TWO NEW RECORDS OF GIANT SQUID (*Architeuthis* sp.) FROM THE PATAGONIAN REGION*

by

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RESUMEN

Dos nuevos registros de calamares gigantes (*Architeuthis* sp.) en la región patagónica. Dos hembras de calamar gigante *Architeuthis* sp. fueron capturadas por barcos arrastreros sobre la plataforma patagónica en los años 1998 y 1999. El primer ejemplar se obtuvo durante una operación de arrastre de fondo (50° 39' S-66° 35' W) en abril de 1998 y el segundo durante un arrastre de media agua (53° 54' S-63° 45' W) en febrero de 1999. Ambos calamares, de 177 y 144 cm de largo de manto y en maduración, se encontraban severamente dañados, especialmente en los tentáculos, brazos y nadaderas. Se examinaron la anatomía externa e interna y los caracteres morfométricos y se compararon con registros anteriores de calamares gigantes del hemisferio sur.

SUMMARY

Two females of giant squid *Architeuthis* sp. were caught by trawlers on the South Patagonian shelf in 1998 and 1999. The first specimen was captured during a bottom trawl at 50° 39' S-66° 35' W in April 1998 and the second during a midwater trawl at 53° 54' S-63° 45' W in February 1999. The animals were severely damaged, specially on the tentacles, arms and fins. Both specimens, of 177 and 144 cm mantle length, were maturing. The internal and external anatomy and morphometric characters were examined and compared to previous records of this genus in the Southern Oceans.

Key words: Giant squid, *Architeuthis* sp., Southwest Atlantic, Patagonian region.
Palabras clave: Calamar gigante, *Architeuthis* sp., Atlántico Sudoccidental, región patagónica.

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INTRODUCTION

The largest invertebrate in the world, the giant squid *Architeuthis* sp. Steenstrup, is also one of the most poorly known cephalopod. Although the genus is reported to occur worldwide (Nesis, 1982; Roper *et al.*, 1984), information on its appearance in the Southwest Atlantic region was contradictory until the first well documented record in brazilian waters appeared in 1989 (Arfelli *et al.*, 1991). The first records in the Patagonian area occurred inside the San Jorge Gulf in 1995 and 1996 when two females were found stranded and a third was caught by a trawler (Ruiz and Fondacaro, 1996; Brunetti *et al.*, 1998; Ré *et al.*, 1998). More doubts than certainties compose the background knowledge on the taxonomic status of the genus. A lot of possibilities of existing species have been proposed by many authors since Steenstrup erected the species *A. dux* in 1857 (Pfeffer, 1912). The trend in the last two decades was to consider that a reduced number of species could be valid (Nesis, 1982; Aldrich, 1991). Recently, Förch (1998) presented a very clear compilation of the history of the Architeuthidae family and supported her hypothesis on the existence of a single genus and species (*A. dux*) but with a high level of variation in the characters normally used to differentiate squid species. This characteristic, together with the low number of specimens available for examination, could have led to the multispecific nature of the genus formerly considered.

Two giant squids were caught by fishing vessels in the South Patagonian area in 1998 and 1999. This paper reports their descriptions in an attempt to contribute to the knowledge of the genus.

MATERIAL AND METHODS

Two giant squids captured during trawl operations in the South Patagonian area were examined (Table 1). The animals were frozen on board and stored at -20 °C until defrosting for 18 hours. Specimen 1 was examined at the INIDEP laboratory while examination of specimen 2 took place at Pesantar fishing company factory.

Table 1. Catch data for two specimens of *Architeuthis* sp. from Patagonian waters.
Tabla 1. Datos de captura de dos ejemplares de Architeuthis sp. de aguas patagónicas.

Specimen	1	2
Date	9 April 1998	15 February 1999
Time	19:35	11:45
Locality	50° 39.0'S-66°35.3' W	53°54.6'S-63°45.9' W
Vessel	Kasuga Maru	Rikusen
Fishing company	Pespasa	Pesantar SA
Fishing method	Bottom trawl	Midwater trawl
Fishing depth	105 m	316-360 m
Bottom depth	105 m	450 m
Surface water temperature	9.1 °C	
Air temperature	14 °C	
Collector	Fishery Inspector	Scientific Observer

After thawing the squids were photographed and measured externally according to Roeleveld and Lipinski (1991) and Förch (1998). The body measurements were taken to the nearest millimetre (mm) using a flexible tape and the sucker diameters to the nearest 0.01 mm with vernier calipers. Then, when relevant, the body measurements were standardized as percentages of mantle length (ML). Coloration and sculpture details were also registered. After dissection, photographs and measurements (to 1 mm) of the internal organs along the ventral midline were taken. The reproductive and digestive organs were removed (those of specimen 1 also weighed to the nearest g) and the stomach content analyzed and sorted out under a binocular microscope.

As preservation of whole animals was not possible, hard and some soft structures were kept for the INIDEP collection. The beaks, radulae, gladius, statoliths and the available sucker rings were preserved in 70% ethyl alcohol while the reproductive and digestive systems and some portions of mantle and arm muscle were fixed in 10% formaldehyde and then transferred to 75% ethyl alcohol.

Beak analysis

After removal of the buccal mass, both upper and lower beaks were easily pulled out from it. Beaks were measured with vernier calipers to the nearest 0.01 mm. Following Wolff (1982) and Clarke (1986) eleven dimensions on the lower beak were measured: rostral length, hood length, crest length, wing length, rostral tip to inner posterior corner of lateral wall, rostral tip to inner margin of wing, rostral tip to baseline, jaw angle width, length of the baseline in profile, distance at which the rostral tip lies behind the wing tip and rostral base length. Eight dimensions on the upper beak were taken (Clarke, 1962; Wolff, 1982): rostral length, hood length, crest length, wing width, wing length, rostral tip to inner margin of wing, jaw angle width and wing to crest length. In order to describe the beak shape some of these dimensions were transformed into ratios.

Statolith analysis

Statoliths were removed and measurements taken under a binocular microscope using a micrometer eyepiece (1/100) and then transformed to millimetres. According to Clarke (1978) and Lipinski (1997) the following dimensions on the anterior side of the right and left statoliths were registered (Figure 1): total length, rostral length, lateral dome length, dorso-lateral length to ventral lobe, dorso-lateral length to dorsal lobe, ventro-lateral length, maximum and minimum lateral dome width, wing length, wing width, spur to tip of rostrum length, spur to apex of dorsal dome length and rostral base to lateral tip of lateral dome length. In order to describe their shape ratios were calculated from the dimensions taken on the statoliths.

RESULTS

Both squids examined were severely damaged, showing heads detached from the almost entirely skinless bodies, and most of arms and tentacles were, if not entirely, at least partially lost. As a result of transport of the frozen animals, specimen 1 had the body divided into two pieces, at approximately halfway along and specimen 2 had fins broken. Body measurements and indices of both animals are shown in Table 2.

