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Nota científica/Scientific note

TWO LATE PLEISTOCENE MEMBERS OF THE WHITE-GRUB COMPLEX, ONE OF THE MOST DESTRUCTIVE INSECT PESTS OF TURFGRASSES

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ABSTRACT – We report the record of two members of one of the most destructive insect pests of turfgrasses from the Late Pleistocene of the Pampean region. The presence of *Cyclocephala signaticollis* and *Diloboderus abderus* 12,000 years BP enables us to consider them as paleobio-indicators besides studying them as agricultural pests. This work constitutes the very first record of the genus and species, and the first Quaternary record of Dynastinae in South America. Moreover, this is one of the first paleoentomological studies that take in consideration beetles as bioproxies for the Quaternary of Argentina, and allows us to adjust the paleoclimatic inferences made for the region. This finding argues against the classic interpretations that indicate arid environmental conditions in the Pampean region during the first pulses of post-glacial climate recovery.

Key words: fossil Scarabaeidae, white-grub complex, *Diloboderus abderus*, *Cyclocephala signaticollis*, Late Pleistocene, Argentina.

INTRODUCTION

White grubs, known locally as "isocas", are the root-feeding larvae of the beetle subfamily Dynastinae Dejean, 1821 and form a complex consisting of many species belonging to several genera that are an increasingly important pest of turfgrasses, pastures and crops arround the world. This subfamily includes a cosmopolitan group of beetles; the majority of species are distributed in the tropics, especially in the Neotropics (Gasca-Álvarez & Amat-García, 2010). There are approximately 220 genera and 1500 species within the Dynastinae worldwide (Ratcliffe, 2003).

Nine species of white grubs are known from the Buenos Aires Province: *Anomala testaceipennis* Blanchard, 1856, *Archophileurus vervex* (Burmeister, 1847), *Bothynus striatellus*, Fairmaire, 1878, *Cyclocephala signaticollis*, *C. modesta* Burmeister, 18'47, *C. putrida* Burmeister, 1847, *Diloboderus abderus* Sturm, 1826, *Heterogeniates bonariensis* Ohaus, 1909, *Philochloenia bonariensis* Bruch, 1909 (Alvarado, 1980).

Cyclocephala is considered the most diverse genus of Dynastinae with about 500 described species (Ratcliffe *et al*., 2013), distributed from southeastern Canada to South Argentina and the Caribbean (Ratcliffe, 2003, 2008; Ratcliffe & Cave, 2006). Two species considered invasive were recorded from Australia and Hawaii (Carne, 1956; Jameson *et al*., 2009). Little is known about the biology of *Cyclocephala*, but it is generally observed that the adults of many species exhibit nocturnal/crepuscular habits (Ratcliffe, 2008; Riehs, 2006). They feed on pollen and flower parts, playing an important role as pollinators of tropical and subtropical plants, such as palms, Annonaceae and Araceae (Young, 1986; Gottsberger, 1989; Gibernau *et al*., 1999, 2000). Their larvae can be considered as destructive agricultural pests (Potter *et al*., 1996; Ritcher, 1966) because they feed on the root system of a wide range of agricultural crops and pastures, sometimes in partnership with other Scarabaeidae phytophagous larvae considered harmful (*e.g*. *Anomala*, *Archophileurus*, *Bothynus*, *Diloboderus*, *Heterogeniates*, *Phylochloenia*, *Phylophaga,* etc).

Cyclocephala signaticollis is native to Argentina and Uruguay and its distribution includes Buenos Aires, east of Córdoba, south of Santa Fe, Entre Ríos and northeast of La Pampa (Remedi de Gavotto, 1964). It feeds on roots of pastures and crops, being one of the most harmful species of white grubs (Remedi de Gavotto, 1964; Alvarado, 1980).

Diloboderus is a monospecific genus belonging to the tribe Pentodontini. Its only species, *D. abderus*, can be found in Argentina, Uruguay and Brazil, although its distribution is not accurately known. Adults usually do not feed. The larvae, on the contrary, are voracious and live hidden in galleries less than 20 cm deep. This species is considered a pest because of the damage they cause in natural pastures and various crops.

