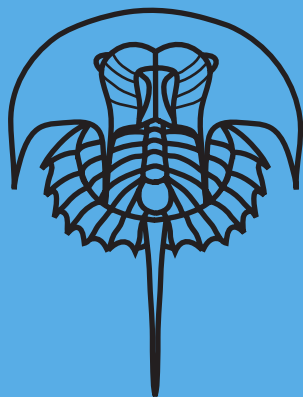




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LATE CRETACEOUS DECAPOD FAUNAS FROM LEBANON

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The Late Cretaceous Konservat-Lagerstätten in Lebanon (Hadjoula, Hakel, En Nammoura, and Sahel Alma) contain diverse and remarkably preserved assemblages dominated by fishes and arthropods, associated with numerous soft-bodied organisms (e.g., cephalopods, annelids). The outcrops of Hadjoula, Hakel, and En Nammoura are Cenomanian in age and yield fossils preserved as compressions on the surface of sublithographic limestone beds, currently still excavated intensely by private quarrymen (FIG. 1). The outcrop of Sahel Alma is Santonian in age and yielded fossils preserved in chalky laminated limestones that are no longer accessible today. Cenomanian outcrops correspond to intrashelf depressions surrounded by small reefs, in which organisms probably lived (CHARBONNIER & others, 2017a, and references therein). This shallow water palaeoenvironment was rather well illuminated. After the Cenomanian, a deepening trend of the Arabian Plate is observed (FERRY & others, 2007), and the Santonian fauna from Sahel Alma recorded this change in palaeodepth with the disappearance of shallow-water taxa and morphological adaptations to dim-light conditions (AUDO & CHARBONNIER, 2013; AUDO & others, 2021) (FIG. 2).

Arthropods are major components of the Lebanese Lagerstätten, in terms of diversity and abundance (ROGER, 1946; GARASSINO, 1994; CHARBONNIER & others, 2017a). They

include malacostracan crustaceans (Decapoda, Isopoda, Lophogastrida, Stomatopoda), thecostracan crustaceans (DAMES, 1885), and thylacocephalan crustaceans (SCHRAM & others, 1999; LANGE & others, 2001; CHARBONNIER & others, 2017b).

Decapods are highly diversified in the Lebanese Lagerstätten, with about 60 species currently recognized (TABLE 1; TABLE 2). Among the decapods, dendrobranchiate shrimps are particularly diverse, represented by five families (Aegeridae, Penaeidae, Benthesicymidae, Carpopenaeidae, and Sergestidae), including 15 genera and 21 species (FIG. 2.1, 2.2). By far, the most frequent shrimp is the emblematic *Carpopenaeus callirostris* GLAESSNER, 1945, found in large numbers on sublithographic beds at Hadjoula (FIG. 1.1). The caridean shrimps are represented by four families (Hippolytidae, Pandalidae, Crangonidae, and Glyphocrangonidae), including four genera and six species, which are often the only known occurrences in the fossil record (FIG. 1.3). Stenopodean shrimps also are recorded at Hadjoula (GARASSINO, 2001). Polychelidan lobsters are represented only by larval stages (HAUG & others, 2015). Glypheid lobsters include *Angarestia damesi* CHARBONNIER & others, 2013, and two erymid lobster species are known. Astacidean lobsters include *Notahomarus hakelensis* (FRAAS, 1878) (FIG. 1.4). Achelatan lobsters are represented by slipper lobsters (Scyllaridae) and spiny lobsters (Palinuridae) as well as several larval



FIG. 1. Cenomanian decapods from Lebanon. 1, *Carpopenaeus callirostris*, MNHN.FA30809; 2, *Carinacaris antennae*, MSNM i26587; 3, *Gladicrangon coriacea*, MNHN.FA51512; 4, *Notahomarus bakelensis*, MNHN.FA30514; 5, *Palibacus praecursor*, MSNM i10401; 6, *Phalangiopsis antoinei*, MNHN.FA53878; 7, *Corazzatocarinus hadjoulai*, MSNM i26053. Photographs: L. Cazes (1), G. Teruzzi (2), D. Audo (3, 5–7), P. Loubry (4). Species authorships in TABLE 1.

