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A new species of ghost shrimp (Decapoda, Thalassinidea, Callianassidae) from the Late Cretaceous (Cenomanian) of Agadir (W Morocco)

Abstract – We report *Neocallichirus agadirensis* n. sp. (Decapoda, Thalassinidea, Callianassidae) from the Late Cretaceous (Cenomanian) of Agadir (W Morocco). This species has been described based upon four specimens that preserve ischium, merus, carpus, propodus, and dactylus of the great cheliped. The new species represents the first report of *Neocallichirus* in Africa and the oldest species known to date belonging to this genus.

Key words: Crustacea, Decapoda, Thalassinidea, Late Cretaceous, Morocco.

Riassunto – Una nuova specie di talassinide (Decapoda, Thalassinidea, Callianassidae) del Cretaceo superiore (Cenomaniano) di Agadir (Marocco occidentale).

Viene descritto ed illustrato *Neocallichirus agadirensis* n. sp. (Decapoda, Thalassinidea, Callianassidae) del Cretaceo superiore (Cenomaniano) di Agadir (Marocco occidentale). Questa specie è stata studiata sulle caratteristiche di quattro esemplari che conservano ischium, merus, carpus, propodus and dactylus del maggiore chelipede. *Neocallichirus agadirensis* n. sp. rappresenta la prima segnalazione di questo genere per il continente africano e la più antica specie finora attribuita a questo genere.

Parola chiave: Crustacea, Decapoda, Thalassinidea, Cretaceo superiore, Marocco.

Introduction and geological setting

The Cretaceous layers, located N-NE of Agadir on the Atlantic coast of W Morocco, are comprised of a thick and deep sequence of compact limestones extending N to S reaching the alluvial plane of the Oued Sous. These layers are delimited to the W by a high cliff directly on the Atlantic coast, while to the E they are in contact with the Jurassic secondary plateau (Geological Map 1:500.000 of Geological Service of Morocco, Rabat).

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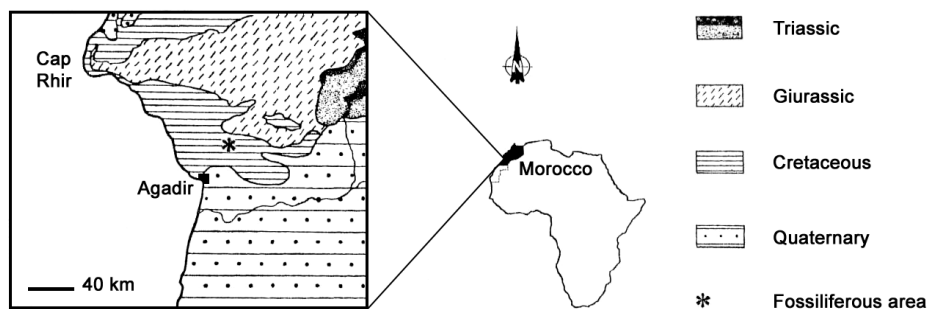


Fig. 1 – Geographic map of the fossiliferous locality. / Cartina geografica della località fossilifera.

The studied specimens were discovered in a Cretaceous marine outcrop located NE of Agadir (W Morocco), along the road leading to Imouzar, close to the locality of Tisoli (Agadir Region) (Tahiri pers. comm., 2008).

The rare decapod crustaceans, usually poorly preserved, were discovered within a lens of grey argillaceous marls, deposited on a series of compact fossiliferous limestones containing a rich assemblage of regular echinoderms, among them *Dorocidaris taouzensis* Lambert 1933, ascribed to the Cenomanian (Late Cretaceous). Without radiometric, sedimentologic, and biostratigraphic data, we assign with reservation the decapod crustaceans to the Cenomanian.