Only seven fossil insects have been assigned to Dynastinae, six of them were described between 1862 and 1914 (Heer, 1862; Heyden & Heyden, 1866; Weyenbergh, 1869; Wickham, 1911, 1914). The more recent correspond to the oldest one, *Oryctoantiquus borealis*, found in deposits from the Middle Eocene of Oregon, USA (Ratcliffe *et al*., 2005). Probably all of extant genera were established by the Miocene (Howden, 1966), and extant species are not older

than the Pleistocene (Crowson, 1981), although Coope (1979) suggested that some species extend back to the late Tertiary.

Upper Pleistocene outcrops exposed in Buenos Aires Province, Argentina, represent one of the most informative sources for paleoecological studies on South American fauna and flora. Several proxies were utilized for the study of Pleistocene environmental conditions in the Pampean region (Scanferla *et al*., 2013 and the references therein). However, only a few studies were based on paleoentomological data (*e.g.* Ramírez, 2015; Ramírez & Alonso, 2014; Petrulevičius *et al*., 2012).

The aim of this study is to present the first fossil record of two members of the white-grub complex from the Late Pleistocene of Buenos Aires Province, and to provide new data on the paleoenvironmental conditions prevailing in the region.

MATERIAL AND METHODS

We followed the extraction and concentration techniques described by Elias (1994). However, we opted for an alternative to kerosene flotation, the most commonly used method. Before treating the sediments with deflocculant (calgon), we checked the clay blocks looking for conspicuous pieces of insects. Once disaggregated, we avoided sieving and checked all the material under the microscope. This method allows recovering fragments of heavy non-floating insects and prevents damage of the material during sieving and detergent washing. Moreover, the material remains suitable for radiocarbon dating. The remains were stored in small vials with 70% ethanol. Measurements were taken using a filar micrometer as follows: pronotal length, straight from anterior to posterior margin along midline; pronotal width, across the widest point; elytral length, across the middle line; elytral width, across the widest point. The fossil specimens were identified by comparison with modern specimens from the author's personal collection, and using published identification keys (Gasca-Álvarez & Amat-García, 2010; Ratcliffe, 2007).

The type-locality is near La Chumbiada, about 30 km east from General Belgrano City, 35°44'47''S, 58°45'49''W, Buenos Aires Province, Argentina (Figure 1). Both specimens are deposited in the Museo Histórico Municipal "Alfredo Enrique Mulgura" of General Belgrano City (**MHM**).

Geological settings. The fossiliferous strata consist of greenish brown sandy clays deposited in a small paleopond environment that was filled by fluvial sediments, exhibiting abundant organic matter, gypsum and carbonate concretions (Scanferla *et al*., 2013). The age of the sediments containing fossil insects could be constrained between 12,100 ± 100 ^{14}C BP and 13,400 ± 200 ^{14}C BP and was obtained by radiocarbon analysis of bone collagen (Scanferla *et al*., 2013) and molluscan

