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Terrestrial crustacean breeding trace fossils from the Cretaceous of Patagonia (Argentina): Palaeobiological and evolutionary significance

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ABSTRACT

The breeding trace fossils described herein along with the high density of *Loloichnus baqueroensis* in the Cretaceous formations of Patagonia suggest that crayfishes were soil engineers along the Cretaceous in southern South America, and that they had acquired many of the K-breeding behaviours recorded by insects in latest and post-Cretaceous soils, such as pelletal constructions and excavation of breeding cells. The K–T event was probably responsible for changes in environmental conditions in such a way that crayfishes finally became restricted to two small distributional areas in southern South America, and K-breeding insects replaced them as keystone organisms in Cainozoic and modern soils. *Dagnichnus titoi* igen. and isp. nov. and *Cellicalichnus meniscatus* isp. nov., are created to include the new trace fossils attributable to crayfishes from the Cretaceous of Patagonia, Argentina. The attribution to crayfishes is based on their association and morphological affinities with the crayfish fossil burrows *L. baqueroensis* from the same geologic units. *D. titoi* is represented by hemispherical chambers surrounded by thick and short, meniscate burrows, which can be arranged in two or three tight whorls in the more regular specimens. Meniscate burrows are curved downwards and have no neck. Walls are unlined. *C. meniscatus* are necked, horizontal, and straight cells, showing meniscate fillings, attached to sub-vertical shafts, which are relatively much wider than the neck of cells. Both, shafts and cells show a thin and smooth lining. The presence of cells or burrows smaller than the putative parental burrows and comparisons with breeding traces of marine Decapoda support the interpretation of breeding traces, Calichnia, of terrestrial crustaceans. *C. meniscatus* is interpreted as cells excavated from parental burrows, whereas *D. titoi* are probably breeding structures completely produced in a different palaeoenvironment where the female release juveniles.

1. Introduction

K-strategy, represented by adults showing parental care of offspring, is shown by ecological keystone groups of insects, such as ants, termites, bees, predatory wasps, and dung-beetles, among others. Many species of these groups nest in soils, and their trace fossils are the most common in post-Cretaceous palaeosols (Genise, 2004). Soils give the suitable support for making and provisioning cells in nests in which to lay eggs and to develop up to adults, a complex behaviour that finally allowed insects to colonize most terrestrial environments, even the most arid ones, and to achieve all their ecological importance. In parallel with insects, freshwater crayfishes are also considered keystone components of continental aquatic ecosystems (Horwitz, 1995). Brood care is rare among crustaceans, and usually eggs hatch in water where larvae and juvenile develop (Powers and Bliss, 1983). However, K-strategy cases occur particularly in terrestrial decapods, in which the female carry on her offspring until they reach the adult stage (Horwitz and Knott, 1983; Horwitz et al., 1985a; Turvey and Merrick, 1997; Rudolph 2002). Until now, reports of breeding trace fossils for crustaceans are scarce in the bibliography and in all cases involve marine examples (Verde and Martínez, 2004; Lewy and Goldring, 2006 and references therein).

Ichnological data presented herein shows that in southern South America, during the Cretaceous, terrestrial crayfishes shown some of the behaviours that K-breeding insects utilized later to become ecological keystone organisms in terrestrial ecosystems and particularly in soils. Crayfish trace fossils have been extensively described from North America (Hasiotis and Mitchell, 1993; Hasiotis and Honey, 2000 and references therein). Only recently, they have been recorded from South America (Bedatou et al., 2006, 2008), and no nesting structure has been described until now. Also recently, different breeding trace fossils, attributed to marine decapods, have been described (Curran, 1976; Verde and Martínez, 2004; Lewy and Goldring, 2006 and references therein). Abundant and diverse crayfish burrows, included in the proposed ichnotaxon *Loloichnus baqueroensis* (Bedatou et al., 2008), along with the new ichnotaxa, *Dagnichnus titoi* igen. and isp. nov. and *Cellicalichnus meniscatus* isp. nov., are outstanding individual