Previous reports of Cretaceous decapods from Morocco

The previous records of decapods from the Late Cretaceous of Morocco are scarce. Secrétan (1961) reported *Titanocarcinus meridionalis* (Tumidocarcinidae Schweitzer, 2005) from the Upper Cretaceous; at present this species cannot be retained in this genus (Schweitzer *et al.*, 2007). Ettachfni & Andreu (2004) reported the presence of “pinces de crabes” respectively from the Cenomanian of the Akrabou-coupe de Ziz formation (C1 unit), and from the late Cenomanian of the coupe de Goulmina (C2 unit – upper part), both located in the Errachidia region, in the SE of Morocco. Before these reports, Dutheil (1999) noted the presence of decapod crustaceans in the faunal assemblage of a locality “close to Gara Sbaa”, in the upper part of the Kem Kem beds, also located in the southeastern area, and Cenomanian in age. Garassino *et al.* (2006) described *Cretapenaeus berberus*, a freshwater decapod crustacean, based upon specimens gathered by Dutheil from this locality. Later, Guinot *et al.* (2008) and Garassino *et al.* (2008) reported a rich assemblage of macrurans, brachyurans, and anomurans from a new locality, discovered in Cenomanian-Turonian limestones (Sereni *et al.*, 1996) at the top of Gara Sbaa escarpment, located in SE Morocco, along the Hamada des Kem Kem, close to the Algerian border. These reports increased the knowledge of the Morocco decapod crustaceans from the Late Cretaceous, as follows: *Cretapenaeus berberus* Garassino, Pasini & Dutheil, 2006 (Penaeidae Rafinesque, 1815), *Glyphea garasbaensis* Garassino, De Angeli & Pasini, 2007 (Glypheidae Zittel, 1885), *Corazzatocarcinus* cfr. *C. hadjoulae* (Roger, 1946) (Necrocarcinidae Förster, 1968), *Telamonocarcinus* cfr. *T. gambalatus* Larghi, 2004 (Dorippidae MacLeay, 1838), *Galathea sahariana* Garassino, De Angeli & Pasini, 2008, *Paragalathea africana*

Garassino, De Angeli & Pasini, 2008, and *Cretagalathea exigua* Garassino, De Angeli & Pasini 2008 (Galatheidae Samouelle, 1819). Finally, some specimens of eubranchyurans not showing strict correlations with any crabs known to date, have been ascribed to the new family Marocarcinidae Guinot, De Angeli & Garassino, 2008, with *Marocarcinus pasinii* Guinot, De Angeli & Garassino, 2008. Recently Ossó-Morales *et al.* (2010) have described *Ophthalmoplax minimus* Ossó-Morales, Artal & Vega, 2010 (Macropipidae Stephenson & Campbell, 1960) and *Costacopluma maroccana* Ossó-Morales, Artal & Vega, 2010 (Retropiumidae Gill, 1894) from the Upper Cretaceous (Campanian) of the Moyenne Moulouya (NE Morocco).

Material

The studied specimens, disarticulated and incomplete, are preserved three-dimensionally and in lateral view and their preparation was easy due to the softness of the surrounding matrix.

The studied specimens were ascribed to *Neocallichirus agadirensis* n. sp. (Callianassidae Dana, 1852).

Some poorly preserved specimens (probably exuviae), referred to glypheids and associated with the thalassinids, were not included in the studied sample for the lack of diagnostic characters useful for a systematic description.

The studied sample is housed in the Palaeontological Collections of the Museo di Storia Naturale di Milano (MSNM).

The measurements are expressed in millimetres (mm).

The systematic paleontology used in this paper follows the recent arrangement proposed by Tsang *et al.* (2008), De Grave *et al.* (2009) and Schweitzer *et al.* (2010).

Abbreviations: lc: length of the carpus; hc: height of the carpus; lpr: length of the propodus; lpa: length of the palm; hpa: height of the palm.