Specimen 1

General morphology

It was a female of 1,766 mm ML with a ventral mantle length reaching 87.03% of dorsal length (Table 2). The body shape was cylindrical anteriorly and conical rearmost. The widest part of the mantle occurred in the anterior third of the

body with a somewhat narrower anterior opening. The body tapered abruptly from midway along the fins. The forward projection of the mid-dorsal region of the mantle aperture was low and broad. A visible gladius line ran along the mid-dorsal region. The mantle texture was firm and muscular and the dorsal wall thickness (MT) ranged from 20 mm at the aperture to 55 mm at the maximum point (lowest MT / highest MT = 36.36%). As a result of the lost skin the mantle was nacreous white and only small fragments of skin, with reddish-brown chromatophores, remained on the dorsal side anterior to the fin insertion. The fins, inserted at 62.63% of the distance from the mantle aperture, extended up to the end of the body (FL / ML = 37.37). They were oval (DFW / FL = 76.67) but narrower posteriorly and slightly extended laterally beyond the mantle (DFW / ML = 28.65). Their texture was thick at the anterior insertion and gradually tapered to weak edges and posterior attachment. The anterior insertion of both fins was 282 mm apart (15.97% ML) but the attachment areas gradually converged towards the posterior end. The head was 25.33% longer than wide and short in relation to ML (DHL / ML = 21.23). It looked flattened dorso-ventrally, reddish-brown on the dorsal side and pinkish-brown in ventral view. The nuchal crest formed a marked and firm border while the neck region was soft. The eyes were rounded and large (ED / ML = 8.04). The funnel groove was low and pale, the edge well delineated by the ventral head skin colour. The external diverticulum of the anterior vena cava was observed between the funnel bri-

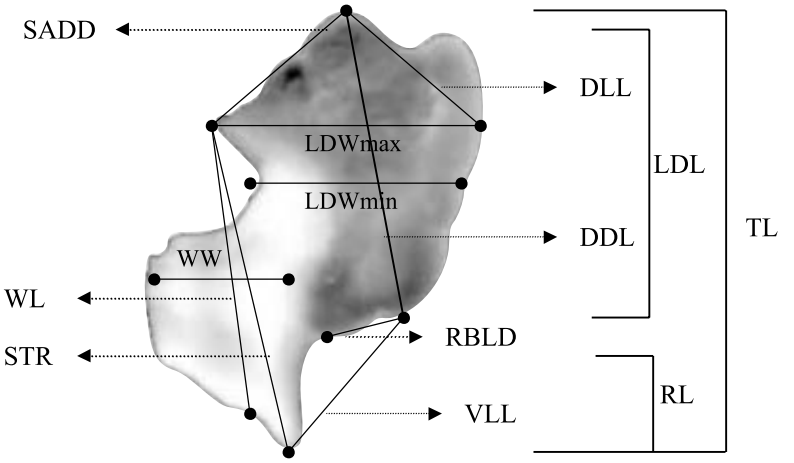

Figure 1. Measurements taken on the anterior side of the statoliths of *Architeuthis* sp. (according to Clarke, 1978 and Lipinski, 1997), illustrated on the left statolith of Specimen 1. TL: total length; RL: rostral length; LDL: lateral dome length; DDL: dorso-lateral length to ventral lobe; DLL: dorso-lateral length to dorsal lobe; VLL: ventro-lateral length; LDWmax - LDWmin: maximum and minimum lateral dome width; WL: wing length; WW: wing width; STR: spur to tip of rostrum length; SADD: spur to apex of dorsal dome length; RBLD: rostral base to lateral tip of lateral dome length.

Figura 1. Mediciones realizadas sobre la cara anterior de los estatolitos de Architeuthis sp. (según Clarke, 1978 y Lipinski, 1997), ilustradas sobre el estatolito izquierdo del ejemplar 1. TL: largo total; RL: largo del rostro; LDL: largo de domo lateral; DDL: largo desde el domo dorsal hasta el lóbulo ventral del domo lateral; DLL: largo desde el domo dorsal hasta el lóbulo dorsal del domo lateral; VLL: largo desde el extremo del rostro hasta el lóbulo ventral del domo lateral; LDWmax - LDWmin: anchos máximo y mínimo del domo lateral; WL: largo del ala; WW: ancho del ala; STR: largo desde la espina hasta el extremo del rostro; SADD: largo desde la espina hasta el extremo del domo dorsal; RBLD: largo desde la base del rostro hasta el lóbulo ventral del domo lateral.

Table 2. Body measurements and indices of the two giant squids examined.
Tabla 2. Datos morfométricos e índices calculados de los dos ejemplares de calamares gigantes examinados.