stages (e.g., phyllosoma) (FIGS. 1.5, 1.6; FIG. 2.3). Axiidea are particularly diverse with six species distributed in three families (Axiidae, Callianassidae, Callianopsidae; PASINI & others, 2020). Anomurans are represented by hermit crabs (Diogenidae) and squat lobsters (Chirostylidae) (FIG. 2.5). Among the brachyuran crabs, five families are present (Cenomanocarcinidae, Paranecrocarcinidae, Raninidae, Homolidae, and Telamonocarcinidae) (FIG. 1.7; FIG. 2.6). Among other crustacean groups,

Lophogastrida (Gnathophausiidae), Isopoda (Cirolanidae; FELDMANN, 2009; FELDMANN & CHARBONNIER, 2011), Stomatopoda (Pseudosculdidae, Sculdidae; AHYONG & others, 2007), and thecostracans (Stramen-tidae) also are present.

Several genera are common to the Late Jurassic Solnhofen-type Lagerstätten and the Late Cretaceous (Cenomanian) outcrops: the dendrobranch shrimps *Acanthochi-rana*, *Aeger*, *Epipenaeus*, and *Libanocaris*; the erymid lobsters *Eryma* and *Pustulina*;

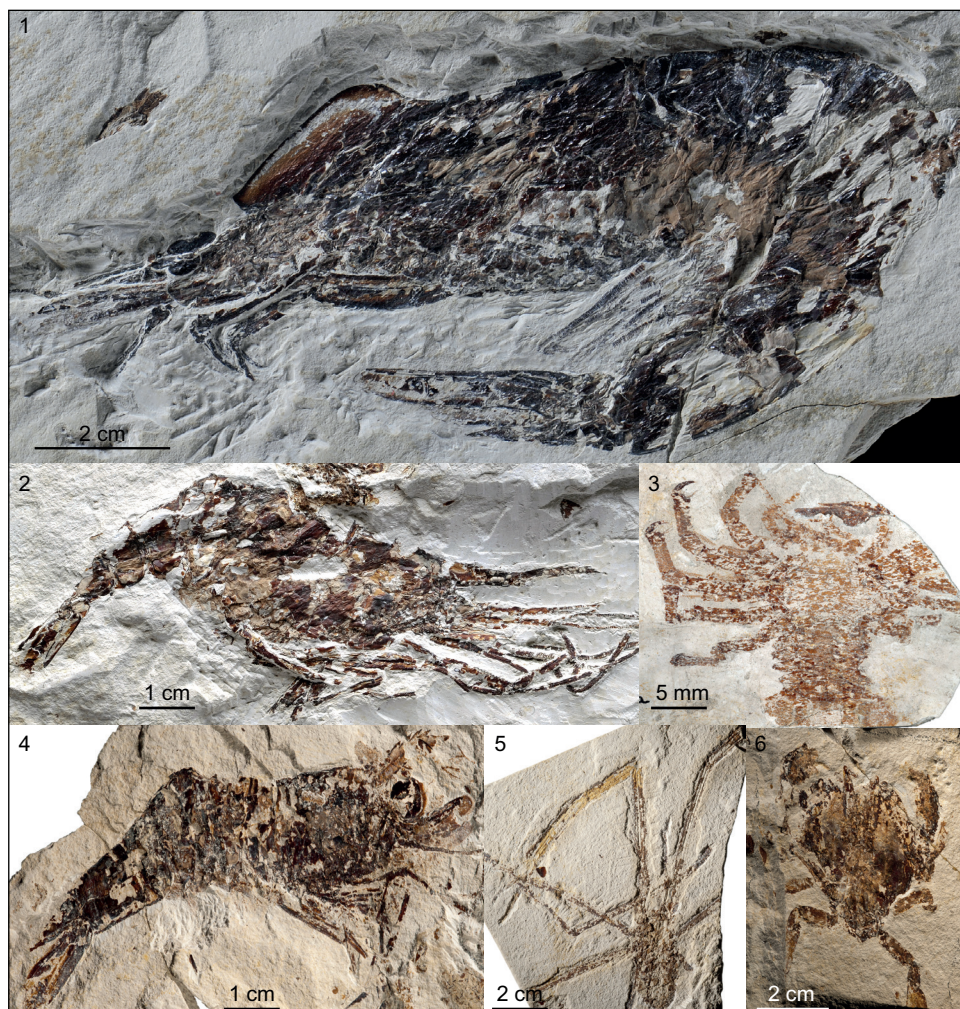