Systematics Paleontology

Infraorder Decapoda Latreille, 1802
 Infraorder Thalassinidea Latreille, 1831
 Superfamily Callianassoidea Dana, 1852
 Family Callianassidae Dana, 1852
 Subfamily Callichirinae Manning & Felder, 1991

Genus *Neocallichirus* Sakai, 1988

Type species: *Neocallichirus horneri* Sakai, 1988

Included fossil species: *N. aetodes* Schweitzer, Iturralde-Vinent, Hetler & Velez-Juarbe, 2006; *N. allegranzi* Beschin, De Angeli, Checchi & Zarantonello, 2005; *N. bona* (Imaizumi, 1959); *N. borensis* Beschin, De Angeli, Checchi & Mietto, 2006; *N. dijki* (Martin, 1883); *N. fortisi* Beschin, Busulini, De Angeli & Tessier, 2002; *N. hattai* Karasawa & Nakagawa, 2010; *N. manningi* Schweitzer, Feldmann, Fam, Hessin, Hetrich, Nyborg & Ross, 2003; *N. matsoni* (Rathbun, 1935); *N. nishikawai* (Karasawa, 1993); *N. okamotoi* (Karasawa, 1993); *N. peraensis* Collins, Dono-

van & Dixon, 1996; *N. porterensis* (Rathbun, 1926); *N. quisquellanus* Schweitzer, Iturralde-Vinent, Hetler & Velez-Juarbe, 2006; *N. rhinos* Schweitzer & Feldmann, 2002; *N. sakiae* Karasawa & Fudouji, 2000; *N. scotti* (Brown & Pilsbry, 1913) (= *Callianassa crassa* A. Milne Edwards, 1870; *C. crassimana* Rathbun, 1918; *C. miocenica* Rathbun, 1919); *N. vaughani* (Rathbun, 1918); *N. wellsii* Schweitzer, Feldmann & Gingerich, 2004.

Neocallichirus agadirensis n. sp.

Figs. 2-6

Diagnosis: chelipeds unequal, major without meral hook; elongate, subcylindric ischium; subtriangular merus, with serrate lower margin; carpus higher than long, with convex lower and posterior margins; rectangular propodus, longer than high, ridged on lower margin; fixed finger relatively long; mobile finger more developed than fixed finger.

Etymology: the trivial name alludes to Agadir where the studied specimens were discovered.

Holotype: MSNM i27103.

Paratypes: MSNM i27099a-b, MSNM i27102a-b, MSNM i27104.

Geological age: Cenomanian (Late Cretaceous).

Type locality: Agadir (W Morocco).

Occurrence and measurements: four specimens of which three preserve the right cheliped (MSNM i27099a-b, i27103, i2704) and one the left cheliped (MSNM i27102a-b).

MSNM i27099 – lc: 5.9; hc: 9.6; lpr: 18.7; hpa: 10.

MSNM i27103 – lc: 5; hc: 8; lpr: 16.2; lpa: 11.5; hpa: 8.8.

MSNM i27104 – lc: 4.2; hc: 7.8; lpr: 14.5; lpa: 11.1; hpa: 8.3.

MSNM i27102 – lc: 6; hc: 7.3; lpr: 16.5; lpa: 11.2; hpa: 8.2.

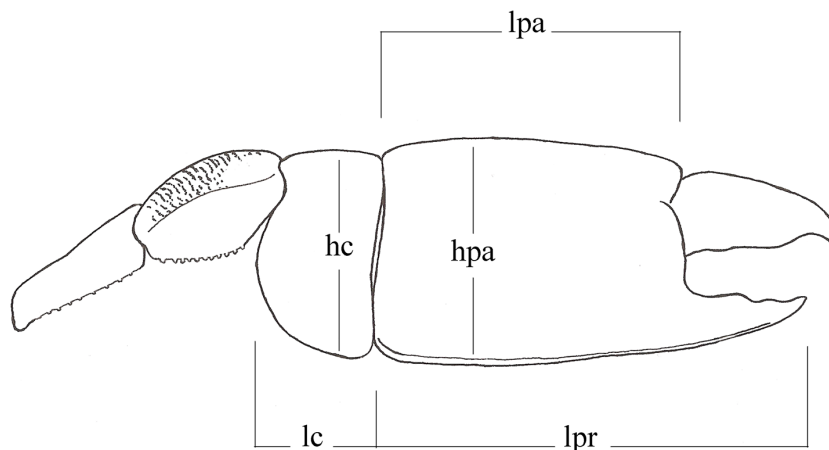


Fig. 2 – Reconstruction of the major cheliped (right)/Ricostruzione del chelipede maggiore (destra); lc: length of carpus/lunghezza del carpo; hc: height of the carpus/altezza del carpo; lpr: length of the propodus/lunghezza del propodo; lpa: length of the palm/lunghezza del palmo; hpa: height of the palm/altezza del palmo.

