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Article

A new genus of slipper lobster (Crustacea: Decapoda: Scyllaridae) from the Eocene of California and Oregon (USA)

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With 3 figures

Abstract: *Parribacus caesius* Squires, 2001 was described from the Eocene of the Llajas Formation, California, based upon one specimen. Two additional specimens, one from the Llajas Formation and one from the early Eocene Lookingglass Formation, Oregon, allow revision of this species. Differences from the studied fossil specimens with *Parribacus* and with the other fossil and extant species within the Scyllaridae Latreille, 1825 warrant establishment of a new genus, *Llajassus*, with *Llajassus caesius* (Squires, 2001) nov. comb. Extant Scyllaridae Latreille, 1825 have a worldwide distribution whereas the fossil record in comparison is rather small. *Llajassus* is the only known fossil record of Scyllaridae from the Northeastern Pacific and with only three representative specimens is also rare in the associated crab faunas of the Llajas and Lookingglass formations.

Key words: Crustacea, Decapoda, Achelata, Eocene, USA.

1. Introduction

Scyllarid lobsters (Scyllaridae) today are found along coastal, continental shelf, and upper slope environments with a worldwide distribution across the Equator, low latitudes, and temperate latitudes influenced by warm waters (Holthuis 1991, 2002; Lavalli & Spanier 2007; Chan 2010). The extant record includes 20 genera with several of those genera also contained within the fossil record (Holthuis 1991, 2002; Chan 2010; amongst others). The fossil record of Scyllaridae is more limited with six genera known from the Cretaceous to sub-recent (Lavalli & Spanier 2007; Schweitzer et al. 2010; Audo & Charbonnier 2012). In addition, several fossil nisto larva of scyllarid lobsters have been recently described (Audo & Charbonnier 2012; Haug & Rudolf 2015). The fossil record of adult Scyllaridae include: *Scyllarides* Gill, 1898, known from the Early Cretaceous of the United Kingdom and Eocene deposits of United Kingdom and Italy (Woods 1925; Förster 1984; De Angeli & Garassino 2008); *Parribacus* Dana, 1852, known from the Eocene to sub-recent deposits of United States, Italy, Taiwan, and Poland (Glaessner 1965; Förster 1984; Hu & Tao 1996; Squires 2001); *Biarctus* Holthuis, 2002, known from the late Pleistocene to Recent of Fuji (Förster 1984); *Scyllarella* Rathbun, 1935, known from the Cretaceous and Paleocene of the United States and United Kingdom (Förster 1984); *Scyllarus* Fabricius, 1775, known from the Miocene of Indonesia (Desmarest 1822; Förster 1984); and *Palibacus* Förster, 1984, known from the Cretaceous of Lebanon (Förster 1984).

Squires (2001) described one specimen from the middle Eocene of the Llajas Formation, California, assigning it to *Parribacus caesius* Squires, 2001. Squires (2001) based his generic assignment on one

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specimen and provisionally placed the specimen within the genus *Parribacus* Dana, 1852. Two additional specimens, one from the Llajas Formation and one from the early Eocene Lookingglass Formation, Oregon, allow revision of this species. Differences from the studied fossil specimens with *Parribacus* and with the other fossil and extant species within the Scyllaridae Latreille, 1825 warrant establishment of a new genus, *Llajassus* with *Llajassus caesius* (Squires, 2001) nov. comb.

2. Geological settings

2.1. California (Llajas Formation)

Two specimens of *Llajassus caesius* are preserved in sandstone collected from the early to middle Eocene (54 to 50 million years ago) Llajas Formation, Simi Valley, Ventura County, California at an elevation of 947 ft. on the south side of Simi Arroyo just above the streambed, 11000 ft. (335 m) north and 1750 ft. (553 m) west of SE corner of section 12, T2N, R18W, Santa Susana Quadrangle, California. The Llajas Formation is a transgressive and regressive sequence of nonmarine to marine deposits exposed in Simi Valley, southern California (Squires 1981, 1983a, b, 1984, 2001). The shallow-marine sands are locally richly fossiliferous and contain a diverse fauna of benthic foraminifera, gastropods, bivalves, nautiloids, scaphopods, crabs, sea urchins, and shark teeth (Squires 1983a, b, 1984, 2001). Most of the fossils are collected from, or just below, a 1 meter thick bed informally known as the "Stewart bed" (Squires 1981, 1983a, b, 1984, 2001). This bed, which occurs only on the north side of Simi Valley, is highly fossiliferous and represents a molluscan-solitary coral paleocommunity that formed near the shelf/slope break (Squires 1981, 1984, 2001). Refer to Squires (1981, 1984, 2001) for detailed locality and stratigraphy of the Llajas Formation. The early to middle Eocene age of the Llajas Formation is based on calcareous nannofossils, mollusks, and benthic foraminifera (Filewicz & Hill 1983: Squires 1984). Decapod crustaceans collected from this formation include: *Paleopinnixa* aff. *P. rathbunae* Schwietzer, Feldmann, Tucker & Berglund, 2000, *Raninoides slaki* Squires, 2001, *Portunites insculpta* Rathbun, 1926, and *Llajassus caesius* (Squires, 2001). The two specimens of *Llajassus caesius* were collected from the same locality, on the south side of Simi Valley. This locality is in the upper part of the shallow-marine transgressive section. Strata higher in the section and equivalent to the "Stewart bed" are not exposed in the vicinity of where the *L. caesius* specimens were collected.

