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MORPHOLOGICAL VARIATION IN MALES OF *VULCANOCTOPUS HYDROTHERMALIS* (MOLLUSCA, CEPHALOPODA)

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ABSTRACT

Seventeen new specimens of *Vulcanoctopus hydrothermalis* were collected during the French cruise HOPE 99 between 1–21 May 1999. The animals were caught at 2631 m depth at 12°48.7′N, 103°56.43′W. Vacuums and creels in seven different submersible samplings collected the specimens. Animals ranged from 22 to 56 mm dorsal mantle length (ML). A total of 26 morphometric and 10 meristic characters were measured and counted. Indices were calculated. Arms with suckers in two rows. Each row with the same number of suckers. The sucker addition is faster in small animals than in bigger animals with a near to total cessation of addition of new suckers during the later stages of arm growth. Arm formula typically 1.2.4.3 or 2.1.4.3. Mean and range of variation of morphological characters examined are given and discussed. The absence of females suggests the existence of spatial segregation by sex. Male maturation is also discussed.

Deep-sea octopods have colonized practically all the habitats throughout the oceans (Voss, 1977). However, within the diverse environments colonized, hydrothermal vent characteristics represent a challenge to the documented adaptative capacity of cephalopods. To collect samples or undertake studies in deep-sea hydrothermal vents is extremely difficult and the mobility of cephalopods represents an additional difficulty. However, a long series of deep-sea submersible-based research expeditions carried out by different nations has resulted in detailed description of the community organization and various aspects of the biology and ecology of some prominent inhabitants of the vent fauna (Chevaldonné, 1997). In the case of octopods, to date, *Vulcanoctopus hydrothermalis* González and Guerra, 1998 is the only cephalopod identified from such a hostile environment. This new octopod was described from two male, one immature and one mature, specimens (González et al., 1998). The present study gives data on morphological variation in new specimens of *V. hydrothermalis* collected in the type locality on the East Pacific Rise.

Material and Methods

Seventeen specimens were collected during the French cruise HOPE 99 (CNRS-IFREMER) between 1–21 May 1999. The animals were collected at 2631 m depth at Genesis, a hydrothermal vent site located in the East Pacific Rise (12°48.7′N, 103°56.43′W) (Fig. 1). All the specimens were caught at the same site, the base of a chimney, where the water temperature at the time of collection ranged from 1.92° to 1.95°C. Temperature in the surrounding seawater, from the site of collection to the proximity of the chimney opening, ranged between 1.8° and 23.5°C. The specimens were caught in different submersible dives using vacuums and creels. They were fixed in formaldehyde (4% in seawater) during 24 h and preserved in 70% ethanol.

A total of 26 morphometric and 10 meristic characters were measured and counted following to Roper and Voss (1983). Morphometric characters measured were: Total Length (TL), Dorsal Mantle Length (ML), Ventral Mantle Length (VML), Mantle Width (MW), Head Width (HW), Arm Length 1 to 4 (AL-L1 to AL-L4 and AL-R1 to AL-R4; R: right arm; L: left arm), Largest Sucker Diameter

