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A male giant squid, *Architeuthis* spec. (Cephalopoda, Architeuthidae) from the Fladen Ground in the northern North Sea

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A specimen of *Architeuthis* was caught on the Fladen Ground, c. 100 miles NE. of Aberdeen (Scotland) in 1982. The animal, a male with a mantle length of 900 mm and a minimum total mass of 18 kg, was probably mature. Some measurements are given and the occurrence of spermatangia (inverted spermatophores) implanted in the ventral arms of the animal is discussed.

Key words: Cephalopoda, *Architeuthis*, morphology, distribution, spermatangia, North Sea.

INTRODUCTION

Squids are cephalopod molluscs that occur from the continental shelf to the very deep parts of the world oceans. They compete with nektonic fish and are important in the diet of a large variety of marine predators, especially cetaceans (Clarke, 1996).

Squids range in size from the very small members (15 mm mantle length) of the family Pickfordioteuthidae to the very large giant squids of the families Cranchiidae and Architeuthidae whose members exceed mantle lengths of 2000 mm. A description of a specimen of the latter family is the subject of this paper.

Although as many as 21 nominal species have been described in *Architeuthis* since the first genus and species description by Japetus Steenstrup in 1857, modern squid taxonomists agree that probably most of these names are synonyms (Sweeney & Roper, 2001). An extensive study on the beak morphology of *Architeuthis* from the Atlantic Ocean and New Zealand waters does not suggest more than one species (Roeleveld, 2000), i.e. *A. dux* Steenstrup, 1857. *Architeuthis* is currently the largest invertebrate of the Animal Kingdom.

Giant squids have a cosmopolitan distribution and information on their biology and distribution is based on specimens from the stomachs of sperm whales, accidental trawl catches by fishermen and specimens that were washed up on the shore. The vertical distribution ranges probably from surface waters to 1200 m depth, but animals are mainly caught on the continental slope between 300-600 m (Förch, 1998; Hoving et al., 2004). Only very recently the first live giant squid was photographed by Japanese scientists at a depth of 800 m (Kubodera & Mori, 2005).