	Measurements (mm)			Indices (%)	
Specimen Number	1	2	Specimen Number	1	2
Sex	F	F	Sex	F	F
Maturity Stage	III	III	Maturity Stage	III	III
Dorsal mantle length (ML)	1,766	1,440			
Ventral mantle length (VML)	1,537	1,270	VML / ML	87.03	88.19
Mantle width (MW), at 10 cm from posterior tip		85	MW, at 10 cm from posterior tip / ML		5.90
Mantle width (MW), at 20 cm from posterior tip		169	MW, at 20 cm from posterior tip / ML		11.74
Mantle width (MW), at 40 cm from posterior tip		340	MW, at 40 cm from posterior tip / ML		23.61
Mantle width (MW), at 60 cm from posterior tip		435	MW, at 60 cm from posterior tip / ML		30.21
Mantle width (MW), at 90 cm from posterior tip		505	MW, at 90 cm from posterior tip / ML		35.07
Mantle width (MW), at 120 cm from posterior tip		458	MW, at 120 cm from posterior tip / ML		31.81
Mantle width (MW), at the aperture		443	MW, at the aperture / ML		30.76
Ventral distance between pallial connectives (PCVD)	370	347	PCDV / ML	20.95	24.10
Mantle thickness (MT) at the anterior margin	20	5	MT at the anterior margin / ML	1.13	0.35
Mantle thickness (MT) at half-way along	55	36	MT at half-way along / ML	3.11	2.50
			Lowest MT / greatest MT	36.36	13.89
Mantle-locking cartilage length (MLCL)	190	152	MLCL / ML	10.76	10.56
Mantle-locking cartilage width (MLCW) at the base	23	23	MLCW at the base / ML	1.30	1.60
Mantle-locking cartilage width (MLCW) maximum	50	42	MLCW maximum / ML	2.83	2.92
Mantle-locking cartilage width (MLCW) at the mantle opening	25	20	MLCW at the mantle opening / ML	1.42	1.39
Distance of anterior fin insertion from mantle aperture (DAFI)		1106	DAFI / ML	62.63	
Separation between fin insertions (SFI)	282		SFI / ML	15.97	
Distance from gladius to the anterior fin insertion (DGAFI)	141		DGAFI / ML	7.98	
Distance from gladius to the posterior fin insertion (DGPFI)	60		DGPFI / ML	3.40	
Fin length (FL)	660		FL / ML	37.37	
Single fin width (SFW)	193		SFW / ML	10.93	
Greatest double fin width (DFW)	506		DFW / FL	76.67	
			DFW / ML	28.65	
Dorsal head length to nuchal crest (DHL)	375	376	DHL / ML	21.23	26.11
Ventral head length (VHL)	304		VHL / ML	17.21	
Dorsal head width (DHW) at nuchal crest	280	248	DHW at nuchal crest / ML	15.86	17.22
Ventral head width (VHW)	219		DHW at nuchal crest / DHL	74.67	65.96
Dorsal head width (DHW) at arm base	360	232	DHW at arm base / ML	20.39	16.11
Eye diameter (ED)	142	105	ED / ML	8.04	7.29
Funnel length median ventral (FuL)	281	260	FuL / ML	15.91	18.06
Funnel width (FuW) at the opening	115	108	FuW at the opening / ML	6.51	7.50
Funnel width (FuW) at the midpoint	208	158	FuW at the midpoint / ML	11.78	10.97
Funnel width (FuW) at the base	270	266	FuW at the base / ML	15.29	18.47
Funnel valve length (FVL)		90	FVL / ML		6.25
Funnel valve width (FVW)		118	FVW / ML		8.19
Funnel-locking cartilage length (FLCL)	198	172	FLCL / ML	11.21	11.94
Funnel-locking cartilage width (FLCW) at the base	40	32	FLCW at the base / ML	2.27	2.22
Funnel-locking cartilage width (FLCW) at the midpoint	43	41	FLCW at the midpoint / ML	2.43	2.85
Funnel-locking cartilage width (FLCW) at the opening	19	15	FLCW at the opening / ML	1.08	1.04
Funnel retractor muscle length (FRML)	482	505	FRML / ML	27.29	35.07
Funnel retractor muscle width (FRMW)	70	50	FRMW / ML	3.96	3.47
Funnel retractor muscle height (FRMH)	28	24	FRMH / ML	1.59	1.67
Ventral distance between funnel-locking cartilages (FLCVD)	350	330	FLCVD / ML	19.82	22.92
Nuchal cartilage length (NCL)		204	NCL / ML		14.17
Nuchal cartilage width (NCW) of anterior section		75	NCW of anterior section / ML		5.21
Nuchal cartilage width (NCW) of narrowest portion		56	NCW of narrowest portion / ML		3.89
Nuchal cartilage width (NCW) of posterior portion		64	NCW of posterior portion / ML		4.44
Arm circumference at the base			Arm circumference at the base		
Arm I Right (AIRC)	239		AIRC / ML	13.53	
Arm II Right (AIIRC)	240		AIIRC / ML	13.59	
Arm III Right (AIIIRC)	275		AIIIRC / ML	15.57	
Arm IV Right (AIVRC)	282	215	AIVRC / ML	15.97	14.93
Arm I Left (AILC)	243	237	AILC / ML	13.76	16.46
Arm II Left (AIILC)	248	245	AIILC / ML	14.04	17.01
Arm III Left (AIIILC)	270	255	AIIILC / ML	15.29	17.71
Arm IV Left (AIVLC)	281		AIVLC / ML	15.91	
Tentacular stalk width (TSW) at the base, left	63	65	TSW at the base, left / ML	3.57	4.51
Gladius length (GL)		1371	GL / ML		95.21
Greatest gladius width (GGW)		167	GGW / ML		11.60
Free rachis length (FRL)		220	FRL / ML		15.28
Cone length (CL)		19	CL / ML		1.32
Gill length (GiL)	499	490	GiL / ML	28.26	34.03
Gill width (GiW) at the base	58	87	GiW at the base / ML	3.28	6.04
Gill width (GiW) at the midpoint		156	GiW at the midpoint / ML		10.83
Gill width (GiW) at the tip	12	33	GiW at the tip / ML	0.68	2.29
N° of lamellae per demibranch	65	65			
Ovary length (OL)	421	510	OL / ML	23.84	35.42
Oocyte major axis mean length	0.69	0.59			
Oviduct length (OvL)	120	108	OvL / ML	6.80	7.50
Oviducal gland length (OGL)	221	200	OGL / ML	12.51	13.89
Nidamental gland length (NGL)	282	235	NGL / ML	15.97	16.32
Nidamental gland width (NGW)	118	120	NGW / ML	6.68	8.33
Stomach length (SL)	442	617	SL / ML	25.03	42.85
Stomach width (SW)	42	110	SW / ML	2.38	7.64
Caecum length (CaL)	120	160	CaL / ML	6.80	11.11
			CaL / SL	27.15	25.93
Ink sac length (ISL)	532	470	ISL / ML	30.12	32.64

dles. The funnel was conical. The ventral length was slightly larger than the base width (FuL / ML = 15.91; FuW at the base / ML = 15.29) but it tapered strongly up to a narrow opening (FuW at the opening / ML = 6.51). The texture of the wall was firm but not thick which produced a dorso-ventral flattening. Simple funnel-locking cartilages were observed on the ventro-lateral surface of the funnel (FLCL / ML = 11.21). They were white, straight, narrow at the anterior tip (FLCW / ML = 1.08) and rounded posteriorly (FLCW / ML = 2.27). The groove was deep and curved anteriorly and became shallower posteriorly. The mantle-locking cartilages consisted of a simple ridge, high, narrow and curved anteriorly and shallow and wider posteriorly. The anterior tip slightly protruded from the mantle edge. A large and elastic buccal membrane mostly covered the buccal mass. The inner surface was colourless while the outer was pink-brown. The buccal membrane connectives were attached to the dorsal borders of arms I, II and IV where they extended up to the second row of suckers and to the ventral borders of arms III, reaching the third sucker row.