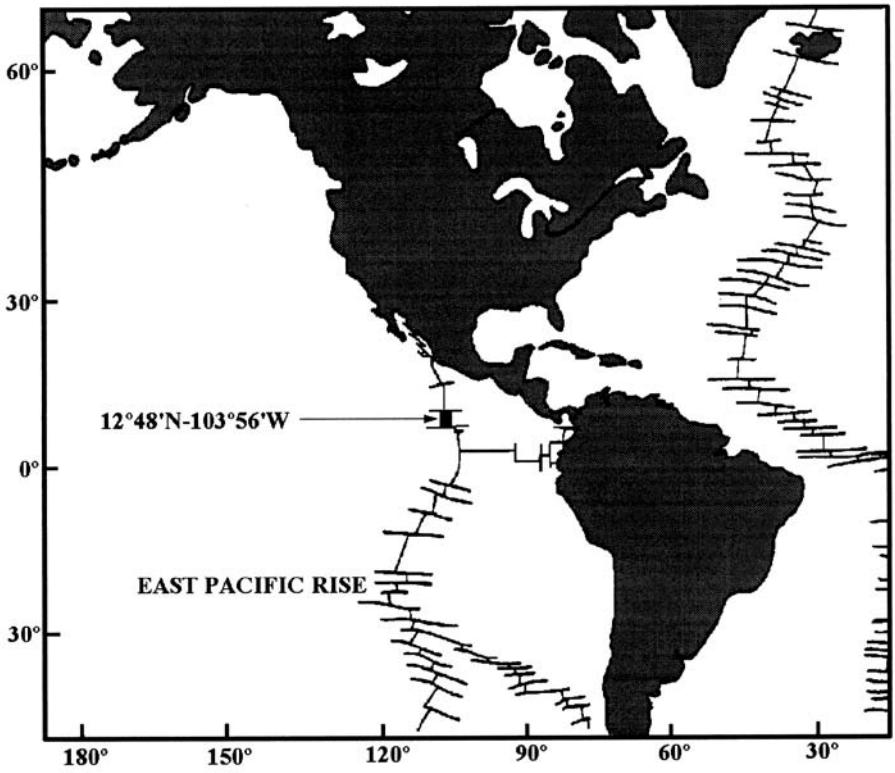

Figure 1. *Vulcanoctopus hydrothermalis*. Map showing the collection site (filled square).

(SD), Ligula Length (LiL), Calamus Length (CaL), Web Depth (WD-A to WD-E), Pallial Aperture (PA), Gill Length (GL), Funnel Length (FuL), Free Funnel Length (FFuL) and Spermatophore Length (SL). Damaged arms were not considered for the analysis undertaken in the present paper. Meristic characters measured were: Arm Sucker Count per row (ASC-L1 to ASC-L4 and ASC-R1 to ASC-R4), Number of Gill Lamellae (NGiL) and Number of Spermatophores (NS; all spermatophores were counted and measured, and none of them were partially uncoiled). Total Body Weight (BW) and Spermathophore Complex Weight (SCW, includes the needham sac and the penis) were also recorded. The length of the right arm 3 corresponds with the measure of the hectocotylized arm, and ASCR3 is the sucker count in one row of the hectocotylized arm. The sucker count was made per row because both rows had the same number of suckers.

The specimens were preserved in alcohol during 4 mo, when they were measured and weighed. Measures were made to the nearest 0.1 mm, and weights with a precision of 0.1 g. Males of *V. hydrothermalis* have a peculiar mitre-like mantle shape that is not due to a fixation process. The testis fits in the tip of the mantle. Therefore, mantle length was the length from its tip to point midway between the eyes.

Indices were calculated according to Roper and Voss (1983) and those used in the original description of González et al. (1998). They were: Arm Formula (AF), Arm Length Index (ALI-L1 to ALI-L4 and ALI-R1 to ALI-R4), Calamus Length Index (CaLI), Free Funnel Index (FFuI), Funnel Length Index (FuLI), Gill Length Index (GiLI), Head Width Index (HWI), Ligula Length Index (LiLI), Mantle Width Index (MWI), Pallial Aperture Index (PAI), Sucker Diameter Index (SDI), Spermatophore Length Index (SpLI), Web Depth Index (WDI), Web Depth for each arm (WDI-A

to WDI-E) and Web Formula (WF). Mean and range of variation of morphological and meristic characters examined are given.

Linear, power, exponential and logarithmic equations were fitted to the relationships made in the present manuscript (Zar, 1999). Only the best fit is shown.

The holotype (MNHN no. 2885) and paratype (MNHN no. 2886) are deposited in the National Museum of Natural History of Paris. The remaining material is at present deposited at the Instituto de Investigaciones Marinas (CSIC, Vigo).

Results

All specimens, except one (22 mm ML; 3.1 g), were submature and mature males ranging from 36 to 57 mm dorsal mantle length (ML) and 24.3 g to 43.9 g of total weight (BW). One specimen (No. 8) could not be measured due to the presence of only some deteriorated arms. Table 1 reports measurements, counts and indices of the sixteen specimens that were in good condition.

Table 2 offers basic statistics of the morphometric and meristic data obtained from the 16 specimens collected during this study, and the holotype and paratype of the species. Figures 2A and 2B illustrate the relationships BW-ML and SL-ML, respectively. All spermatophores were measured (average length per individual and standard deviation are shown in Table 2) and their length in each individual was normally distributed. All the spermatophores belonging to a particular animal had approximately the same length. Spermatophore length increases with maturity and size of animals.