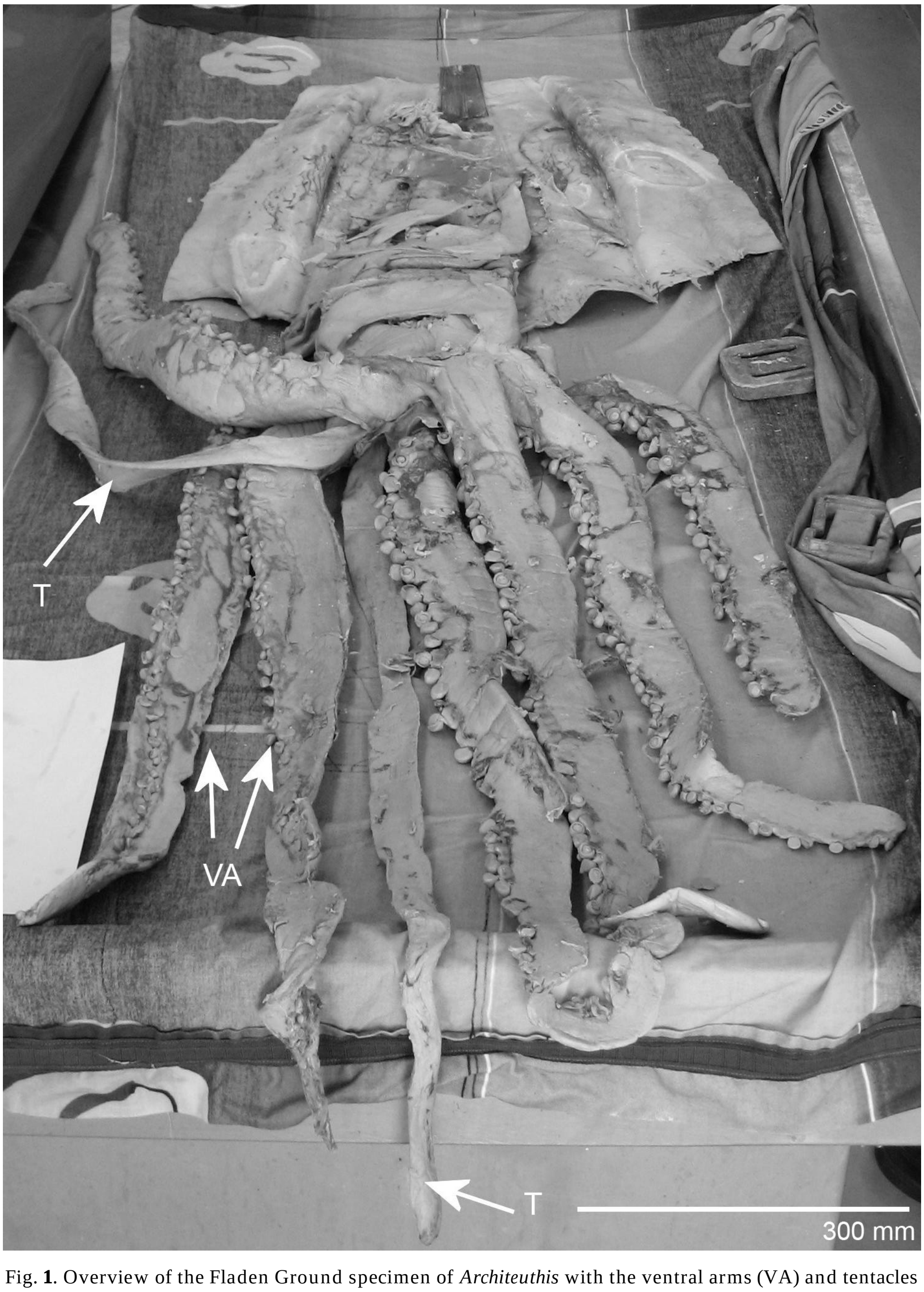

Fig. **1**. Overview of the Fladen Ground specimen of *Architeuthis* with the ventral arms (VA) and tentacles (T) indicated.

Giant squids are predated by a wide variety of oceanic predators during different stages of their life cycle, e.g. juvenile giant squids have been found in the stomach of albatrosses (Imber, 1992) and mature animals are often found in the stomachs of sperm whales and sleeper sharks (*Somniosus* spec.) (Clarke, 1996; Cherel & Duhamel, 2003). Giant squids on their turn prey on medium-sized prey such as crustaceans, octopus, other squids and fish species such as blue whiting (Lordan, Collins & Peralez-Raya, 1998). Interestingly, tissue of *Architeuthis* was found in the stomachs of Australian and New Zealand giant squids, suggesting cannibalism (Bolstadt & O'shea, 2004; Deagle et al., 2005).

Although the number of specimens available to science has increased in the last decennia, mainly due to the development of deep-sea fisheries, the description and documentation of individual specimens can still contribute to a better understanding of the animal's biology, which is still largely unknown. The present study reports and describes a male *Architeuthis* caught by Dutch fishermen in the northern North Sea. It is in the collection (public galleries) of the National Museum of Natural History (Leiden).

RESULTS

The specimen was caught by the beam trawler Urk 56, operating from IJmuiden harbour, in September 1982, fishing on the northern North Sea, Fladen Ground, c. 59°N 0.5°E (c. 100 miles NE. of Aberdeen, Scotland). The fishing depth is unknown but the depth in the area ranges between 100 and 150 m.The mantle length of the specimen was 900 mm and the preserved animal had a minimum total mass of 18 kg. This is not the original total mass since the specimen was damaged and most of the viscera were gone. Additionally,

