 100 cm TL, it has a long and pointed snout, dorsal surface of disc mainly smooth with thorns generally absent, somewhat rugose on snout and anterior margins ventrally, dark brown above with large scattered bluish-grey blotches, Vtr = 35. The smooth skate, *R. innominata* from New Zealand is a large species (150 cm TL) ; it is greyish above with large dark blotches, predominantly grey below, Vtr = 33 - 35. Last *et al.* (1983) mention two probably new skates, of which the «green-backed skate», *Raja* sp. 1 should most probably be assigned to subgenus *Dipturus* ; it is a large skate (140 cm TL) closely related to *R. gudgeri*, but it is grey-green above and whithish below, often mottled with dark patches.

A probably new species from New Caledonia known from a single female 643 mm TL (under study by the present author) and related to *R. macrocauda*, is distinguished from *R. crosnieri* in having : tail wide and depressed on whole length, dorsal surface greyish-brown, and ventral surface greyish with pale markings (30 Vtr, 56 Vprd, 92 pectoral radials, 39 tooth rows in upper jaw).

Acknowledgements : I sincerely thank Dr. L.J.V. Compagno of «Shark Research Center» (RUSI) for his valuable, unpublished data on South African skates, he kindly provided me, and for reviewing the manuscript. My special thanks to Dr. J. D. McEachran (Texas A. & M. University) and Mr. H. Ishihara (University of Tokyo) for their useful advice about the manuscript. I am grateful to Ms. M. Holloway (BMNH) for the loan of the specimens of *Raja johannisdavisi*, to Dr. P. C. Heemstra (RUSI) for the loan of a specimen of *Raja springeri*, to Mr. R. Von Cosel (ORSTOM contractor) and Mr. R. Cleva (MNHN) for collecting additional specimens of the new species, and to Ms. C. Vachelot who did the drawings of *Raja crosnieri* (Figs 1, 2).

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Reçu le 10.06.1988
Accepté pour publication le 10.08.1988.