2.1. Oregon (Lookingglass Formation)

One specimen of *Llajassus caesius* is preserved within a calcareous concretion collected from a road cut exposure near the town of Agness, Oregon in the SW ¼, NE ¼, sec. 9, T35S, R11W, Agnes 15' quadrangle, Oregon. The area has been mapped as part of the Tenmile Member of the Lookingglass Formation (Baldwin et al. 1973; Baldwin 1974; Walker & MacLeod 1991). The Lookingglass Formation is one of three formations, Roseburg, Lookingglass, and Flournoy formations of the Umpqua Group (Baldwin 1974). The Umpqua Group consists of several thousand meters of early to middle Eocene strata exposed in southwestern Oregon (Baldwin et al. 1973; Baldwin 1974; Prothero 2009). The Lookingglass Formation consists of about 1400 m of finer-grained sandstones and siltstones, with occasional conglomerates (Baldwin 1974). The formation was divided by Baldwin (1974) into three members: a lower conglomerate member (Bushnell Rock Member), a middle rhythmically-bedded turbidite sandstone and siltstone member (Tenmile Member), and an upper conglomerate and pebbly sandstone member (Ollala Creek Member). Recent studies by Prothero (2009) on the magnetic stratigraphy, combined with the occurrence of P8 planktonic foraminifera Zone and NP12/CP10 nannofossil Zone, constrain the age estimates of the formations within the Umpqua Group to 52.3-47 Ma, with the early Eocene Lookingglass Formation assigned an age of 49.8-50.8 Ma. The Tenmile Member is highly fossiliferous with a large fauna of foraminifera, mollusks, echinoderms, crabs, and a nautilid previously reported (Orr & Kooser 1971; Kooser & Orr 1973; Berglund & Feldmann 1989; Schweitzer 2000; Schweitzer & Feldmann 2000; Schweitzer & Feldmann 2001; Schweitzer et al. 2003).

3. Systematic paleontology

Abbreviations: LACMIP – Natural History Museum of Los Angeles County, Invertebrate Paleontology Section; UWBM – The Burke Museum of Natural History and Culture, University of Washington, Seattle, Washington State, U.S.A.; CL – length of carapace (including lateral spines); CW – width of carapace; s1-s3 – pleonal somites s1-s3.

