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MARK BOSSELAERS (*), FREDDY VAN NIEULANDE (**), ALBERTO COLLARETA (***)

A NEW RECORD OF *CETOPIRUS COMPLANATUS* (CIRRIPEDIA: CORONULIDAE), AN EPIBIONT OF RIGHT WHALES (CETACEA: BALAENIDAE: *EUBALAENA* spp.), FROM A BEACH DEPOSIT OF MEDITERRANEAN SPAIN

Abstract - M. BOSSELAERS, F. VAN NIEULANDE, A. COLLARETA, *A new record of Cetopirus complanatus (Cirripedia: Coronulidae), an epibiont of right whales (Cetacea: Balaenidae: Eubalaena spp.), from a beach deposit of Mediterranean Spain.*

An isolated right lateral compartment belonging to the rare extant whale barnacle species *Cetopirus complanatus* (a symbiotic organism found on the skin of the right whales, *Eubalaena* spp.) was collected from Recent beach deposits at Benidorm (Mediterranean Spain). Here we describe this specimen and briefly discuss its (palaeo-)biogeographical significance. Since no species of *Eubalaena* is currently present in the Mediterranean, the site of our finding stands outside the current biogeographic range of *C. complanatus*. As such, it contributes to shed light on past distribution patterns of North Atlantic right whales prior to the almost complete extirpation of *Eubalaena* due to centuries of heavy whaling activities by various European populations.

Key words - invertebrate palaeontology, palaeobiogeography, symbiosis, whale barnacle, host specificity, migrations

Riassunto - M. BOSSELAERS, F. VAN NIEULANDE, A. COLLARETA, *Nuova segnalazione di Cetopirus complanatus (Cirripedia: Coronulidae), un epibionte delle balene franche (Cetacea: Balaenidae: Eubalaena spp.), da un deposito di spiaggia della costa Mediterranea della Spagna.*

Viene riportata la scoperta di un compartimento laterale destro di un crostaceo coronulide in un deposito di spiaggia attuale di Benidorm (costa Mediterranea della Spagna). Il reperto è descritto ed attribuito alla rara specie vivente *Cetopirus complanatus*, nota come epibionte fortemente ospite-specifico delle balene franche (*Eubalaena* spp.). Poiché nessuna specie di *Eubalaena* popola oggi il bacino Mediterraneo, il sito di provenienza del compartimento qui illustrato ricade al di fuori dell'areale attuale di *C. complanatus*. Il suo ritrovamento può essere quindi correlato ad antichi pattern di distribuzione delle balene franche dell'Atlantico settentrionale prima che secoli di intensa caccia da parte di varie popolazioni europee ne causassero la quasi completa estirpazione.

Parole chiave - paleontologia degli invertebrati, paleobiogeografia, simbiosi, coronulidi, specificità d'ospite, migrazioni

INTRODUCTION AND SETTING

The so-called whale barnacles (Crustacea: Cirripedia: Coronulidae) are obligate epizoic phoronts of various species of cetaceans. These highly apomorphic,

crown-shaped, suspension-feeding barnacles enjoy a continuous flow of seawater and nutrient particles by attaching on a motile and long-living substrate such as the skin of toothed whales (Cetacea: Odontoceti) and, especially, baleen-bearing whales (Cetacea: Mysticeti). Known as fossils from Pliocene to Recent marine deposits worldwide (Collareta *et al.*, 2016a, *cum bibl.*), whale barnacles currently exhibit a high degree of host specificity: for example, *Cetopirus complanatus* (Mörch, 1853) (Fig. 1) is only found on right whales