None of the arms was intact and the longest portion available, 1,750 mm, corresponded to left arm IV. The skin was dark reddish-brown on the lateral faces, while the oral and aboral faces were less pigmented. The aboral surfaces ran on a longitudinal band of fibrous tissue extended from the head skin. The oral surfaces carried two series of suckers in oblique pairs, placed on pad-like elevations that left a depression along the midline and between successive suckers. There were distinct folds of skin surrounding the sucker pads and well-developed protective membranes with two trabeculae per sucker placed proximally and distally to each pad. The membranes appeared on the ventral side from the bases of all arms while, on the dorsal side, they could be seen from the first row of suckers of arms I, II and IV and from the base of arms III. Some fragments of keel were detected on arms III and IV. The cross section of all arms was rectangular, with circumference generally decreasing from the base even though, in arms II and III, a small expansion up to 150 mm distal to the arm base was observed. The circumference at the base ranged between 239 and 282 mm, showing the following arm circumference formula: IV>III>II>I. The circumference of all arms decreased distally, more strongly on arms II and III than on arms IV. The sucker diameters of the first three pairs of arms ranged between 11.6 and 22.4 mm, while those of arms IV were lower, ranging between 7.4 and 16.7 mm (Figure 2). Besides, very small suckers (5.7 mm) were present on the base of arms I. Sucker diameters increased abruptly from the base up to rows 4/5 and decreased slightly afterwards. While the shape of the suckers was constant along the arms,

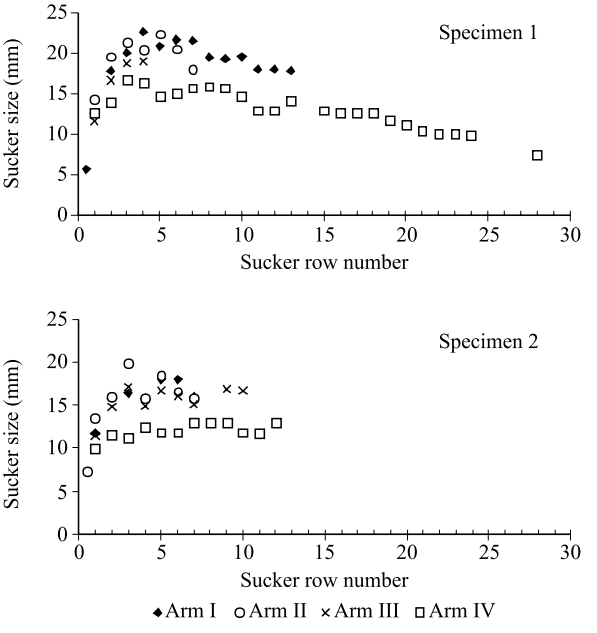

Figure 2. Relationship between sucker size and sucker row number for the four pairs of arms of the two giant squids examined.

Figura 2. Relación entre el diámetro de las ventosas y el número de hilera de ventosas de los cuatro pares de brazos de los dos calamares examinados.

the sucker rings changed significantly. The ring of arms I basal sucker showed 7 distal teeth (3 central triangular and 2 lateral rounded ± fused) and a smooth proximal edge. From the first row of suckers up to row 13 (last available) of arms I the number of teeth increased up to 48, occurring around the entire ring and being sagittate in shape. Most rings of arms II and III were missing but in arms IV, where rings up to row 25 were available, the pattern of increasing number of teeth was observed up to the third row, reaching 48 around the complete ring. From there, the number of teeth decreased (5 teeth in row 25) and the relative extension of the smooth proximal edge increased.

The tentacles were mutilated near the base where the stalks were laterally compressed and 63 mm wide. A tentacular stalk of 1,931 mm and triangular cross section was found separated from the body. It showed two equal size sides (41 mm) while the third side measured 25 mm. No suckers were observed on any of the sides.

Internal organs

The mantle cavity, the visceral sac, the funnel retractor muscles and the suspensory membrane of gills were lined with a reddish-brown integument, more intense in colour than the skin-remains observed on the external surface of the body (Figure 3). The gills were grey, long (GiL / ML = 28.26) and tapered from the base (GiW / ML = 3.28) to the anterior tip (GiW / ML = 0.68). Each demibranch bore 65 lamellae. Branchial hearts were present at the base of the gills and the systemic heart was observed between them.

A long, conical, pale yellow ovary of 3.694 kg in weight, occupied the last quarter of the mantle cavity (OL / ML = 23.84), hanging from the dorsal wall of the genital coelom. Two regions were identified at the cross section: a central core of connective tissue with blood vessels and a filamentous zone containing oocytes at different developmental stages. Along the filaments, the size and maturity of the oval oocytes

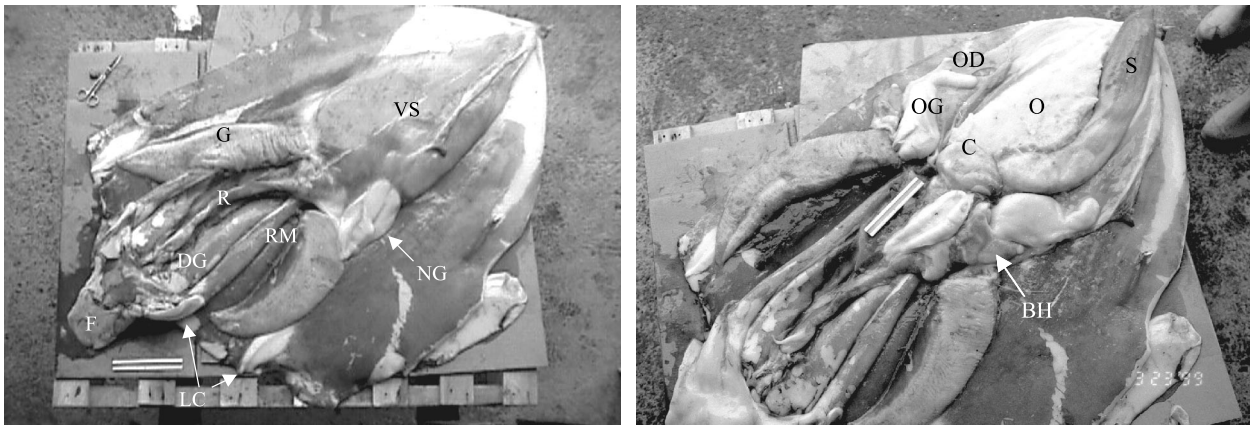

Figure 3. Left: Internal view of the mantle cavity of *Architeuthis* sp. showing the funnel (F), funnel and mantle-locking cartilages (LC), funnel retractor muscles (RM), visceral sac (VS), gills (G), nidamental glands (NG), digestive gland (DG) and rectum (R). Right: Internal view of the mantle cavity with the visceral sac opened, showing the branchial hearts (BH), stomach (S), caecum (C), ovary (O), oviducal glands (OG) and oviducts (OD). (Specimen 2; scale bar: 150 mm).