The average number of suckers per row and arm, except the hectocotylized one, for each individual ranged from 45 to 75 (Fig. 3). However, the average number of suckers per row in the hectocotylized arm for each animal ranged from 29 to 42 (Fig. 3). As shown in Figure 3, the average sucker addition per row and arm slows in the largest specimens.

The relationship between the ligula length (LiL) and the mantle length (ML) is shown in Figure 2C. The relation between CaL-ML is illustrated in Figure 2D. Calamus length in relation to ligula length increases with maturity and size of specimens.

From the above data, male diagnosis of *V. hydrothermalis* given in González et al. (1998) can be completed as follows:

Male Diagnosis of *V. hydrothermalis*.—Small benthic animals up to 56 mm ML and 45 g BW. Arms 1.5–4.3 times ML. Right arm III hectocotylized (1.5–2.1 times ML). Ligula short (8–10% of the hectocotylized arm in fully mature males), lance-shaped and without transverse ridges. Calamus represents 30 to 50% of the Ligula length in fully mature specimens. Adult males have no enlarged suckers, the diameter of the largest sucker ranges from 4.0% to 6.3% of the ML. Maximum number of suckers per row on each arm were 87, 76, 72 and 71 in left arms 1, 2, 3 (hectocotilyzed arm) and 4, and 83, 82, 42 and 70 in the right arms 1, 2, 3 and 4, respectively. Two rows of suckers on each arm. Both rows have the same number of suckers. Arm formula typically 1.2.4.3 or 2.1.4.3. Maximum depth of the largest sector of the web about 22% of the longest arm. Gills with seven or eight lamellae per demibranch, most commonly eight. Spermatophore length ranged between 24.0 and 61.7 mm, with a mean and standard deviation of 39.4 (6.6 mm (representing 70 to 125% of ML). Number of spermatophores in mature males ranged between 5 and 114, with a mean of 45.9 ± 28.0.

Table 1. *Vulcanoctopus hydrothemalis*. Measurements (mm), weights (g) and counts of the specimens analysed in the present study and the holotype and paratype of the species (González et al., 1998). See Material and Methods section for abbreviations. Method of collection: ASP=Vacuum. Values of Spermatophore length (SL) are mean lengths considering all spermatophores present in the Needham sac.