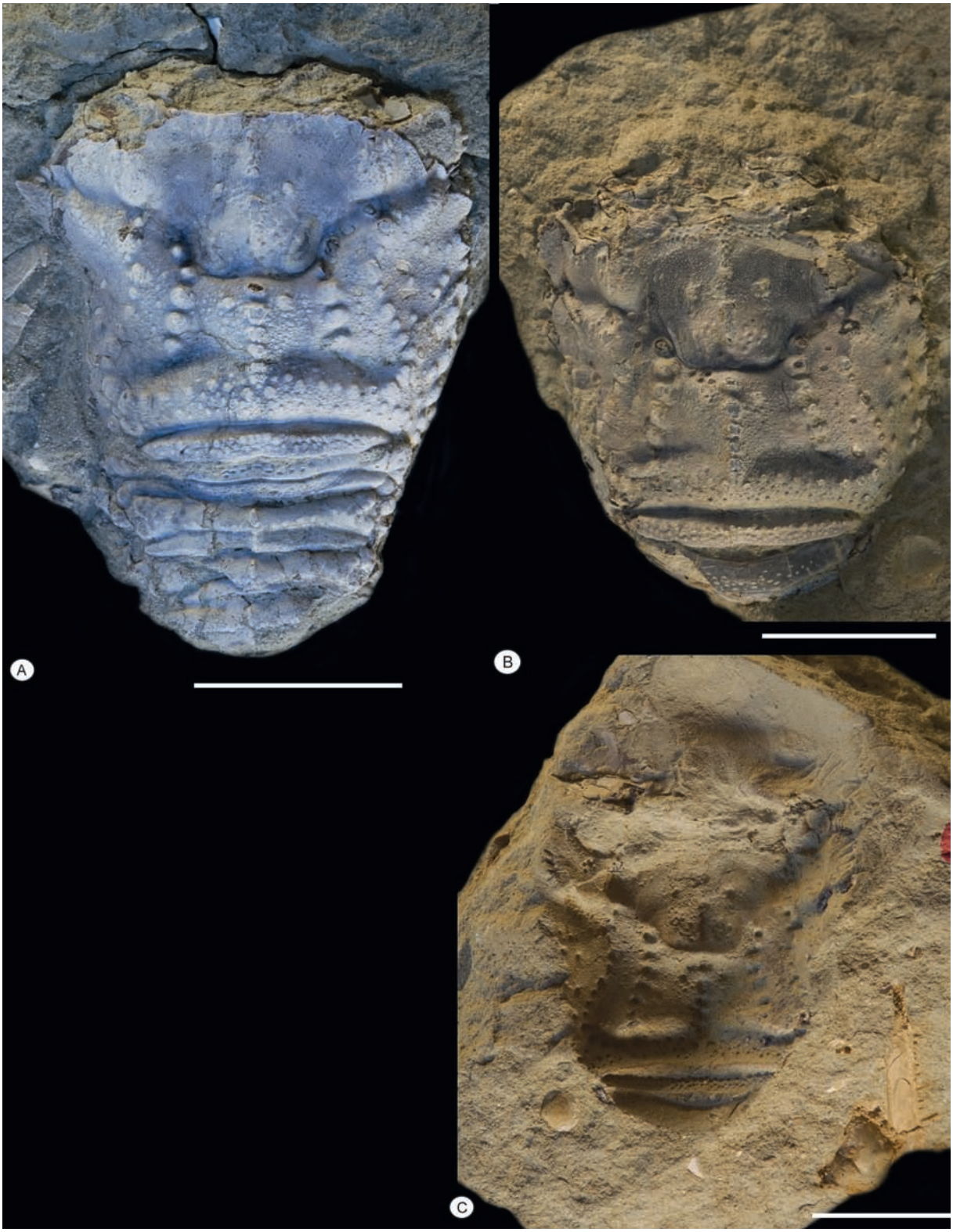

Fig. 1. *Llajassus caesius* (Squires, 2001) nov. comb. **A** – dorsal view of the carapace, LACMIP 14646. Note the color reflects the actual color of the fossil specimen. **B** – Dorsal view of the carapace, LACMIP 12760. **C** – Counterpart, dorsal view of the carapace, LACMIP 12760. Scale bar equals 1 cm.

Fig. 2. *Llajassus caesius* UWBM 105851. **A** – Dorsal view of the carapace within concretion. **B** – counterpart of concretion. Scale bar equals 1 cm.

Achelata Scholtz & Richter, 1995
Family Scyllaridae Latreille, 1825
Subfamily indet.

Genus *Llajassus* nov.

Etymology: From the Llajas Formation, California, where the holotype was collected.

Type species: *Llajassus caesius* (Squires, 2001) nov. comb., monotypic.

Diagnosis: Carapace wider than long; postrostral carina and four branchial carinae markedly elevated; inner branchial carina stronger than the outer; mesogastric region markedly elevated, with a pair of tubercles, each lateral to postrostral carina; shallow cervical incision; very deep cervical groove, distinctly dividing anterior portion from the median and posterior portions of carapace; anterolateral margin with three strong spines (first two bifid and the third single); posterolateral margin serrate with small single spines; pleonal somites without median carina.

Discussion: *Llajassus* is placed within the family Scyllaridae based upon the general shape of the carapace with flattened shovel-like antennae and a lateral margin having blunt to sharp spines. The three specimens of *Llajassus* used in this study lack the morphological characters necessary to assign the new genus to a subfamily; however some characteristics of the studied specimens can be observed as they relate to the subfamilies within the family Scyllaridae. *Llajassus* has shallow cervical incisions not seen within the subfamily Ibacinae Holthuis, 1985. *Llajassus* differs from Arctidinae Holthuis, 1985 by the position and shape of cervical and postcervical incisions, they are closer, shallower and placed more posteriorly in Arctidinae. *Llajassus* is similar to Theninae Holthuis, 1985 as they both have a tapering carapace and four carinae, however, the exact position of the orbits is difficult to determine on the examined specimens of *Llajassus.* In addition, the very deep cervical groove in *Llajassus* is not seen in Theninae. *Llajassus* is similar to Scyllarinae Latreille, 1825 in carapace morphological characters; however the shape of the carapace is distinctly different: indeed in *Llajassus* the carapace is wider than long, whereas the carapace is longer than wide in Scyllarinae. Therefore, due to lack of morphological characters, *Llajassus* is not placed within a subfamily until additional specimens are made available for study.