Figura 3. Izquierda: Vista interna de la cavidad del manto de Architeuthis sp. donde se observan el sifón (F), los cartílagos de cierre del sifón y el manto (LC), los músculos retractores del sifón (RM), el saco visceral (VS), las branquias (G), las glándulas nidamentales (NG), la glándula digestiva (DG) y el intestino (R). Derecha: Vista interna de la cavidad del manto con el saco visceral abierto, se observan los corazones branquiales (BH), el estómago (S), el ciego (C), el ovario (O), las glándulas oviductales (OG) y los oviductos (OD). (Ejemplar 2; escala: 150 mm).

increased from the proximal (oocyte longest axis range = 0.40-0.69 mm; mean = 0.53 mm) to the distal (range = 0.46-0.86 mm; mean = 0.69 mm) zone. In the largest oocytes, longitudinal stripes were clearly observed on the surface, indicating vitellogenesis. A pair of white, short (OvL / ML = 6.80) and robust oviducts, included in the inner surface of the visceral sac, opened into large (OGL / ML = 12.51), white and globular oviducal glands. The oviducal glands, in turn, opened into the pallial cavity at the base of the gills. The nidamental glands, fused medially, were placed in the middle of the pallial cavity. They were short (NGL / ML = 15.97) and white. The posterior border was rounded and pointed and sliced anteriorly, like a calla lily.

The stomach was creamy white, long (SL / ML = 25.03) and lined internally with a transparent cuticle (Figure 4). The wall of the anterior region was thick and strongly folded, resembling a crop, while the wall of the posterior zone was thinner and less folded. It contained 500 ml of grey fluid and some remains (scales, bones) of very small fish that could not be identified. The stomach opened into a conical five-coiled spiral caecum, pink-orange in colour, through a sphincter-groove system. The rectum, whose ventral surface was coloured as the inner mantle, ended in D-shaped flaps and elongated anal papillae. The ink sac was long (ISL / ML = 30.12) and enlarged posteriorly with a white 20 mm long knob at the tip. It ran laterally to the rectum and both structures were united at their anterior ends while the posterior portion of the ink sac was free. A flat and light brown digestive gland ran from the base line of the gills through the neck region between the funnel retractor muscles and the digestive gland appendages, placed at the base of the gland, looked spongy and beige.

Radula

The radula supported tricuspid rachidian (R), bicuspid first lateral (L1), unicuspid second lateral (L2) and marginal (M) teeth, and rectangular marginal plates. The central cusp of the rachidian teeth was taller than the lateral symmetrical cusps as well as the inner cusp of the first lateral teeth, which was taller than the outer one. The height of the teeth ranged between 0.6 and 1 mm with the following formula: M > L2 > R > L1.

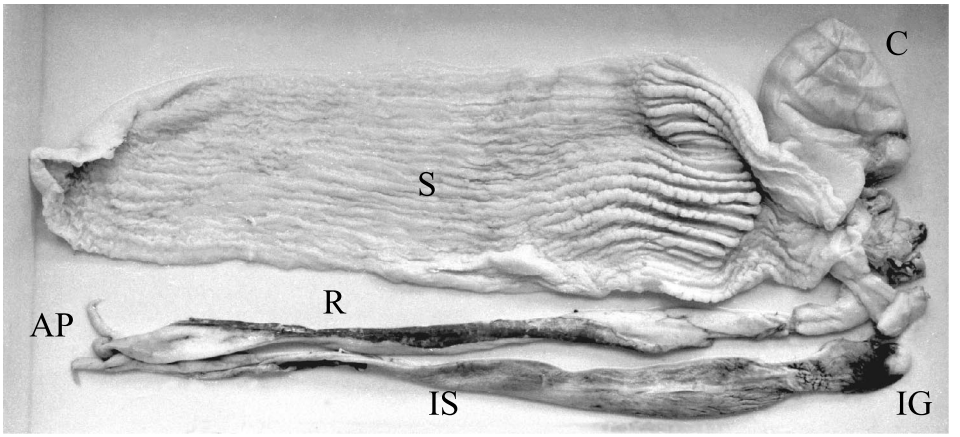

Figure 4. Dissected digestive tract of *Architeuthis* sp. (stomach opened (S), caecum (C), rectum (R), anal papillae (AP), ink gland (IG) and ink sac (IS); specimen 1).

Figura 4. Aparato digestivo disecado de Architeuthis sp. (estómago abierto (S), ciego (C), intestino (R), papilas anales (AP), glándula de la tinta (IG) y bolsa de la tinta (IS); ejemplar 1).

Beaks

The lower beak was slightly squat (c/d = 0.91; Table 3; Figure 5) and square (d/f = 1.37) and protruding forward (d/e = 3.20). It had a rostrum longer than deep (g/a = 1.68) and broad (a/j = 1.15), with a small hook at the tip. The rostral length reached 24.18% of the distance between the rostral tip and the inner posterior corner of the lateral wall (RC/RL = 4.14). No wing fold was present (i = a (Clarke, 1986) = 16.50 mm). The hood was broad (f/g = 1.68) and separated from the crest, with a broad deep notch in the posterior edge. The wings were long in relation to the rostral length (b/a = 2.88) and very broad. A conspicuous tooth was present on the shoulder. The crest was thickened and almost straight in profile. Lateral wall without ridges or folds and with parallel free corners. In lateral view, the wing angle was obtuse. The rostrum, the anterior portion of the hood and the shoulders were black while the posterior portion of the hood, the wings, crest and lateral wall were brown with thin transparent edges.

The upper beak showed a long (RL = 16.85 mm), broad (RL/JW = 1.35) and curved rostrum. The strongly curved hood was almost four times the length of the rostrum (HL/RL = 3.88) and