DATE	13/02/1996	11/05/1999	19/02/1996	20/05/1999	11/05/1999	12/05/1999
METHOD	ASP	ASP5	ASP	CREEL D	ASP4	ASP4
SPECIMEN	Paratype	3	Holotype	17	2	7
ML	21.2	22.3	34.7	35.9	40.0	40.1
VML	-	18.07	-	30.74	33.31	-
TL	103	100	163	182	156	-
BW	-	3.06	-	24.25	17.37	-
MW (MWI)	14.8 (69.8)	13.13 (58.77)	29.0 (83.6)	28.70 (79.86)	22.18 (55.39)	36.44 (90.96)
HW (HWI)	10.5 (49.5)	9.07 (40.60)	19.4 (55.9)	17.39 (48.39)	16.98 (42.41)	21.41(53.44)
AL-L1 (ALI-L1)	75.3 (355.2)	71.00 (317.82)	129.4 (372.9)	-	-	-
AL-L2 (ALI-L2)	-	62.00 (277.53)	-	-	-	-
AL-L3 (ALI-L3)	73.3 (345.8)	59.00 (264.10)	105.5 (304.0)	127.00 (353.37)	93.00 (232.27)	-
AL-L4 (ALI-L4)	60.5 (285.4)	44.00 (196.96)	99.7 (287.3)	115.00 (319.98)	-	-
AL-R1(ALI-R1)	-	41.00 (183.53)	115.0 (331.4)	147.00 (409.02)	-	-
AL-R2 (ALI-R2)	-	57.00 (255.15)	-	136.00 (378.41)	105.00 (262.24)	-
AL-R3 (ALI-R3)	-	39.00 (174.57)	67.4 (194.2)	77.00 (214.25)	66.00 (164.84)	-
AL-R4 (ALI-R4)	51.8 (244.3)	48.00 (214.86)	105.6 (304.3)	113.00 (314.41)	97.00 (242.26)	-
AF	-	II. IV. I. III	-	I. II. IV. III	-	-
ASC-L1	62	51	80	-	-	-
ASC-L2	-	46	-	-	-	-
ASC-L3	65	54	67	64	56	-
ASC-L4	58	34	68	56	-	-
ASC-R1	-	-	75	73	-	-
ASC-R2	-	46	-	71	66	-
ASC-R3 (HASC)	-	29	40	38	37	-
ASC-R4	45	38	70	60	62	-
SD (SDI)	1.30 (6.10)	1.34 (6.00)	2.00 (5.70)	2.01(5.59)	1.60 (4.00)	2.52 (6.29)
LiL (LiLI)	-	1.88 (4.82)	6.10 (9.00)	5.53 (7.18)	5.37 (8.14)	6.75
CaL (CaLI)	-	0.69 (36.70)	1.10 (17.90)	2.32 (41.95)	2.32 (43.20)	2.48 (36.74)
WD-A (WDI-A)	2.50 (11.90)	13.78 (61.68)	4.40 (12.70)	28.90 (80.41)	17.09 (42.68)	-
WD-B (WDI-B)	3.00 (14.10)	14.17 (63.43)	5.60 (16.10)	26.61 (74.04)	17.67 (44.13)	-
WD-C (WDI-C)	3.01 (14.20)	12.22 (54.70)	5.20 (15.00)	23.56 (65.55)	18.70 (46.70)	-
WD-D (WDI-D)	2.70 (12.50)	12.15 (54.39)	5.00 (14.40)	23.47 (65.30)	17.41 (43.48)	-
WD-E (WDI-E)	1.90 (9.00)	11.50 (51.48)	4.80 (13.70)	21.77 (60.57)	13.39 (33.44)	-
WDel	3.98	19.96	4.33	19.66	17.81	-
WF	C.B.D.A.E	B. A. C. D. E	B.C.D.E.A	A. B. C. D. E	C. B. D. A. E	-
PA (PAI)	10.50 (49.50)	4.96 (22.20)	14.20 (40.90)	10.65 (29.63)	12.62 (31.52)	-
GiL (GiLI)	9.10 (42.90)	4.65 (20.81)	12.60 (36.30)	10.02 (27.88)	10.06 (25.12)	11.24 (28.06)
NGiL	8	8	8	7	8	7
FuL (FuLI)	5.30 (25.00)	4.72 (21.13)	9.50 (27.30)	6.05 (16.83)	4.45 (11.11)	11.56 (28.86)
FFu (FFuI)	2.40 (11.30)	4.47 (20.01)	4.50 (12.90)	2.42 (6.73)	2.43 (6.07)	2.88 (7.19)
SCW	-	0.05	-	0.58	0.63	2.44
NS	-	-	64	6	54	114
SL (SLI)	-	-	43.38 (125.00)	30.71 (85.45)	31.95 (79.80)	36.93 (92.19)

Table 1. *Vulcanoctopus hydrothemalis*. (Cont.)