FIG 2. Santonian decapods from Lebanon. 1, *Palaeobenthescymus libanensis*, MNHN.FA30593; 2, *Carpopenaeus garassinoi*, MNHN.FA33532; 3, *Polzicaris sabelalmae*, MNHN.FB18905; 4, *Pseudodrobna natator*, MNHN.FA30697; 5, *Phalangiopsis rogeri*, MNHN.FA30771; 6, *Pseudoranina guinotae*, MNHN.FR03873; Photographs: C. Lemzaouda (1, 2), J. Haug (3), D. Audo (4–6). Species authorships in TABLE 1.

and the axiidean *Magila*. All these genera, which occur from the Late Jurassic to the Late Cretaceous, demonstrate links between these faunas. Lebanese Lagerstätten often include the last occurrences of these taxa, so they probably belong to a Mesozoic fauna that subsequently became extinct, possibly during the Cretaceous–Paleogene mass extinction. In conclusion, the Late Cretaceous Lebanese Lagerstätten offer two snapshots into crustacean palaeobiodiversity during the Cenomanian and Santonian. By

their palaeobiodiversity, they are witnesses of the transition between the Mesozoic faunas and modern ones (CHARBONNIER & others, 2017a; AUDO & others, 2021).

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Table 1. Decapod faunal list for Late Cretaceous (Cenomanian) Konservat-Lagerstätten in Lebanon (Hadjoula, Hakel, and En Nammoura).