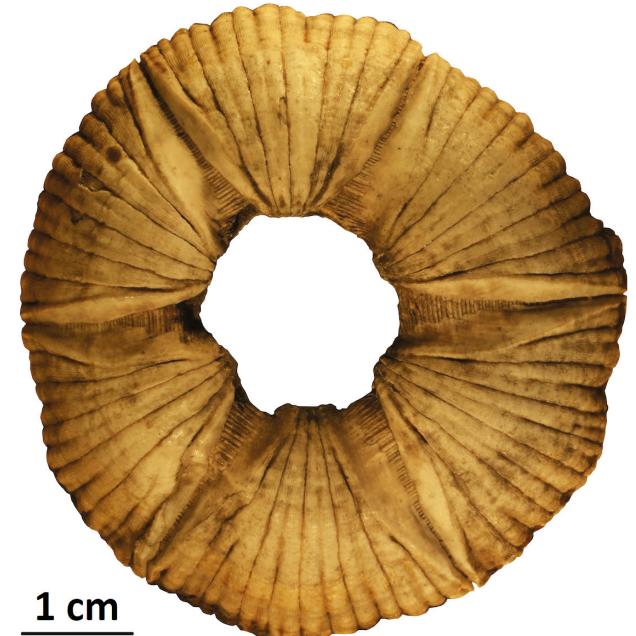


Fig. 1 - The wall plates of a complete and articulated Recent specimen of *Cetopirus complanatus* from the Southern Hemisphere. This specimen is part of the invertebrate zoological collection of the Koninklijk Belgisch Instituut voor Natuurwetenschappen (Brussels, Belgium) with accession number KBIN 95996. Image modified after Collareta *et al.* (2016b).

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(Balaenidae: genus *Eubalaena* Gray, 1864), *Cryptolepas rhachianecti* Dall, 1872 is considered exclusive of gray whales (Eschrichtiidae: *Eschrichtius robustus* (Liljeborg, 1861)), whereas *Coronula diadema* (Linnaeus, 1767) attaches preferentially (but not exclusively) on humpback whales (Balaenopteridae: *Megaptera novaeangliae* (Borowski, 1781)). This high host specificity is believed to date to the Pliocene (Bosselaers & Collareta, 2016, *cum bibl.*). That said, and considering that the detachment of whale barnacles from living cetaceans has been observed along migratory routes and especially in occurrence of breeding areas (Bianucci *et al.*, 2006b, *cum bibl.*), remains of Coronulidae from palaeontological and archaeological sites have been recently exploited as markers of ancient cetacean biogeographical patterns and migration paths (Bianucci *et al.*, 2006a, b; Bosselaers & Collareta, 2016; Collareta, 2016; Collareta *et al.*, 2016b, 2017).

In August 2010, one of the authors (F.v.N.) collected an isolated compartment of *Cetopirus complanatus* from a sandy beach ("Playa de Poniente", or Poniente

beach) near the port of Benidorm (Valencian Community, Spain; geographic coordinates: N 38°32'08", E 0°08'02") (Fig. 2).

This specimen (Figg. 3-4) was deposited into the invertebrate palaeontological collection of the Koninklijk Zeeuwse Genootschap der Wetenschappen, currently kept at Middelburg (Zeeland Province, The Netherlands) and managed by the Zeeuws Museum. In this short paper we provide a description of the Benidorm specimen and speculate on its (palaeo-)biogeographical meaning.

SYSTEMATICS

Class MAXILLOPODA Dahl, 1956

Subclass CIRRIPEDIA Burmeister, 1834

Order SESSILIA Lamarck, 1818

Suborder BALANOMORPHA Pilsbry, 1916

Superfamily CORONULOIDEA Newman & Ross, 1976

Family CORONULIDAE Leach, 1817

Genus *Cetopirus* Ranzani, 1817

Cetopirus complanatus (Mörch, 1853) (Figg. 3-4)

Nomenclatural caveat: Among Recent whale barnacles, *Cetopirus complanatus* does not present major taxonomic problems; by contrast, its nomenclatural history (whose origin dates back to the late XVIII century) is rather troubled and complex. At this regard, a thorough rationale and an exhaustive discussion have been provided by Holthuis *et al.* (1998). For an updated synonymic list of *Cetopirus complanatus*, see instead Collareta *et al.* (2017).

Material examined: A single right lateral compartment (i.e., right latus or carinolatus) collected from beach deposits at Benidorm (Spain) and hereinafter identified by its accession number NHG 27 013.