DATE	14/05/1999	20/05/1999	17/05/1999	19/05/1999	01/05/1999	12/05/1999
METHOD	ASP5	CREEL C	ASP3	ASP1	ASP 3	ASP1
SPECIMEN	9	16	11	13	1	4
ML	41.9	43.0	43.6	44.0	44.3	45.8
VML	-	42.62	36.15	-		40.52
TL	214	220	191	221	180	166
BW	37.8	39.01	26.42	43.91	25.16	21.11
MW (MWI)	38.66 (92.16)	36.30 (84.44)	24.01 (55.04)	34.98 (79.50)	29.34 (66.23)	22.90 (50.03)
HW (HWI)	20.88 (49.77)	21.51(50.03)	18.55 (42.53)	20.67 (46.98)	21.30 (48.08)	18.35 (40.09)
AL-L1 (ALI-L1)	-	-	128.00 (293.44)	162.00 (368.18)	139.00 (313.77)	100.00 (218.48)
AL-L2 (ALI-L2)	-	161.00 (374.51)	129.00 (295.74)	-	114.00 (257.34)	117.00 (255.63)
AL-L3 (ALI-L3)	149.00 (355.18)	150.00 (348.92)	118.00 (270.52)	143.00 (325.00)	100.00 (225.73)	99.00 (216.30)
AL-L4 (ALI-L4)	139.00 (331.35)	143.00 (332.64)	116.00 (265.93)	135.00 (306.82)	114.00 (257.34)	90.00 (196.64)
AL-R1(ALI-R1)	167.00 (398.09)	183.00 (425.68)	133.00 (304.91)	-	131.00 (295.71)	122.00 (266.55)
AL-R2 (ALI-R2)	165.00 (393.33)	163.00 (379.16)	131.00 (300.32)	161.00 (365.91)	121.00 (273.14)	123.00 (268.73)
AL-R3 (ALI-R3)	-	80.00 (186.09)	74.00 (169.65)	-	71.00 (160.27)	68.00 (148.57)
AL-R4 (ALI-R4)	125.00 (297.97)	136.00 (316.35)	-	-	117.00 (264.11)	75.00 (163.86)
AF	-	I. II. IV. III	-	-	I. II. IV. III	II. I. IV. III
ASC-L1	83	-	63	69	61	56
ASC-L2	-	68	64	-	54	72
ASC-L3	72	68	72	65	49	57
ASC-L4	71	66	62	60	-	48
ASC-R1	83	74	71	-	61	65
ASC-R2	82	69	72	66	62	63
ASC-R3 (HASC)	35	38	36	-	35	40
ASC-R4	57	63	-	-	52	43
SD (SDI)	2.53 (6.03)	2.69 (6.26)	2.44 (5.59)	2.51(5.70)	2.34 (5.28)	2.00 (4.37)
LiL (LiLI)	-	6.42 (8.03)	5.02 (6.78)	-	7.18 (10.11)	4.75 (6.99)
CaL (CaLI)	-	3.18 (49.53)	1.49 (29.68)	2.87	2.32 (32.31)	2.04 (42.95)
WD-A (WDI-A)	30.74 (73.28)	29.33 (68.23)	22.28 (51.08)	28.43 (64.61)	23.01 (51.94)	27.06 (59.12)
WD-B (WDI-B)	31.89 (76.02)	25.80 (60.01)	19.30 (44.25)	24.11 (54.80)	26.71 (60.29)	26.14 (57.11)
WD-C (WDI-C)	27.78 (66.22)	20.14 (46.85)	19.41 (44.50)	-	21.57 (48.69)	26.31 (57.48)
WD-D (WDI-D)	25.69 (61.24)	22.64 (52.66)	18.30 (41.95)	18.22 (41.41)	-	22.03 (48.13)
WD-E (WDI-E)	24.71 (58.90)	23.15 (53.85)	20.10 (43.08)	17.87 (40.61)	17.28 (39.01)	19.82 (43.30)
WDel	19.10	16.03	16.75	17.55	19.22	22.00
WF	B. A. C. D. E	A. B. E. D. C	A. E. C. B. D	-	-	A. C. B. D. E
PA (PAI)	15.68 (37.38)	13.67 (31.80)	16.71 (38.31)	16.78 (38.14)	-	10.72 (23.42)
GiL (GiLI)	14.76 (35.18)	11.26 (26.19)	14.10 (32.32)	11.09 (25.20)	12.04 (27.18)	10.55 (23.05)
NGiL	8	8	8	8	8	8
FuL (FuLI)	9.20 (21.93)	6.18 (14.38)	10.27 (23.54)	-	-	8.37 (18.29)
FFu (FFuI)	3.76 (8.96)	4.02 (9.35)	3.41 (7.82)	1.47 (3.34)	5.13 (11.58)	3.16 (6.90)
SCW	1.56	1.63	0.48	2.39	1.35	0.91
NS	41	70	5	72	40	24
SL mean (SLI)	30.45 (72.59)	41.35 (96.19)	29.54 (67.72)	46.61 (105.93)	36.51 (82.42)	40.05 (87.50)

Table 1. *Vulcanoctopus hydrothemalis*. (Cont.)