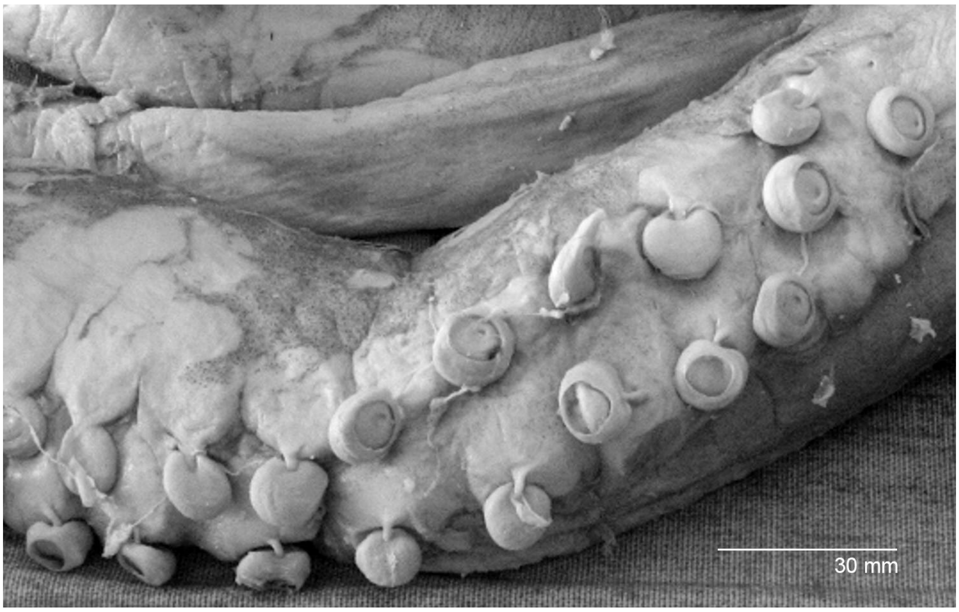

Fig. **2**. An arm of the *Architeuthis* specimen showing the biserial distribution of the suckers.