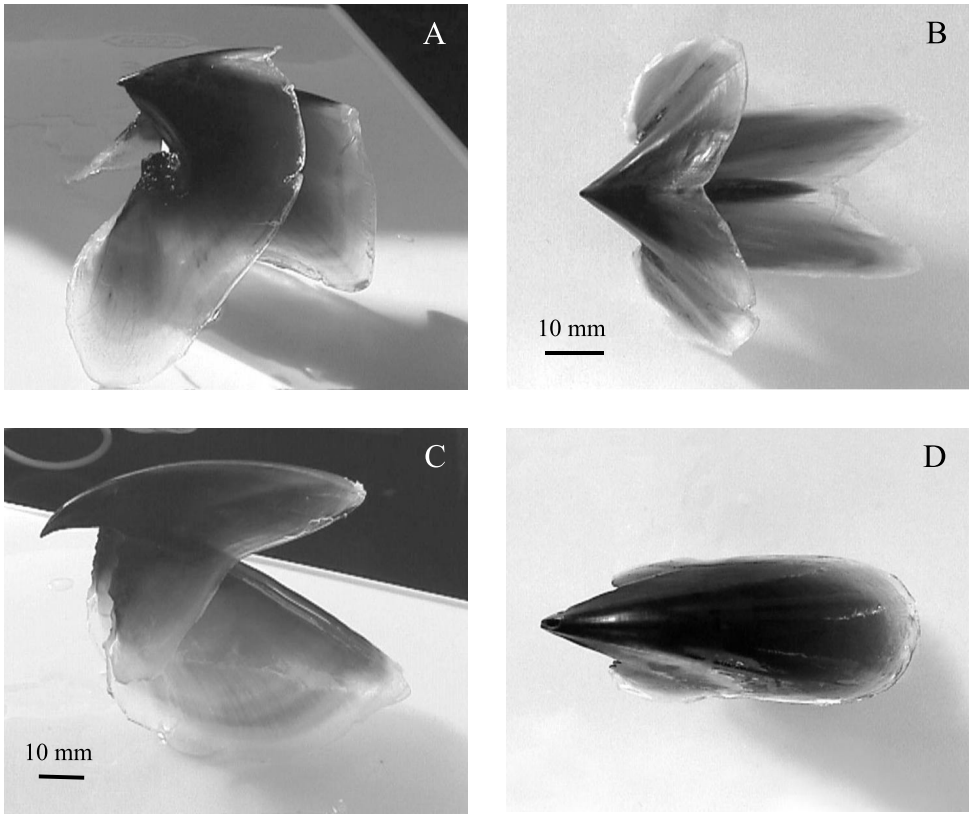

Figure 5. Lateral (A) and outer (B) view of the lower beak and lateral (C) and outer (D) view of the upper beak of *Architeuthis* sp. (specimen 1).

Figura 5. Vista lateral (A) y superior (B) de la mandíbula inferior y vista lateral (C) y superior (D) de la mandíbula superior de Architeuthis sp. (ejemplar 1).

Table 3. Measurements and indices of the lower and upper beaks of the two giant squids examined.
Tabla 3. Mediciones e índices correspondientes a las mandíbulas inferior y superior de los dos calamares gigantes examinados.

Specimen Number	1	2		1	2
Sex	F	F		F	F
Maturity Stage	III	III		III	III
Dorsal mantle length	1,766	1,440		1,766	1,440
Lower Beak	**Measurements (mm)**			**Indices**	
Rostral length (Wolff, 1982, rl; Clarke, 1986, a)	16.50	14.55	b/a	2.88	3.15
Hood length (Clarke, 1986, g)	27.75	23.55	c/d	0.91	0.85
Crest length (Clarke, 1986, f)	46.65	43.15	d/e	3.20	3.65
Wing length (Wolff, 1982, wl; Clarke, 1986, b)	47.45	45.80	f/g	1.68	1.83
Rostral tip to inner posterior corner of lateral wall (Wolff, 1982, rc)	68.25	65.85	d/f	1.37	1.44
Rostral tip to inner margin of wing (Wolff, 1982, rw)	58.50	56.94	g/a	1.68	1.62
Rostral tip to baseline (Clarke, 1986, c)	58.00	53.00	a/j	1.15	1.16
Jaw angle width (Wolff, 1982, jw; Clarke, 1986, j)	14.40	12.50	RC/RL	4.14	4.53
Length of the baseline in profile (Clarke, 1986, d)	64.00	62.00	RC/WL	1.44	1.44
Distance the rostral tip lies behind the wing tip (Clarke, 1986, e)	20.00	17.00			
Rostral base length (Clarke, 1986, h)	18.90	17.11			
Upper Beak	**Measurements (mm)**			**Indices**	
Rostral length (Clarke, 1962, 1; Wolff, 1982, rl)	16.85	15.45	WL/RL	1.72	1.63
Hood length (Clarke, 1962, 2; Wolff, 1982, hl)	65.30	61.35	RL/JW	1.35	1.24
Crest length (Clarke, 1962, 3; Wolff, 1982, c)	97.90	94.20	HL/RL	3.88	3.97
Wing width (Wolff, 1982, ww)	19.75	20.40	HL/CL	0.67	0.65
Wing length (Clarke, 1962, 4)	29.00	25.15			
Rostral tip to inner margin of wing (Wolff, 1982, rw)	36.10	34.30			
Jaw angle width (Wolff, 1982, jw)	12.45	12.45			
Wing to crest length (Wolff, 1982, wcl)	78.00	62.30			

67% of the crest length, lying high above the latter. The shoulders and wings were long in relation to the rostral length (WL/RL = 1.72). A ridge, originating at the jaw angle, was present in the limit between the hood and wings. The jaw angle was acute. The crest was almost straight and no ridges were observed on the lateral wall. The rostrum and the anterior portion of the hood and wings were black and brown towards the posterior side with a narrow colourless border. The crest and the lateral wall were also brown with transparent edges.

Table 4. Measurements and indices of the left and right statoliths of the two giant squids examined.
Tabla 4. Mediciones e índices correspondientes a los estatolitos izquierdo y derecho de los dos calamares gigantes examinados.

Specimen Number	1		2	
Sex	F		F	
Maturity Stage	III		III	
Dorsal mantle length	1,766		1,440	
Statolith	Left	Right	Left	Right
Measurements (mm)				
Total length (TL)	1.96	1.96	2.14	2.37
Ventro-lateral length (VLL)	0.94	1.02	1.02	1.12
Dorso-lateral length to ventral lobe (DDL)	1.18	1.16	1.22	1.29
Dorso-lateral length to dorsal lobe (DLL)	0.51	0.71	0.51	0.61
Lateral dome length (LDL; Clarke, 1978)	1.10	1.16	1.18	1.27
Lateral dome length* (LDL*; Lipinski, 1997)	1.20	1.23	1.43	1.51
Maximum lateral dome width (LDWmax)	1.22	1.22	1.16	1.20
Minimum lateral dome width (LDWmin)	0.84	0.98	0.84	0.86
Length from spur to apex of dorsal dome (SADD)	0.92	0.82	0.67	0.82
Length from spur to tip of rostrum (STR)	1.49	1.53	1.76	1.76
Rostral length (RL)	0.76	0.73	0.71	0.86
Rostral base to lateral tip of lateral dome (RBLD)	0.41	0.45	0.55	0.55
Wing width (WW; + broken)	0.55	0.61	0.29+	0.45
Wing length (WL)	1.33	1.41	1.29	1.33
Indices				
LDL / TL	0.56	0.59	0.55	0.54
LDL* / TL	0.61	0.63	0.67	0.64
LDL / RL	1.45	1.59	1.66	1.48
LDWmax / TL	0.62	0.62	0.54	0.51
DDL / TL	0.60	0.59	0.57	0.54
RL / TL	0.39	0.37	0.33	0.36
VLL / TL	0.48	0.52	0.48	0.47
RBLD / LDL	0.37	0.39	0.47	0.43
SADD / TL	0.47	0.42	0.31	0.35
WL / TL	0.68	0.72	0.60	0.56
WW / TL	0.28	0.31		0.19
WW / LDWmax	0.45	0.50		0.38

Statoliths

Statoliths were elongated (LDWmax / TL = 0.62) with well-developed dorsal and lateral domes and rostrum. The lateral dome was large (LDL / TL = 0.56-0.59; RBLD / LDL = 0.37-0.39) and bilobated (Table 4). From the anterior view it looked like a ridge emerging laterally from a noticeable central groove whose thickness decreased from the inferior to the superior lobe. The dorsal dome was rounded and aligned straight with the rostrum. A well-developed dorsal ridge was placed between the dorsal dome and

the dorsal spur. The medial fissure was deep. The rostrum was long (RL / TL = 0.37-0.39) and narrow. The long (WL / TL = 0.68-0.72) and wide (WW / LDWmax = 0.45-0.50) wing extended from the prominent dorsal spur almost to the end of the rostrum.