Description and remarks: NHG 27 013 is unambiguously attributed to the extant species *Cetopirus complanatus* (Fig. 1) owing to the following characters: *i*) radius narrow and almost as thick as the whole compartment; *ii*) sheath sub-straight; *iii*) ala thin and square; *iv*) external ribs or buttresses broad and flat, flaring downwards in a fan-like, triangular fashion; *v*) inner ribs or buttresses protruding beyond the basal margin of the sheath; and *vi*) buttresses presenting inner, transversely elongated tubes (e.g., Darwin, 1854; Pastorino & Griffin, 1996; Seilacher, 2006) (Figg. 3-4). NHG 27 013 measures ca. 13 mm in height and 15 mm in basal width. Basally it displays 9 external ribs, thus suggesting a sub-adult barnacle individual. This is also supported by the moderate size of the specimen.

NHG 27 013 is almost complete, uniformly ivory-white colored, exquisitely preserved, and translucent (right-most depiction in Fig. 3), so that it can be excluded that it underwent any process of fossilization (e.g., im-

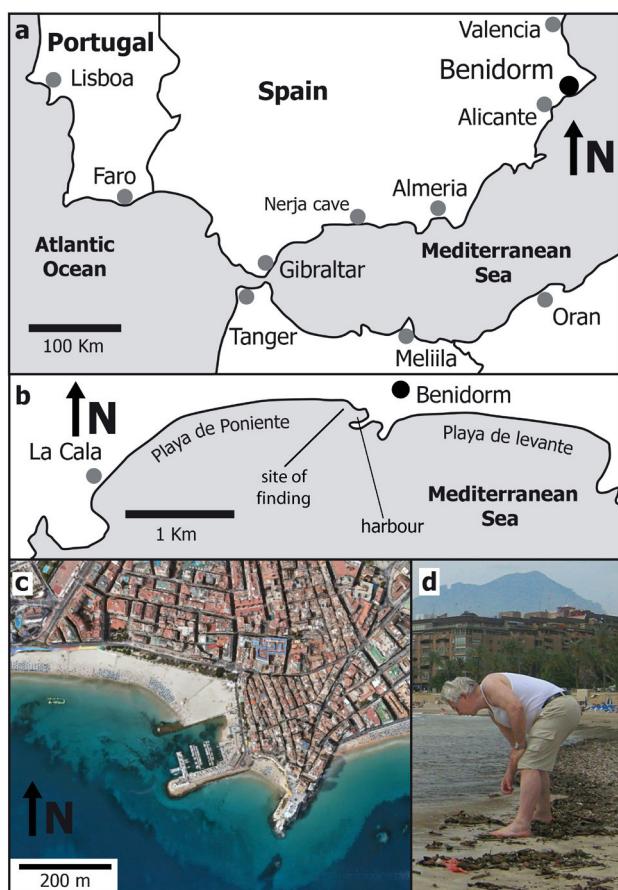


Fig. 2 - a) Location of Benidorm in southern Spain. b) Location of the finding site of NHG 27 013 in the bay of Benidorm. c) Satellite view of the bay of Benidorm (image obtained by Google Earth). d) One of the authors (F.v.N.) looking for barnacles at Poniente beach.