DATE	17/05/1999	20/05/1999	19/05/1999	20/05/1999	12/05/1999	12/05/1999
METHOD	ASP2	CREEL B	ASP1	CREEL A	ASP4	ASP4
SPECIMEN	10	15	12	14	5	6
ML	46.1	46.2	50.6	52.9	53.4	56.4
VML	-	39.38	41.93	41.82	41.33	45.02
TL	212	167	195	233	192	235
BW	42.8	31	42.75	-	35.1	43.32
MW (MWI)	38.87 (84.39)	33.09 (71.58)	33.81(66.78)	38.76 (73.31)	30.69 (57.44)	28.76 (50.98)
HW (HWI)	21.07 (45.74)	19.87 (42.98)	20.46 (40.41)	22.93 (43.37)	21.64 (40.50)	23.02 (40.81)
AL-L1 (ALI-L1)	154.00 (334.35)	-	-	178.00 (336.67)	147.00 (275.13)	-
AL-L2 (ALI-L2)	-	128.00 (276.88)	-	160.00 (302.63)	-	175.00 (310.23)
AL-L3 (ALI-L3)	122.00 (264.87)	120.00 (259.57)	118.00 (233.06)	149.00 (281.82)	-	125.00 (221.59)
AL-L4 (ALI-L4)	115.00 (249.67)	113.00 (244.43)	-	139.00 (262.91)	-	142.00 (251.73)
AL-R1(ALI-R1)	164.00 (356.06)	123.00 (266.06)	130.00 (256.76)	173.00 (327.22)	145.00 (271.38)	158.00 (280.09)
AL-R2 (ALI-R2)	151.00 (327.83)	126.00 (272.55)	-	170.00 (321.54)	-	175.00 (310.23)
AL-R3 (ALI-R3)	84.00 (182.37)	70.00 (151.42)	-	97.00 (183.47)	82.00 (153.47)	95.00 (168.41)
AL-R4 (ALI-R4)	130.00 (282.24)	115.00 (248.76)	111.00 (219.24)	144.00 (272.37)	125.00 (233.95)	142.00 (251.73)
AF	I. II. IV. III	II. I. IV. III	-	I. II. IV. III	-	II. I. IV. III
ASC-L1	69	-	-	65	87	-
ASC-L2	-	67	-	61	-	76
ASC-L3	54	63	68	60	-	49
ASC-L4	53	60	-	55	-	67
ASC-R1	68	70	-	61	54	77
ASC-R2	64	67	-	62	-	76
ASC-R3 (HASC)	35	35	-	37	36	42
ASC-R4	55	62	66	56	56	66
SD (SDI)	2.66 (5.78)	2.02 (4.37)	2.42 (4.78)	2.76 (5.22)	2.26 (4.23)	2.73 (4.84)
LiL (LiLI)	7.67 (9.13)	5.56 (7.94)	-	8.81(9.08)	6.42 (7.83)	6.96 (7.33)
CaL (CaLI)	3.24 (42.24)	2.59 (46.58)	-	-	2.42 (37.69)	2.57 (36.93)
WD-A (WDI-A)	24.82 (53.89)	20.38 (44.08)	25.09 (49.56)	29.81 (56.38)	29.42 (55.069	28.35 (50.26)
WD-B (WDI-B)	23.64 (51.32)	25.97 (56.18)	22.54 (44.52)	30.63 (57.93)	29.45 (55.12)	30.84 (54.67)
WD-C (WDI-C)	22.41 (48.65)	25.12 (54.34)	16.36 (32.31)	24.08 (45.55)	24.08 (45.07)	26.14 (46.34)
WD-D (WDI-D)	20.41 (44.31)	20.03 (43.33)	-	21.27 (40.23)	24.17 (45.24)	20.06 (35.56)
WD-E (WDI-E)	18.14 (39.38)	16.46 (35.60)	19.10 (37.72)	22.64 (42.82)	26.19 (49.02)	28.09 (49.80)
WDel	15.13	20.29	19.30	17.21	20.03	17.62
WF	A. B. C. D. E	B. C. A. D. E	-	B. A. C. E. D	B. A. E. D. C	B. A. E. C. D
PA (PAI)	20.10 (43.64)	11.62 (25.14)	13.13 (25.93)	15.63 (29.56)	13.99 (26.18)	14.07 (24.94)
GiL (GiLI)	10.87 (23.60)	12.28 (26.56)	11.98 (23.66)	15.39 (29.11)	11.79 (22.07)	16.48 (29.21)
NGiL	8	8	8	-	8	8
FuL (FuLI)	11.26 (24.45)	8.20 (17.74)	11.05 (21.83)	11.94 (22.58)	12.52 (23.43)	12.43 (22.04)
FFu (FFuI)	4.56 (9.90)	3.87 (8.37)	3.98 (7.86)	5.39 (10.19)	5.98 (11.19)	5.24 (9.29)
SCW	2.17	1.28	1.79	2.67	1.33	1.67
NS	74	32	39	37	39	42
SL mean (SLI)	41.20 (89.45)	42.86 (92.71)	43.74 (86.39)	54.04 (102.21)	38.55 (72.15)	42.58 (75.48)

Table 2. *Vulcanoctopus hydrothermalis*. Mean, standard deviation (SD), range (Maximum: Max; Minimum: Min) and number (N) of measurements (mm), weights (g) and counts of body proportions.