Dendrobranchiata Aegeridae <i>Acanthochirana smithwoodwardi</i> (VAN STRAELEN, 1940) <i>Aeger libanensis</i> ROGER, 1946 Carpopenaeidae <i>Carpopenaeus callirostris</i> GLAESSNER, 1945 <i>Carpopenaeus septemspinatus</i> (DAMES, 1886) <i>Epipenaeus abisaadorum</i> CHARBONNIER & others, 2017 ?Penaeidae <i>Carinacaris teruzzii</i> GARASSINO, 1994 <i>Carinacaris antennae</i> CHARBONNIER & others, 2017 <i>Hakelocaris uvassorii</i> GARASSINO, 1994 <i>Libanocaris rogeri</i> GARASSINO, 1994 <i>Macropenaeus incertus</i> (ROGER, 1946) <i>Microchela rostrata</i> GARASSINO, 1994 <i>Joinvilleicaris longirostris</i> CHARBONNIER & others, 2017 Sergestidae <i>Cretasergestes sahelalmaensis</i> GARASSINO & SCHWEIGERT, 2006 Caridea Pandalidae <i>Palaeopandalus komaii</i> CHARBONNIER & others, 2017 Crangonidae <i>Odontochelion cretaceum</i> (ROGER, 1946) Glyphocrangonidae <i>Armacrangon edwardsi</i> CHARBONNIER & others, 2017 <i>Gladicrangon coriacea</i> CHARBONNIER & others, 2017 Stenopodea Stenopodidae <i>?Phoenice pasinii</i> GARASSINO, 2001 Polychelida Larval stages Glypheidea Glypheidae <i>Angarestia damesi</i> (GARASSINO, 2001) Erymidae <i>Eryma oscari</i> CHARBONNIER & others, 2017 <i>Pustulina cretacea</i> (ROGER, 1946) Astacidea Nephropidae <i>Notahomarus hakelensis</i> (FRAAS, 1878) Achelata Cancrinidae <i>Paracancrinus libanensis</i> (GARASSINO & SCHWEIGERT, 2006) <i>Charbelicaris maronites</i> HAUG & others, 2016	Palinuridae <i>Palaeopalinurellus jbeilensis</i> GARASSINO & PASINI, 2020 <i>Palinurus teruzzii</i> CHARBONNIER & others, 2017 <i>Limuparus secretanae</i> CHARBONNIER & others, 2017 Achelatan larval stages <i>Polzicaris</i>-like larvae and phyllosoma Scyllaridae <i>Acanthophoenicides peterpani</i> AUDIO & CHARBONNIER, 2012 <i>Palibacrus praecursor</i> (DAMES, 1886) Axiidea Axiidae <i>Cretaxiopsis libanotica</i> CHARBONNIER & others, 2017 <i>Libanoaxius beatae</i> CHARBONNIER & others, 2017 <i>Magila cretacea</i> CHARBONNIER & others, 2017 Callichiridae <i>"Neocallichirus" agadirensis</i> GARASSINO, DE ANGELI & PASINI, 2011 Callianopsidae <i>Cretacalliax levantina</i> PASINI, POORE & GARASSINO, 2020 Eucalliidae <i>Calliaxina hadjoulaensis</i> CHARBONNIER & others, 2017 Anomura Diogenidae <i>Striadiogenes frigerioi</i> GARASSINO, DE ANGELI & PASINI, 2009 Chirostylidae <i>Phalangiopsis antoinei</i> CHARBONNIER & others, 2017 Brachyura Cenomanocarcinidae <i>Cenomanocarcinus nammourensis</i> BESCHIN & DE ANGELI, 2013 <i>Cenomanocarcinus vanstraeleni</i> STENZEL, 1945 <i>Corazzatocarcinus hadjoulae</i> (ROGER, 1946) Paranecrocarcinidae <i>Paranecrocarcinus libanoticus</i> FÖRSTER, 1968 <i>Paranecrocarcinus</i> cf. <i>P. milbournei</i> COLLINS, 2010 Raninidae <i>Lophorarinella cretacea</i> (DAMES, 1886) Homolidae <i>Homolopsis</i> cf. <i>H. edwardsii</i> BELL, 1863 Telamonocarcinidae <i>Telamonocarcinus gambalatus</i> LARGHI, 2004
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Table 2. Decapod faunal list for Late Cretaceous (Santonian) Konservat-Lagerstätten in Lebanon (Sahel Alma).

Dendrobranchiata Aegeridae <i>Aeger</i> sp. Benthescymidae <i>Palaeobenthescymus libanensis</i> (BROCCHI, 1875) <i>Palaeobenthonectes arambourgi</i> (ROGER, 1946) ? <i>Bentheogennema phoenicia</i> CHARBONNIER & others, 2017 Carpopenaeidae <i>Carpopenaeus garassinoi</i> CHARBONNIER in PETIT & CHARBONNIER, 2012 <i>Carpopenaeus syriacus</i> (ROGER, 1946) Penaeidae <i>Pseudodrobna natator</i> (GLAESSNER, 1945) ?Penaeidae <i>Libanocaris curvirostra</i> CHARBONNIER & others, 2017	Caridea Hippolytidae Genus incertae sedis Crangonidae <i>Odontochelion bicarinatum</i> CHARBONNIER & others, 2017 Achelata Larval stages <i>Polzicaris sahelalmae</i> (ROGER, 1944) Anomura Chirostylidae <i>Phalangiopsis rogeri</i> CHARBONNIER & others, 2017 Brachyura ?Raninidae <i>Pseudoranina guinotae</i> CHARBONNIER & others, 2017
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ABBREVIATIONS FOR MUSEUM REPOSITORIES

MNH.N.F: Muséum National d'histoire naturelle, Paris, Collection de Paléontologie, France

MSNM: Museo Civico di Storia Naturale di Milano, Italy

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