Llajassus can be easily separated from all fossil and extant genera within Scyllaridae based upon the main morphological characters of the studied specimens, such as: a postrostral carina; four branchial carinae markedly elevated; a mesogastric region markedly elevated, with a

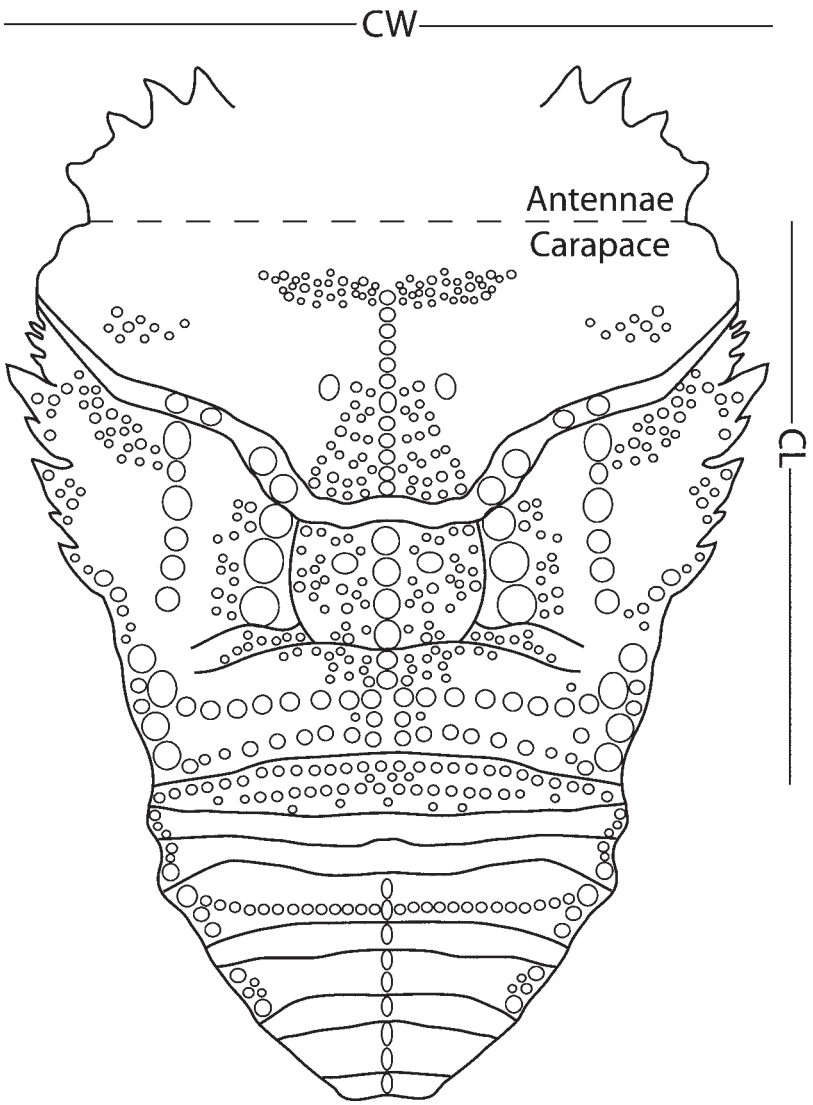

Fig. 3. Diagrammatic representation of *Llajassus caesius.*

pair of tubercles, each lateral to the postrostral carina; and a very deep cervical groove, distinctly dividing anterior portion from the median and posterior portions of carapace. Therefore, we justify the description of the new genus *Llajassus* within the Scyllaridae, with *L. caesius* (Squires, 2001).

Squires (2001) described one specimen from the Eocene of the Llajas Formation, California, assigning it to *Parribacus caesius* Squires, 2001. He assigned "provisionally" the new species to *Parribacus*, pointing out that *P. caesius* could belong to a different or new genus within the Scyllaridae. Indeed, *Llajassus* has a postrostral and branchial carinae that *Parribacus* does not have (Holthuis 1991; Chan 1998). Therefore, *P. caesius* cannot belong to this extant and fossil genus.