Variable	Mean	SD	Max	Min	N
Total Length	184.12	39.58	235.0	100.0	17
Body Weight	30.93	12.05	43.9	3.1	14
Dorsal Mantle Length	42.36	9.41	56.4	21.2	18
Ventral Mantle Length	37.35	7.69	45.0	18.1	11
Mantle Width	29.69	7.77	38.9	13.1	18
Head Width	19.17	3.81	23.0	9.1	18
Arm Length Left 1	128.37	35.94	178.0	71.0	10
Arm Length Left 2	130.75	35.73	175.0	62.0	8
Arm Length Left 3	115.67	26.56	150.0	59.0	16
Arm Length Left 4	111.80	30.12	143.0	44.0	14
Arm Length Right 1	138.00	34.92	183.0	41.0	14
Arm Length Right 2	137.23	32.66	175.0	57.0	13
Arm Length Right 3	74.65	14.63	97.0	39.0	13
Arm Length Right 4	109.03	29.79	144.0	48.0	15
Arm Suckers Count per Row Left 1	67.82	11.33	87.0	51.0	11
Arm Suckers Count per Row Left 2	63.50	9.74	76.0	46.0	8
Arm Suckers Count per Row Left 3	61.44	7.51	72.0	49.0	16
Arm Suckers Count per Row Left 4	58.31	9.79	71.0	34.0	13
Arm Suckers Count per Row Right 1	69.33	8.04	83.0	54.0	12
Arm Suckers Count per Row Right 2	66.62	8.50	82.0	46.0	13
Arm Suckers Count per Row Right 3	36.64	3.10	42.0	29.0	14
Arm Suckers Count per Row Right 4	56.73	9.09	70.0	38.0	15
Sucker Diameter	2.23	0.46	2.8	1.3	18
Ligula Length	6.03	1.62	8.8	1.9	14
Calamus Length	2.26	0.73	3.2	0.7	14
Web Depth A	22.67	8.64	30.7	2.5	17
Web Depth B	22.59	8.35	31.9	3.0	17
Web Depth C	19.76	7.31	27.8	3.0	16
Web Depth D	18.23	6.70	25.7	2.7	15
Web Depth E	18.05	7.01	28.1	1.9	17
Pallial Aperture	13.44	3.44	20.1	5.0	16
Gill Length	11.68	2.63	16.5	4.7	18
Number of Gill Lamellae	7.88	0.33	8.0	7.0	17
Funnel Length	8.94	2.84	12.5	4.5	16
Free Funnel length	3.84	1.22	6.0	1.5	18
Spermatophoric Complex Weight	1.43	0.76	2.7	0.1	16
Number of Spermatophores	47.06	27.38	114.0	5.0	16
Spermatophore Length	39.40	6.60	54.0	29.5	16