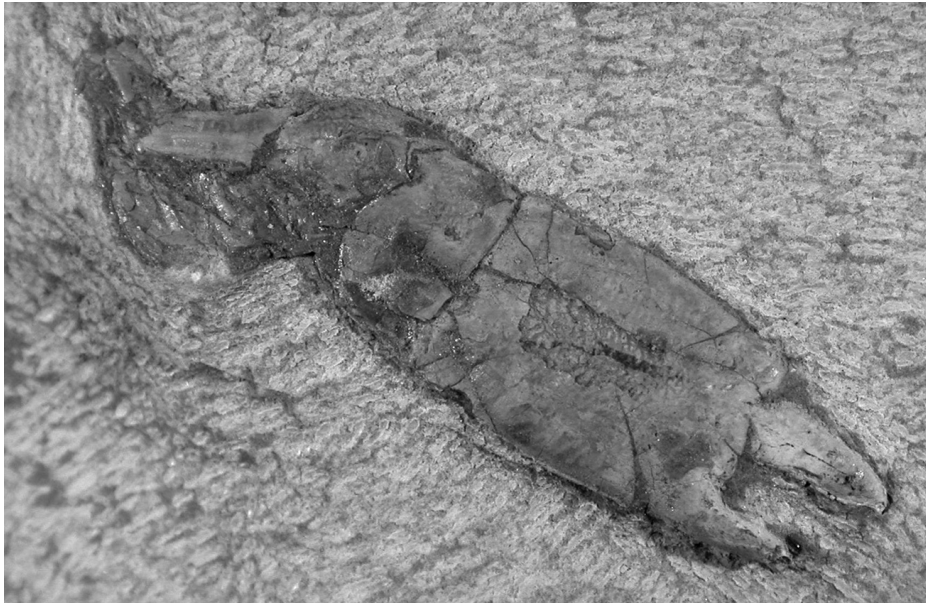


Fig. 3 – *Neocallichirus agadirensis* n. sp., holotype/olotipo MSNM i27103, right cheliped/chelipede destro (x 4.6).



Fig. 4 – *Neocallichirus agadirensis* n. sp., paratype/paratipo, MSNM i27099a, right cheliped/chelipede destro (x 3).