Specimen 2

General morphology

Specimen 2 was a female of 1,440 mm ML with a ventral mantle length of 1,270 mm (VML / ML = 88.19; Table 2; Figure 3). The general body shape agreed with that of specimen 1, with the greatest mantle width (MW / ML = 35.07) placed at 540 mm from mantle aperture, and a mantle aperture width of 443 mm (MW / ML = 30.76). The mantle wall was also firm and muscular but narrower than in specimen 1 (maximum thickness = 36 mm). The fins were damaged and no remains of skin were observed on the mantle. The head was almost as long as that of specimen 1 but narrower (DHW / DHL = 65.96) and similar in colour. The nuchal cartilage was white and rectangular, with the anterior and posterior edges slightly expanded; the anterior border was the widest. The eyes were smaller than in specimen 1 in relation to ML (ED / ML = 7.29). The funnel shape resembled that of specimen 1 but, related to ML, it was larger (FuL / ML = 18.06, FuW / ML = 18.47). The funnel valve, attached on the dorsal wall of the funnel, was oval (90 mm long, 118 mm wide). The funnel and mantle-locking cartilages of both specimens were similar. The buccal membrane connectives extended up to the second row of suckers of arms I and II and reached the third sucker row of arms III and IV.

All arms were broken and none of the available portions exceeded 300 mm. When comparing both animals a different arm circumference formula at the base, III>I>II>IV, and a similar decrease of all arms was observed. The protective membranes were similar although significant differences in the place of insertion were observed. They were inserted at the first pair of suckers of arms I, III and IV, at the basal sucker of arms II dorsally and, at the base of arms I, at the basal sucker of arms II and at the first row of suckers of arms III and IV, ventrally. As a result of loss of skin keels were not observed. The overall pattern of arrangement and relative size of the suckers along the arms and between arms agreed with what was observed in specimen 1 but the size ranges were lower (Figure 2). The tentacles were flat and 65 mm wide near the base, where they were mutilated.

Gladius

The gladius was thin, fragile and shorter than the mantle (GL / ML = 95.21; Table 2). The widest portion (167 mm) was placed at 27.78% from the anterior edge of mantle while the free rachis was 220 mm long, tapering from 82 to 20 mm wide. A concave depression extended on the ventral midline of the rachis along the vane but it was not visible at the free portion. The lateral edges curled ventrally at the posterior tip forming a hollow short cone (CL / ML = 1.32).

Internal organs

The internal appearance resembled that of specimen 1 (Figure 3). The gills were larger in relation to the ML (GiL / ML = 34.03; GiW / ML = 10.83) and bore the same number of lamellae (65; Table 2). Conspicuous branchial hearts with rounded appendages and beige in colour were observed at the base of the gills. The systemic heart was slightly larger and paler than the branchial hearts and located between them.

All components of the reproductive system looked similar to that of specimen 1 although they were slightly larger relative to ML (Table 2), with the only exception of the oocytes whose mean sizes were smaller (proximal zone: range = 0.31-0.54, mean = 0.44; distal zone: range = 0.49-0.66, mean = 0.59). Both specimens showed the characteristics of a maturing female (maturity stage III).

The structure and colour of the digestive organs resembled those of specimen 1. The stomach was considerably larger than in specimen 1 in relation to ML (SL / ML = 42.85; SW / ML = 7.64), probably due to a higher degree of distension; consequently, the caecum was shorter when related to the stomach length (CaL / SL = 25.93).

Stomach content

Very small fragments of different hard structures and no remains of soft tissues were found in the stomach. Bones, cycloid scales (3.4 mm diameter), vertebrae (1.5 mm diameter) and lenses (0.46-4.68 mm diameter) indicated the ingestion of small fish and beaks (0.66-1.60 mm lower beak rostral length, 1.06-1.72 mm upper beak rostral length) showed consumption of small squid. In all cases, given the high degree of fragmentation, the structures did not allow any specific identification.

Radula and beaks

The radula showed the same characteristics as that of specimen 1.

In general, the shape of both beaks agreed with that observed in specimen 1. Nevertheless, the lower beak was slightly squater (c/d = 0.85; Table 3), the notch at the posterior edge of the hood was deeper and the jaw angle and the shoulder tooth were less prominent than in specimen 1, showing the characteristics of a young beak in spite of the absence of an angle point. Its colour resembled that of specimen 1 with the exception of the wings where a brown spot joining the hood darkening was observed; the transparent edges of the crest and lateral wall were wider. The same enlargement of the transparent edges of the crest and lateral wall occurred in the upper beak.

Relationship between lower rostral length and mantle length

Data of lower rostral length and mantle length of giant squids caught in the Southern Hemisphere were pooled in order to determine their relationship. The data set included 12 individuals from South Africa (Roeleveld, 2000), 10 from New Zealand (Förch, 1998) and the two indviduals described here together with that reported by Ré *et al.* (1998) from Argentina (Figure 6).

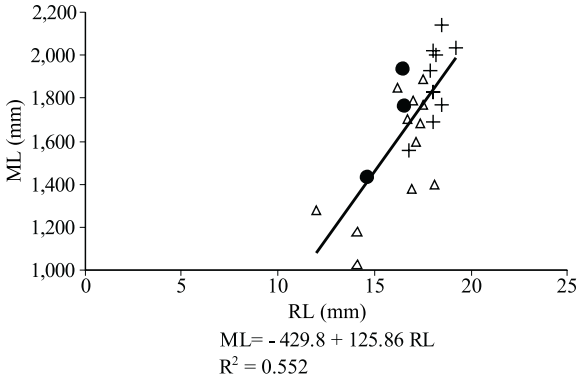

Figure 6. Relationship between the rostral length (RL) of the lower beak and the mantle length (ML) of 25 giant squids from the Southern Hemisphere. Argentine current and Ré *et al.* (1998) data (●), New Zealand data (△) from Förch (1998) and South African data (+) from Roeleveld (2000).

Figura 6. Relación entre el largo del rostro (RL) de la mandíbula inferior y el largo del manto (ML) de 25 calamares gigantes del hemisferio sur. Datos de Argentina (●) actuales y tomados de Ré et al. (1998), datos de Nueva Zelanda (△) tomados de Förch (1998) y datos de Sudáfrica (+) tomados de Roeleveld (2000).