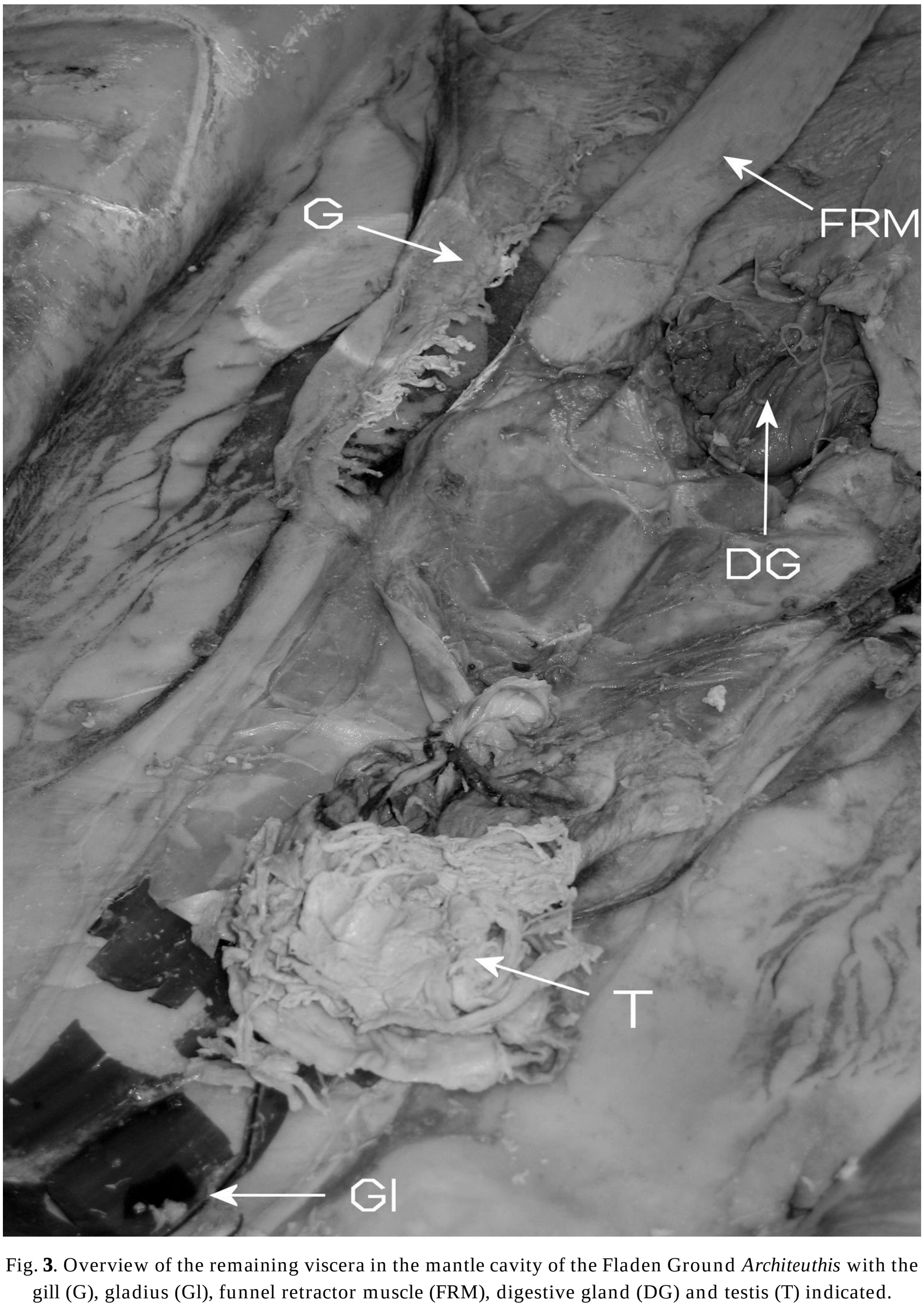

Fig. **3**. Overview of the remaining viscera in the mantle cavity of the Fladen Ground *Architeuthis* with the gill (G), gladius (Gl), funnel retractor muscle (FRM), digestive gland (DG) and testis (T) indicated.

Fig. **4**. Hypodermically implanted spermatangia indicated by arrows. Coin diameter 23.25 mm

the preserved weight is significantly lower than the fresh weight. The measurements were taken after almost 25 years of preservation in formalin. The complete specimen is illustrated in fig. 1.

The arm lengths of arms I, II, III and IV (left = L and right = R) were respectively LI = 700+ and RI = 750+; LII = 610+ and RII = 870+; LIII = 980+ and RIII = 790+; LIV = 830+ and RIV = 940+ mm. The right tentacle measured 1040+ and the left one 810+ mm. Maximum mantle thickness was 22 mm. Eye diameter was 80 mm. The diameter of the largest suckers on the arms was 15 mm and the suckers were present in two rows on all arms (fig. 2). Gill length was 250 mm and the diameter of the funnel was 55 mm. The funnel locking cartilage was 115 mm in length.

Most of the internal organs were lost. Because the posterior tail and fins were cut off, the organs may have been washed out of the specimen. However, a small piece of testis is still present in the posterior part of the mantle cavity, indicating that the sex of animal is male (fig. 3). Small fragments of the thick red-pigmented membrane, that normally covers the viscera, were also present.

Between 180 and 350 mm from the base of the left arm IV, spermatangia had been implanted deeply into the arm tissue (fig. 4). A spermatangium is the inverted spermatophore and in *Architeuthis* it can be up to 300 mm long, with a maximum width of approximately 1 mm, which decreases orally to 0.1 mm. The spermatangium has a tightly zigzag structure with an oral and aboral end (fig. 5a). The aboral end, which is sometimes protruding out of the point of entrance in the tissue, is open. The oral end is the part that has entered the tissue first during the implantation process. This end is characterized by a round to amorphous mass, which has a red colour after preservation. SEM images show that the tunic that surrounds the sperm mass of the spermatangium (the inner tunic in the intact spermatophore) enters the amorphous oral mass (fig. 5b).

DISCUSSION

Although 115 specimens of *Architeuthis* have been recorded in the literature from the North East Atlantic between the years 1545 to 2004 (Guerra et al., 2004), the present specimen is the first one caught by Dutch fishermen. It has recently been established that giant squids live and hunt at a depth of 500-800 m and most trawl records are from this depth (Kubodera & Mori, 2005). Therefore the finding of *Architeuthis* on the Fladen Ground in 1982 is probably an incident rather than a sign of natural occurrence of giant squid at this depth in this region. Interestingly, Norwegian fishermen fishing in the North Atlantic off Radoy near Bergen caught another specimen of Architeuthis (total length about 10 m and total body mass about 220 kg) in August of 1982. This specimen was used for blood analysis and Brix (1983) found a fourfold decrease in oxygen affinity of the squid haemocyanine with an increase of temperature from 6.4ºC to 15ºC. This finding suggests that squids may suffocate from arterial desaturation when they encounter increased temperatures in shallower waters. The capture of two specimens of *Architeuthis* in more or less the same period and relatively close to each other may suggest that a certain local oceanographic feature or event has been responsible for these large squids to be brought to shallow waters. The Fladen Ground is known to trap a bell of cold water in its central deeper parts due to the stratification during the summer months. Additionally, in the period June-August an increased influx of East Shetland Atlantic Inflow (ESAI) is known for the Fladen Ground (Witbaard, 1996). Giant squids may have been brought into the region with the cold water of the ESAI, and/or they may have been trapped in the bell of cold water. Subsequently they may have been caught because of their weakened condition due to food shortage or due to increased water temperatures. However, it is not known how often giant squids are being brought into this region and the presented data are too meagre to establish a correlation between giant squid captures and the magnitude of ESAI. Aldrich (1968) related the strandings of giant squids in New Foundland with the inflow of warm water, suggesting that an increased temperature may have caused their death.