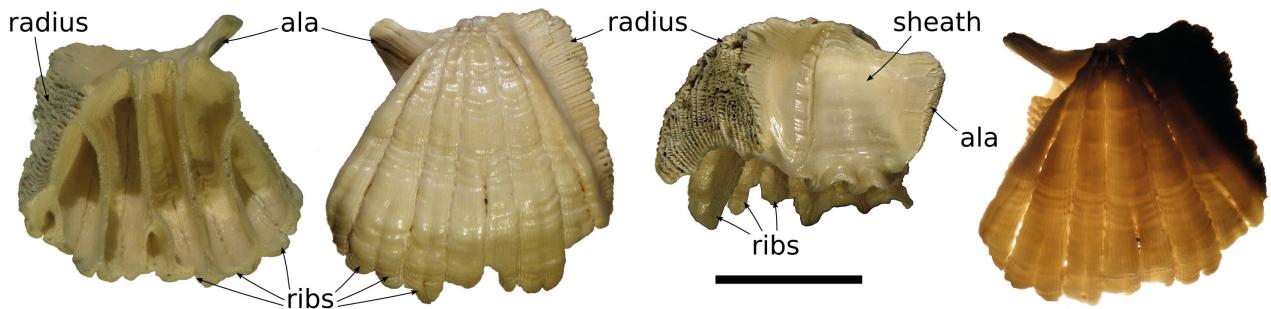


Fig. 3 - NHG 27 013, *Cetopirus complanatus* (Mörch, 1853), isolated right compartment (latus or carinolatus) collected from Recent beach deposits in Benidorm (Valencian Community, Spain). From left to right: basal view; outer view; central view; translucency of the specimen. Scale bar: 10 mm.

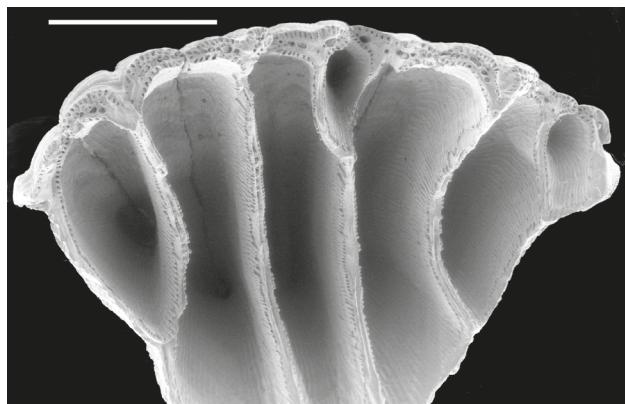


Fig. 4 - NHG 27 013, *Cetopirus complanatus* (Mörch, 1853), isolated right compartment (latus or carinolatus) collected from Recent beach deposits in Benidorm (Valencian Community, Spain). Close-up on the basal aspect of the compartment, showing the well-developed tubes-and-septa pattern which characterises the terminal transverse loops of the ribs of extant *Cetopirus*. Scale bar: 5 mm. Scanning Electron Microscope (SEM) image by Julien Cillis, taken at the Koninklijk Belgisch Instituut voor Natuurwetenschappen (Brussels, Belgium) using an environmental SEM Quanta 200.

pregnancy or recrystallization). Although it is impossible to date the whale barnacle plate from Benidorm without recurring to destructive methods (e.g., radiocarbon analyses), its preservation state strongly suggests that it is Recent (i.e., Holocene) in age, and possibly no more than some centuries old. It should be noted that, in 1991, the eastern side of Poniente beach (where the specimen here studied comes from) was replenished with sand coming from the dredging of the seabed next to Sierra Helada mountain, near the town of Alicante, ca. 60 km SSW to Benidorm (Aragonés *et al.*, 2015). Therefore, the coronulid compartment here studied could have been originally embedded into the seafloor sediment utilised for beach nourishment at Benidorm.