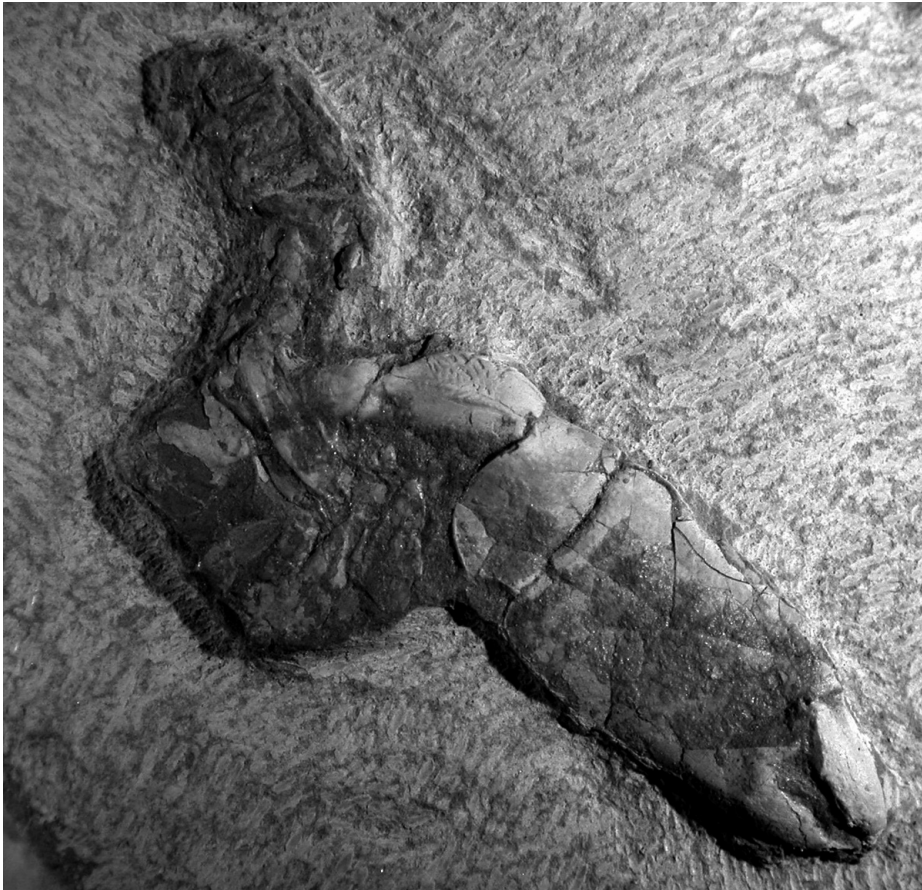


Fig. 5 – *Neocallichirus agadirensis* n. sp., paratype/paratipo, MSNM i27104, right cheliped/chelipede destro (x 3.9).

Description. Well developed chelae of cheliped. Great cheliped with elongate, subcylindric ischium, more enlarged anteriorly, with lower margin having small granulations. Subtriangular merus, longer than high; with curved upper margin and convex, serrate lower margin without meral hook; outer surface strongly rounded and ridged medially; upper part of outer surface with some transverse roughness. Carpus higher than long, with rounded lower margin; merus-carpus joint concave. Strong, rectangular propodus, more restricted anteriorly; carpus-propodus joint of larger chela perpendicular to palm; palm longer than high; lower, upper margins slightly curved, lower margin ridged externally, outer surface slightly convex and smooth. Fixed finger slightly extended (about $\frac{1}{4}$ the length of propodus), relatively high, with lower margin slightly convex and occlusal margin sinuous. Movable finger more developed than fixed finger, with convex upper margin and pointed, curved distal extremity. Inner part of propodus not observable. The studied specimens have traces of articles of pereopods; the specimen MSNM i27102a has also merus and carpus of small cheliped (Fig. 6).



Fig. 6 – *Neocallichirus agadirensis* n. sp., paratype/paratipo, MSNM i27102a, left cheliped/chelipede sinistra (x 3.7).

Discussion. The diagnostic characters of *Neocallichirus* have been discussed by Manning & Felder (1991), Sakai (1999) and Schweitzer & Feldmann (2002). The great cheliped of *Neocallichirus*, figured by Manning & Felder (1991), differs from the other genera in having the subtriangular merus, with serrate lower margin and without meral hooks.

The fossil species known to date preserve only the chelipeds.

One species is known from the Late Cretaceous: *N. manningi* Schweitzer, Feldmann, Fam, Hessin, Hetrich, Nyborg & Ross, 2003 [Late Cretaceous (Campanian) - Southern Vancouver Island, British Columbia, Canada] (Schweitzer *et al.*, 2003).

Five species are known from the Eocene: *N. allegranzi* Beschin, De Angeli, Checchi & Zarantonello, 2005; *N. borensis* Beschin, De Angeli, Checchi & Mietto, 2006; *N. fortisi* Beschin, Busulini, De Angeli & Tessier, 2002 (middle and late Eocene, Vicenza, Italy); *N. rhinos* Schweitzer & Feldmann, 2002 (Eocene - California); *N. wellsi* Schweitzer, Feldmann & Gingerich, 2004 (middle Eocene - Pakistan) (Beschin *et al.*, 2002, 2005, 2006; Schweitzer & Feldmann, 2002; Schweitzer *et al.*, 2004).