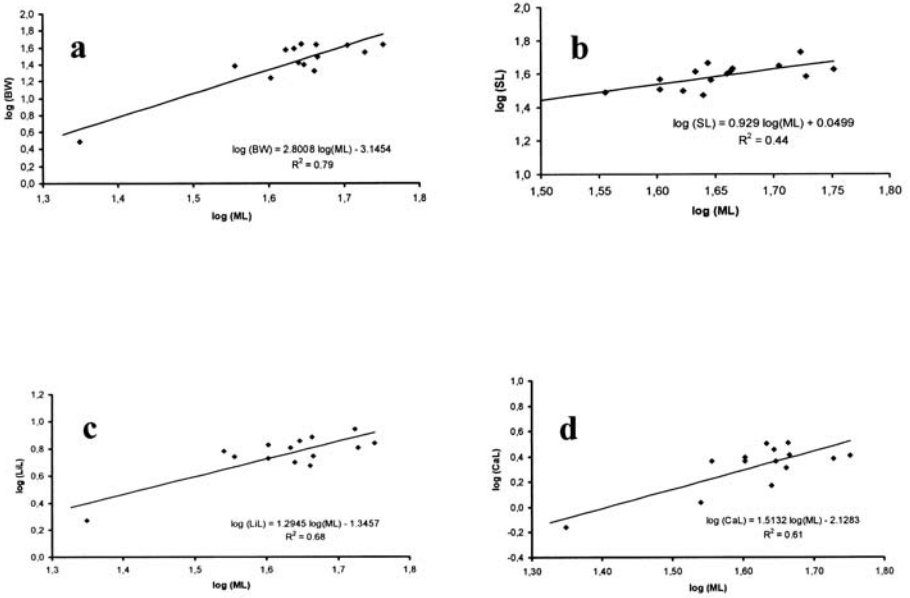

Figure 2. *Vulcanoctopus hydrotermalis*. Relationships between (a): Body Weight (BW) and Dorsal Mantle Length (ML); (b) Mean Spermatophore Length (SL) and Dorsal Mantle Length (ML) in males; (c) Ligula Length (LiL) and Dorsal Mantle Length (ML); (d) Calamus Length (CaL) and Dorsal Mantle Length (ML).

Discussion

Biometric data of males *V. hydrothermalis* offered in this paper completes the description of this unique and rare species. These measurements are very important to undertake in species descriptions of cephalopods (Roper and Voss, 1983). In this case, it is interesting to know about intra-specific variation in males characters if members of this species actually do occur away from hydrothermal vents, and if they have color, these data might be very important for recognizing them. However, some considerations must be taken into account for a correct interpretation of these morphological data: (1) measurements were all made from formaldehyde fixed and ethanol preserved animals. Therefore, these could be influenced by deformation induced by preservation (Roper and Voss, 1983; Vecchione et al., 1989). However, Voight (1991) pointed out that preservation-linked deformations of *Octopus* species is minimal. (2) High variation found in the number of spermatophores could have two origins, small submature specimens or post-copulatory mature males. (3) The only immature specimen (without spermatophores in the spermatophoric's sac) was a male of 22 mm ML. This animal shows a small but well developed ligula.

Toll (1988) noted that the total number of suckers on the arms of octopods is perhaps the second most salient meristic feature after the nominal character of the order (Octopoda = eight arms). Pattern of sucker addition per arm, excluding the hectocotylized one, coincides with that observed by Toll (1988) in shallow water octopuses. The sucker addition is faster in small animals than in bigger animals with a near to total cessation of addition

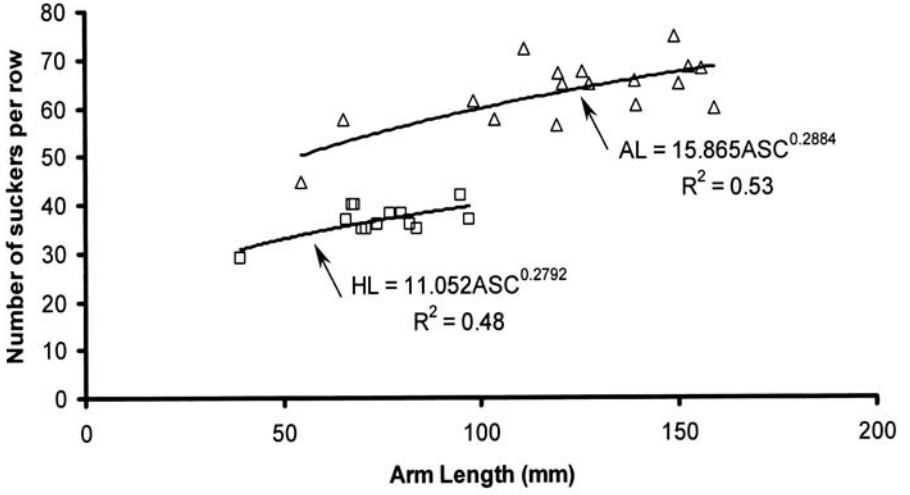

Figure 3. *Vulcanoctopus hydrotermalis*. Relationship between the average number of suckers per row and arm length, for each individual. Triangles: considering all arms excluding the hectocotylized one; Squares: considering only the hectocotylized arm.

of new suckers during the later stages of arm growth. A similar tendency is shown in the hectocotylized arm.

The absence of females in the sampling suggests the existence of a spatial segregation by sex, as observed in other cephalopod species. A preponderance of females at depths less than 20 m was observed in *Octopus dofleini*, whereas males were preponderant at depths between 20 and 40 m (Hartwick, 1983). A spatial segregation between males and females in the intertidal waters (up to 20 m depth) during autumn and spring periods were observed in *Octopus tehuelchus* and *Eledona massyae*, respectively (Ré, 1998). More studies are needed (basically to get some females) to complete the description of the only known species of cephalopod inhabiting a deep-sea hydrothermal vent site.

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