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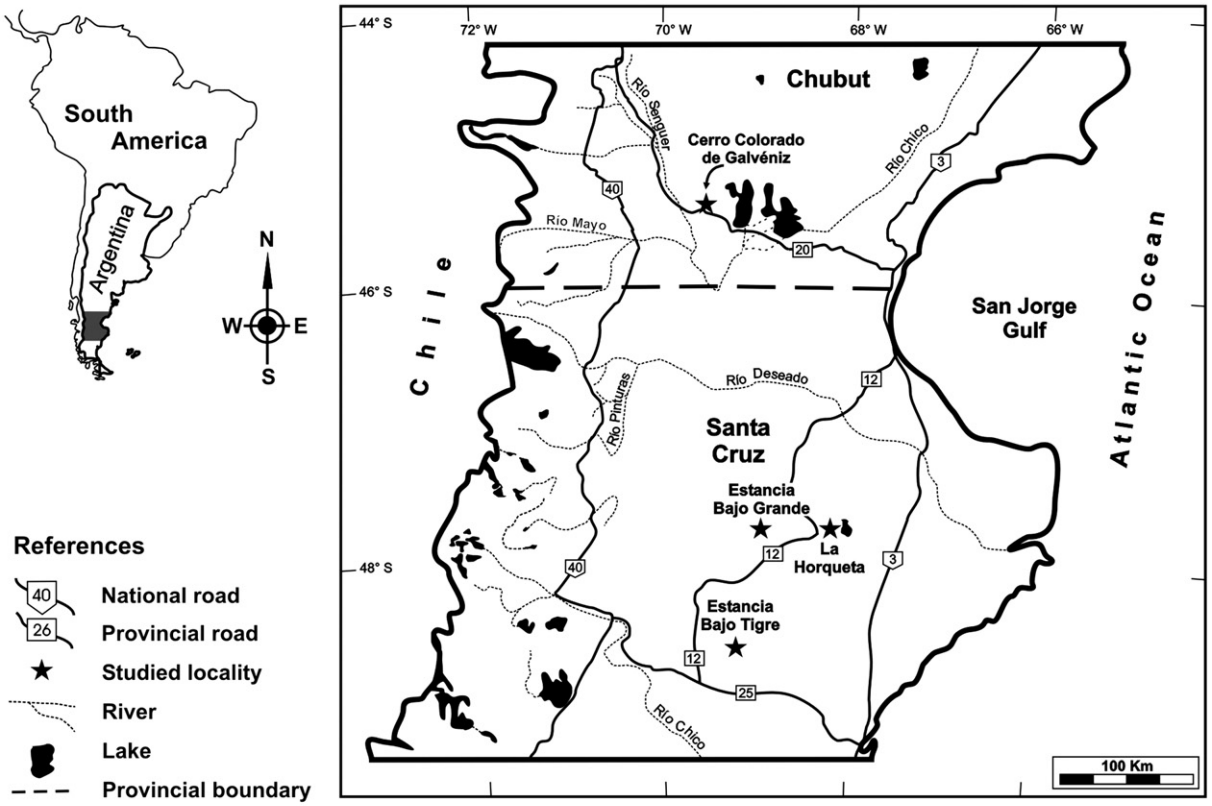
components of an ichnofabric that dominate Cretaceous palaeosols along hundreds of square kilometres in southern South America.

The objectives of this contribution are: (1) to describe for the first time breeding trace fossils from terrestrial crustaceans; (2) to provide an ichnotaxonomical treatment for them; (3) to analyze the evolutionary and palaeobiological significance of terrestrial crustacean breeding trace fossils.

2. Geological setting

The trace fossils described in this paper were recovered from three Cretaceous units of central Patagonia: the Bajo Tigre and Punta del Barco formations of the Baqueró Group and the Laguna Palacios Formation of the Chubut Group. The Baqueró Group represents Early Cretaceous (Barremian to Aptian–early Albian) (Cladera et al., 2002; Corbella, 2005) continental volcaniclastic sedimentation in the southern area of the Deseado Massif (Santa Cruz Province), whereas the Chubut Group corresponds to Late Cretaceous (Sciutto, 1981) sedimentation in lacustrine, fluvial, and pyroclastic settings in the San Jorge Basin (Chubut Province) (Fig. 1). The Bajo Tigre Formation is characterized by volcaniclastic gravity-flow deposits composed of tuffaceous breccias and massive, bioturbated tuffites, which are arranged in fining-upward cycles (Cladera et al., 2002; Bedatou et al., 2008). The Punta del Barco Formation contains lithic, massive conglomerates deposited by braided rivers, which are replaced upward by thick primary and reworked pyroclastic deposits with weakly developed palaeosols (Cladera et al.,



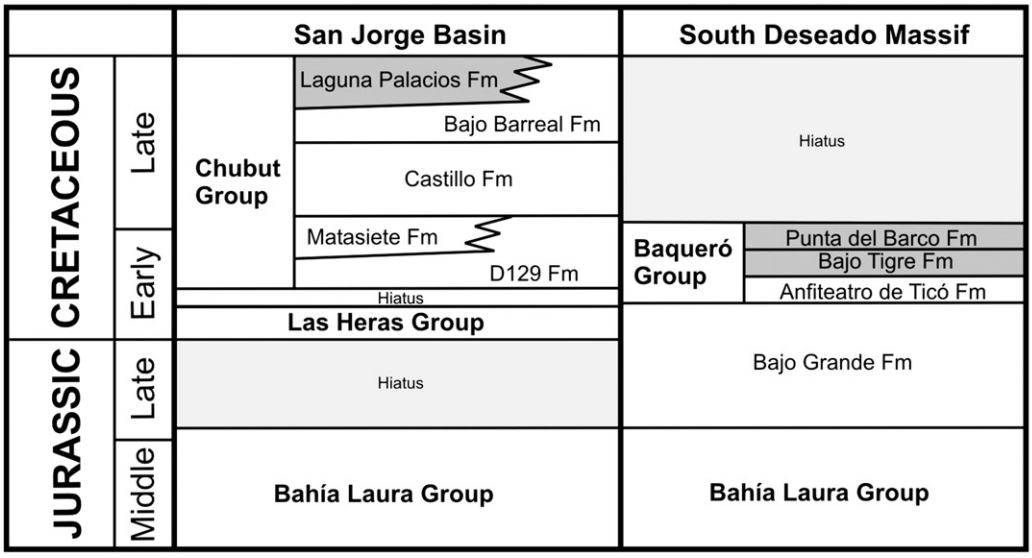


Fig. 1. Location map of studied localities (stars) and simplified stratigraphic chart of the Cretaceous continental units in the surveyed areas. Studied units in dark grey.