Giant squid males generally mature at a mantle length of approximately 1 m (Lordan, Collins & Peralez-Raya, 1998; Hoving et al., 2004; etc.). The present specimen was a male with an estimated ML 900 mm and therefore this specimen could very well be a mature animal.

Implanted spermatangia in male giant squid, as described here, are not exceptional (Hoving et al., 2004; Kjennerud, 1958; Guerra et al., 2004). In males the spermatangia are mainly found on the ventral arms while in females they are found in the mantle, eyes, arms and head. In the present specimen the spermatangia were embedded between 180 and 350 mm from the ventral left arm base. This is the area where the distal opening of the terminal organ is situated.

The terminal organ of males extends from the mantle for approximately half its total length (total length is c. 1 m). Pressure on the terminal organ during capture in the trawl could make the spermatophores to become expulsed from it and under influence of seawater the spermatophores evaginate and implant themselves in the nearest tissue, in this case the ventral arms. Although male-to-male mating is known from squids (*Illex coindetii* (Vérany, 1839);Lordan & Casey, 1997) spermatangia implants in male giant squid are probably self-induced. Besides the size of the specimen, the fact that the animal probably had spermatophores in its terminal organ supports further that the animal was mature.

Although the spermatangium of *Architeuthis* has been elaborately described by Hoving et al. (2004), a detailed illustration of the mass at the oral end of the spermatangium was not presented yet. The mass is possibly what the cement body is in the intact spermatophore, and is expelled first from the spermatophore during the spermatophoric reaction. In other squids the cement in the spermatophores acts as a glue to attach the spermatangium to the female. In *Architeuthis* it may function as an anchor, to prevent the spermatangium from being pulled out of the tissue again (Hoving et al., 2004).

The hypodermic implantation of spermatangia in squid is still not understood. It is

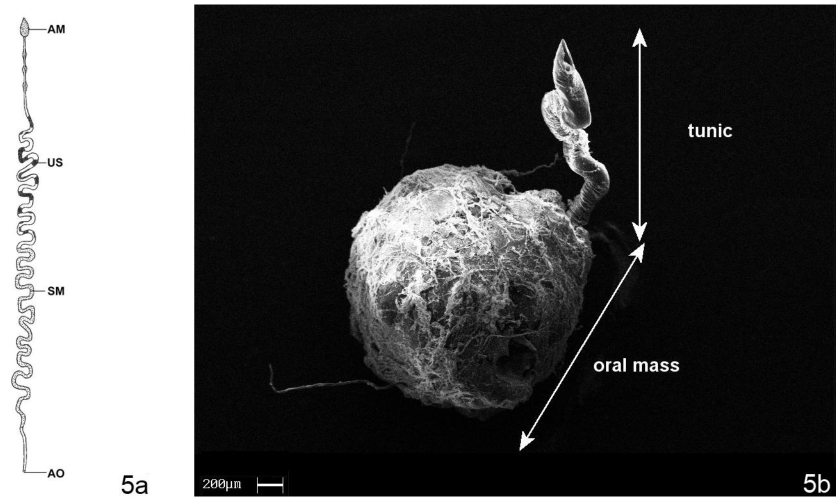

Fig. **5a, b**. Anatomy of spermatangia of *Architeuthis species*. **5a**, a spermatangium with amorphous mass (AM), unknown substance (US, probably cement body) and aboral opening (AO) indicated (courtesy Zoological Society of London); **5b**, SEM picture of the amorphous mass showing the tunic of the spermatangium entering the mass (photo M. Waldron). Note: the material for this picture is from a mature male (mantle length 1280+ mm) *Architeuthis* spec. from South Africa accessioned in Iziko Museums of Cape Town as SAM-S3386.

not known which process is responsible for the actual implantation of spermatangia in body tissue. Some authors hypothesize that in squid species with a large muscular terminal organ, like *Architeuthis*, this organ is responsible for hydraulically implanting spermatangia into the tissue like a stapler (Jackson & O'shea, 2003; Norman & Lu, 1997). Others say that an intrinsic mechanism, perhaps under influence of proteolytic ferments, in the spermatophore allows it to implant in the tissue autonomously after contact with seawater (Nesis et al., 1998). The latter process would better explain the self-implantation of spermatangia by the male in this study since the implants were exactly at the position where the terminal organ opens.

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