Four species are known from the Oligocene: *N. aetodes* Schweitzer, Iturralde-Vinent, Hetler & Velez-Juarbe, 2006 (early late Oligocene - Puerto Rico); *N. okamotoi* (Karasawa, 1993) (late Oligocene - Japan); *N. porterensis* (Rathbun, 1926) (late Oligocene - Oregon) and *N. saki* Karasawa & Fudouji, 2000 (early Oligocene - Japan) (Rathbun, 1926; Karasawa, 1993; Karasawa & Fudouji, 2000; Schweitzer *et al.*, 2006).

Seven species are known from the Miocene: *N. bona* (Imaizumi, 1959) (Miocene - Japan); *N. dijki* (Martin, 1883) (late Miocene - Java, Philippines); *N. hattai* Karasawa & Nakagawa, 2010 (Miocene - Japan); *N. matsoni* (Rathbun, 1935) (early Miocene - Florida); *N. nishikawai* (Karasawa, 1993) (middle Miocene - Japan); *N. quisquellanus* Schweitzer, Iturralde-Vinent, Hetler & Velez-Juarbe, 2006 (early late-early middle Miocene - Dominican Republic) and *N. vaughani* (Rathbun, 1918) (Miocene - Panama) (Martin, 1883; Rathbun, 1918, 1935; Imaizumi, 1959; Karasawa, 1993; Karasawa *et al.*, 2008; Karasawa & Nakagawa, 2010; Schweitzer *et al.*, 2006).

Two species are known from the Pliocene: *N. peraensis* Collins, Donovan & Dixon, 1996 (late Pleistocene - Jamaica); *N. scotti* (Brown & Pilsbry, 1913) (early Pliocene - Panama, late Pliocene - Costa Rica) (Brown & Pilsbry, 1913; Collins *et al.*, 1996).

The comparison of *Neocallichirus agadirensis* n. sp. with the other known species reveals the following differences: *N. dijki*, *N. quisquellanus*, *N. matsoni*, and *N. scotti* have a shorter propodus; *N. aetodes*, *N. bona*, *N. nishikawai*, *N. okamotoi*, and *N. wellsii* have a shorter propodus and elongate, rounded carpus; *N. vaughani*, *N. porterensis* have a shorter propodus and more elongate fixed, movable fingers; *N. peraensis* and *N. allegranzii* have a propodus with serrate lower margins and more elongate fixed, movable fingers; *N. borensis* has a shorter propodus, with serrate lower margin, and an outer surface with granulations; *N. hattai* and *N. sakiae* have a longer carpus; *N. rhinos* has a longer carpus and well-developed movable finger with two teeth on occlusal margin; *N. fortisi* has a fixed, movable fingers more developed.

Finally *Neocallichirus manningi* differs from the new species in having a longer carpus and a propodus with serrate inner lower margin.

Neocallichirus agadirensis n. sp. represents the first report of this genus in Africa and the oldest species known to date ascribed to *Neocallichirus*.

Palaeoenvironment and palaeoecological notes

The carcinologic assemblage and the lithology of the sediment permit some palaeoenvironment considerations. The presence of glypheids and thalassinids in the same sediment indicates the establishment in this area of a tidal environment on a shallow platform during the Late Cretaceous (Cenomanian-Turonian), connecting to the opening of the pre-Atlas Gulf that was the origin, during this interval time, of a direct connection between the Meso-Tethys and the Atlantic Ocean. These data have been supported also by recent geo-sedimentologic research carried on along the southern area of Atlantis, above all in Errachidia Province, SW. Morocco (Ettachfini & Andreu, 2004).

Fossils and living thalassinids are specialized crabs that have adopted a fossorial mode of life. At present they live in sandy soft substrata in nearshore, shallow water in tropical and subtropical lagoons near or in seagrass beds. Moreover, the soft bottom nature of the shelf deposits was a suitable habitat also for glypheids, that some authors consider probable fossorial forms (Sellwood, 1971; Bromley & Asgaard, 1972) or symbiotic-opportunist cohabitants in the thalassinid burrows. They also fed on the nearshore bottom of the beds using the long dactyli of the subchelate chelipeds like chemoreceptors to find their prey (Schäfer, 1962).

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