DISCUSSION AND CONCLUSIONS

The pre-modern era record of *C. complanatus* is currently limited to a few upper middle Pleistocene to upper Holocene (i.e., medieval) sites of Argentina, The Netherlands, Spain, and South Africa (Pastorino & Griffin, 1996; Holthuis *et al.*, 1998; Alvarez-Fernández *et al.*, 2014; Collareta *et al.*, 2017). Another fossil species of *Cetopirus*, *Cetopirus fragilis* Collareta *et al.*, 2016b, has been recently described based on an isolated compartment from the early Pleistocene of Italy. Being *C. complanatus* a strictly genus-specific phoront of *Eubalaena* spp. (Scarff, 1986; Holthuis *et al.*, 1998), the finding of NHG 27 013 at Benidorm indicates the passage of a right whale individual in the waters off Mediterranean Spain, several hundreds of kilometers east of Gibraltar. Nowadays, right whales are absent from the Mediterranean; therefore, the site from where NHG 27 013 was collected stands well outside the current biogeographic range of *C. complanatus*. To date, there are only four confirmed or plausible modern records of *Eubalaena* inside the Mediterranean (Rodrigues *et al.*, 2016, *cum bibl.*), plus one sub-fossil record from Saint Martin, an archaeological site of southern France dated to the Late Antiquity (Speller *et al.*, 2016). Moreover, Alvarez-Fernández *et al.* (2014) reported on the co-occurrence of *Cetopirus complanatus* and *Tubicinella major* Lamarck, 1802 (both known as exclusive phoronts of right whales) in the Late Glacial (i.e., ca. 15 to 12 ka) human settlement of Nerja Cave (Maro, Andalusia Community), ca. 380 km SSW of Benidorm. Originally regarded as depicting scavenging on a southern right whale (*Eubalaena australis* (Desmoulin, 1822)), the coronulid remains from Nerja Cave have more recently been interpreted by Rodrigues *et al.* (2016) and Collareta *et al.* (2017) as hosted by a North Atlantic right whale (*Eubalaena glacialis* (Müller, 1776)). As a matter of fact, however, Tsai *et al.* (2017) have recently shown that at least one taxon of Southern Hemisphere mysticetes, best identifiable as

the pygmy right whale *Caperea* Gray, 1864, was present in the Mediterranean basin during the global cold phase at the Gelasian/Calabrian passage, thus possibly providing indirect support to the putative presence of *Eubalaena australis* in the Northern Hemisphere in Late Glacial times.

Based on *i*) the few confirmed Holocene occurrences of right whales within the Mediterranean basin, *ii*) new interpretations of reports by Roman authors such as Pliny (I century AD) and Aelian (II-III centuries AD), and *iii*) the whale barnacle record from Nerja Cave, Rodrigues *et al.* (2016) argued that, in the past, *E. glacialis* could have been regularly encountered in the Mediterranean, at least during Antiquity. Rodrigues *et al.* (2016) also hypothesized that the coastal areas of the central Mediterranean could have represented a calving ground for *E. glacialis* in Holocene times. Interestingly, the utilization of some areas of the Mediterranean basin as a right whale breeding/calving ground during part of the Pliocene and Pleistocene epochs has also been proposed by Collareta *et al.* (2016b). Therefore, our finding of a compartment of *C. complanatus* from the Mediterranean coast of Spain contributes to shed light on the past distribution patterns of this poorly known species of whale barnacles and further strengthens the hypothesis that *E. glacialis* may have been present in the Mediterranean before its almost complete extirpation from the Northeastern Atlantic occurred during the last millennium (Brown, 1986). Coronulid remains can thus represent a powerful addition to the fossil and subfossil record of cetaceans when aiming at investigating the historical distribution patterns of these marine mammals. We acknowledge that phoront-host relationships for coronulid species other than *Coronula diadema* (including *Cetopirus complanatus*) are based on a limited number of published co-occurrences of whale barnacles and their cetacean hosts. Therefore, we take advantage of this space for launching a plea to fellow naturalists interested in whale barnacles: to our knowledge, *C. complanatus* has not been observed on (or extracted from) the skin of cetaceans for a very long time. Due to the heavy whaling activities which threatened for centuries (and largely still threaten) *Eubalaena* spp. worldwide, the opportunity that the extreme rarefaction of right whale populations could have caused the extinction of *C. complanatus* cannot unfortunately be ruled out. Indeed, whereas two species of *Eubalaena* (i.e., *E. glacialis* and *E. japonica* (Lacépède, 1818)) are currently regarded as endangered taxa (Reilly *et al.*, 2012a, b), nothing is paradoxically known about the status of their crustacean phoronts, which would be obviously exposed to the threat of co-extinction. Thus we invite all those colleagues who do fieldwork with cetaceans, those that are in charge of managing cetacean carcasses, or are interested in the biology of

Coronuloidea, to take note (and possibly notify to the writers) of every whale barnacle species they are able to identify on living or dead right whales. Such a census would represent a much needed attempt to clarify the current status of *C. complanatus* and closely allied species, as well as a mean to field-validate current knowledge about the host preferences of Coronulidae.

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