Statoliths

Although the animal was smaller, the statoliths of specimen 2 were not only larger than those of specimen 1; they also differed in dimensions and shape (Table 4). The left statolith was smaller (TL = 2.14 mm) than the right one (TL = 2.37 mm) and showed a bilobated lateral dome, which resembled the statoliths of specimen 1, while the latter bore a trilobed lateral dome. Furthermore, the left statolith had a shorter rostrum than that in specimen 1 (RL / TL = 0.33).

DISCUSSION

Even though the inferences regarding the general body shape of giant squid are highly influenced by the distorsion produced during handling and freezing, already mentioned by Förch (1998), the shape of all the animals described for the Southwest Atlantic region could be assessed as anteriorly cylindrical and then conical, with the widest portion situated anterior to the half-way point along the mantle length (Arfelli *et al.*, 1991; Brunetti *et al.*, 1998; Ré *et al.*, 1998). The mantle wall thickness increased (13-36%) from the aperture up to half-way along. The reddish-brown external skin was usually damaged, more on the mantle surface than on the head and arms. The fins, though damaged in most specimens, were generally small, oval, dorsally attached at 58-63% from the mantle aperture and extended up to the end of the mantle, with the only exception of the specimen described by Ré *et al.* (1998), whose fins had two anterior lobes and did not reach the end of the mantle. In all animals, while the anterior insertion of the fins was somewhat separated, the attachment areas gradually converged towards the posterior end. The FL / ML and DFW / ML indices ranged between 31.44-37.37 and 21.52-34.03 respectively, falling within the previously reported ranges (Förch, 1998). The highly variable head shape, that looked wide in some individuals and long in others, did not allow to make a general description.

The cross section of the arms at the base exhibited wide variation, going from oval to rectangular (Brunetti *et al.*, 1998; Ré *et al.*, 1998), as reported in the literature (Aldrich, 1991; Roeleveld and Lipinski, 1991; Förch, 1998). Regarding the sucker diameters on the first three arms, those of specimens caught around New Zealand were reported to increase up to rows 10-15 (Förch, 1998) while an abrupt increase, but only up to rows 4-6, followed by a slight decrease distally was reported for the Southwest Atlantic squids (Brunetti *et al.*, 1998; Ré *et al.*, 1998). More agreement was found on arms IV, where the maximum size of the suckers (17 mm) occurred on the fifth row followed by a decrease lower than that of arms I-III. The specimens collected in South Africa showed similar maximum sizes of the suckers of the four pairs of arms (Roeleveld and Lipinski, 1991).

In general, the structure and coloration of the internal organs appeared to be fairly constant with slight differences among individuals from the Southwest Atlantic region and those from other latitudes (Aldrich, 1991; Roeleveld and Lipinski, 1991; Brunetti *et al.*, 1998; Förch, 1998; Ré *et al.*, 1998). Among the most variable internal structures of Southwest Atlantic animals it is worth mentioning the branchial hearts, well developed in the present specimens but that could not be observed in the squid caught in 1995 and 1996 (Brunetti *et al.*, 1998; Ré *et al.*, 1998). Roeleveld and Lipinski (1991) reported the apparent absence of these organs in the South African animals while Förch (1998) mentioned that they were present in sixteen specimens from New Zealand analyzed and they were especially obvious in three of them.

All specimens reported from the Southwest Atlantic region were females. The conical, pale yellow ovary was long in all cases (23-65% of ML) and, depending on the maturity of the animal, occupied from one to two-thirds of the mantle cavity. Two regions were identified in cross section: a central core of connective tissue with blood vessels and a filamentous zone containing oocytes at different developmental stages (long axis size range: 0.31-2.52 mm). After the ovary, the oviducal glands were the most voluminous organs of the reproductive system; in contrast, oviducts were short. The important development of the oviducal glands observed in our specimens disagrees with the characteristics reported by Förch (1998), who described a pair of oval or pear-shaped structures whose anterior lobe rep-

resented the oviducal glands and the posterior the oviducts, probably due to a lower maturity stage. The fused nidamental glands were short, reaching from 15% of ML in a maturing animal to 27% of ML in a fully mature female (Brunetti *et al.*, 1998). In all cases, arms broken or skin lost made it impossible to observe if, as reported by Norman and Lu (1997), there were signs of insemination.

The stomach content of specimen 2, composed of very small fish and squid, denoted that the remains corresponded to a past meal. Other authors also reported the consumption of fish and squid, but of larger sizes (Pérez-Gándaras and Guerra, 1978; Förch, 1998; Lordan *et al.*, 1998).

The radulae of the specimens examined here resembled very much those described by other authors (Pérez-Gándaras and Guerra, 1978; Roeleveld and Lipinski, 1991; Förch, 1998; Ré *et al.*, 1998).

The beak shape of both specimens examined agreed with the description provided by Clarke (1986) for the Architeuthidae family. Moreover, when comparing both specimens, some changes associated to the ontogeny of the lower beak described by the author (less intense coloration, jaw angle and shoulder tooth less prominent) could be observed.

The regression equation for lower rostral length against mantle length proposed using 25 individuals from the Southern Hemisphere showed the high variability associated with these parameters. Calculations using this equation resulted in an underestimation of the mantle length of the three animals from Argentina, particularly in the 1996 specimen for which underestimation amounted to 15%. Ré *et al.* (1998) have already reported the serious underestimation of the size of this animal when equations proposed by Clarke (1986) are used.

High variability, even in hard structures, already reported by Förch (1998) and Roeleveld (2000), is confirmed not only among different animals but also between paired structures of the same animal. That is the case of the statoliths of specimen 2, which differed in their total length, relative size of the lateral dome and rostrum and number of lobes in the lateral dome. Analyzing the present data together with those provided by the literature (Brunetti *et al.*, 1998; Ré *et al.*, 1998), the main features of the statoliths of the giant squid caught in the Southwest Atlantic region could be described as follows: dorsal dome small and rounded, convex posteriorly and flat anteriorly, clearly or slightly separated from lateral dome by a dorso-lateral groove, the gap between the dorsal spur and the apex of the dorsal dome wide (SADD / TL: 0.31-0.50), the lateral dome elongated and large, more than half of the total length and roughly 1.5 times the length of the rostrum, divided into two or three lobes with the ventral one larger, rostrum long and narrow with a slightly wider base and the very well developed wings long (WL / TL: 0.56-0.72) and broad (WW / LDWmax: 0.19-0.31).

Up to date, including the two animals described in this paper, six records of giant squid have been reported for the Southwest Atlantic region (Arfelli *et al.*, 1991; Ruiz and Fondacaro, 1996; Brunetti *et al.*, 1998; Ré *et al.*, 1998). All of them were females and the last five specimens appeared in the last five years on the South Patagonian shelf between 45° S and 54° S.

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