Llajassus is most similar to the genera *Scyllarus* Fabricius, 1775, *Palibacus* Förster, 1984, *Scyllarella* Rathbun, 1935, and *Scyllarides* Gill, 1898 in the general morphological characters of the carapace. *Llajassus* and *Scyllarus* both have a weak cervical incision; a serrate antero- and posterolateral margins; and the postrostral carina (not always present in the extant species). However, the pair of branchial carinae and the very deep cervical groove distinguish *Llajassus* from *Scyllarus.* Moreover, *Llajassus* has a carapace distinctly wider than long, whereas the carapace appears longer than wide in *Scyllarus.* Finally, the cervical groove in *Llajassus* is at least twice as deep than any other extant species within *Scyllarus. Llajassus* has a carapace distinctly wider than long, whereas in *Palibacus* the carapace is longer than wide. In addition, *Llajassus* has a

deep cervical incision, and smooth antero- and posterolateral margins not seen in *Palibacus*. *Scyllarella* lacks the prominent postrostral carina and smooth antero- and posterolateral margins seen in *Llajassus*. Finally, *Scyllarides* has a weak cervical incision similar to *Llajassus*, however, *Scyllarides* lacks a postrostral and branchial carinae.

Llajassus caesius (Squires, 2001) nov. comb.
Figs. 1-3

2001 *Parribacus caesius* Squires, pp. 21, 22, figs. 44-46.
2010 *Parribacus caesius* Squires, 2001. – Schweitzer et al., p. 47.

Holotype: LACMIP 12760 (Fig. 1b, c).

Type locality and horizon: LACMIP 40548 [= CSUN 548]; Llajas Formation, California (middle Eocene); refer to Squires (1984, 2001) for detailed locality information.

Stratigraphic range: Early – middle Eocene.

Occurrence and measurements: Holotype and two additional specimens, two from the Llajas Formation, California (LACMIP 12760, 14646) and one from the Lookingglass Formation, Oregon (UWBM 105851). LACMIP 12760 – CL: 14 mm (incomplete); CW: 18 mm (incomplete). LACMIP 14646 – CL: 8 mm (incomplete); CW: 9 mm (incomplete). UWBM 105851 – CL: 5 mm (incomplete); CW: 6 mm (incomplete).

Emended description: Anteriormost antennal segment on the right side of carapace with four very strong teeth. Carapace wider than long, granulated, dorsoventrally more or less flattened. Frontal area, poorly preserved in all specimens, with a row of small tubercles. Orbits probably near anterolateral margin. Gastric region inflated, finely granulate and crossed by the anterior portion of the postrostral carina; mesogastric region markedly elevated, with a pair of tubercles, each lateral to the anterior portion of the postrostral carina medially; anterior portion of the postrostral carina less elevated and stronger than the posterior portion of the same carina; anterior portion of the postrostral carina weakly tuberculate; posterior portion of the postrostral carina extending from the posterior margin to the cardiac region; posterior portion of the postrostral carina markedly elevated and strongly tuberculate; a pair of tubercles, each lateral to the posterior portion of the postrostral carina anteriorly. A pair of markedly elevated branchial carinae, strongly tuberculate; inner branchial carina carries four rounded tubercles stronger than those of the outer carina; inner branchial carina extending within the deep cervical groove with three rounded strong tubercles; outer branchial carina carries seven rounded tubercles. Shallow cervical incision. Deep wide cervical groove, distinctly dividing anterior portion from the median and posterior portions of carapace. Hepatic regions finely granulate. Branchial regions with strong tubercles arranged randomly. Posterior margin markedly elevated and rimmed with small and large tubercles. Anterolateral margins with three strong spines, the first two bifid and the third one single. Posterolateral margins serrate with small single spines; s1-s3 without median carina and finely tuberculate.

4. Conclusions

Parribacus caesius Squires, 2001 was described from the Eocene of the Llajas Formation, California, based upon one specimen. Two additional specimens, one from the Llajas Formation and one from the early Eocene Lookingglass Formation, Oregon, warrant a new genus *Llajassus* within the family Scyllaridae Latreille, 1825, with *L. caesius* (Squires, 2001). Although the specimen from the Lookingglass Formation is not as complete as the two specimens from the Llajas Formation, the main morphological characters exist between these specimens, namely: the carapace is wider than long; the position and size of spines along the lateral margins are the same; a postrostral carina is present; there are four branchial carinae markedly elevated; and a deep cervical groove, distinctly dividing anterior portion from the median and posterior portions of carapace exist. *Llajassus* is the only known fossil record of Scyllaridae from the Northeastern Pacific and with only three representative specimens is also rare in the associated crab faunas of the Llajas and Lookingglass formations.

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