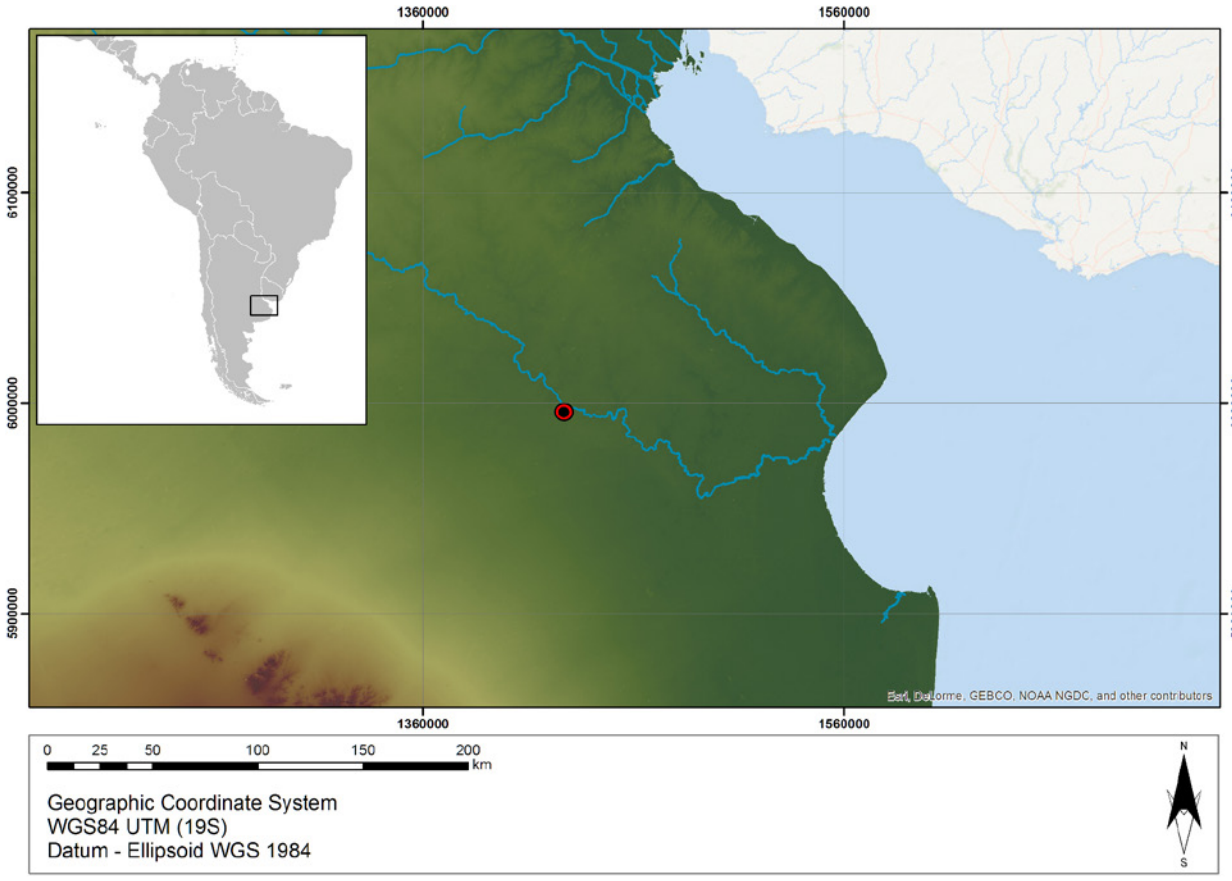

Figure 1. Location of the General Belgrano site, Buenos Aires Province, Argentina.

shells (Fucks *et al*., 2012). These deposits correspond to the time span represented by the Guerrero Member of the Luján Formation (Fidalgo *et al*., 1973). The deposition of the Guerrero Member began around the Last Glacial Maximum (ca. 21,000 yrs. BP) and continued at least until ca. 10,000 yrs. BP (Tonni *et al*., 2003).

On the exposed sediments, from the base to the top, four sedimentary units are recognized (Figure 2). A total of 476 specimens were recovered from the units 2 and 3. Most of the remains came from the dark deposits of level 3. Due to the preservation of specific characters observable in the remains we recognized the two species in which this work make focus.

SYSTEMATIC PALEONTOLOGY

Order COLEOPTERA Linnaeus, 1758
Suborder POLYPHAGA Emery, 1886
Superfamily SCARABAEOIDEA Latreille, 1802
Family SCARABAEIDAE Latreille, 1802
Subfamily DYNASTINAE Dejean, 1821

Cyclocephala Dejean, 1821

Cyclocephala signaticollis Burmeister, 1847
(Figures 3A-B)

Description. The fossil consists of a pronotum and left elytron of an adult. The pronotum is 3,11 mm long and 6,32 mm wide, and the left elytron is 7,85 mm long and 3,76 mm wide. The dorsal surface of both structures is smooth, glabrous, moderately convex, and light brown to brownish-beige. The pronotum bear complex, bilaterally symetrical, dark brown markings and shallow irregular punctation (Figure 1A), which allowed us to identify the remains to species level. Sexual dimorphism in this species is evidenced in the shape of the anterior claws, the hind tibial spurs, and the antennal club, therefore it was not possible to determinate the sex of the specimen.
Label. "*Cyclocephala signaticollis* MHM-PI 24/Col. Ramírez, L.C. 2013".

Subfamily DYNASTINAE Dejean, 1821

Diloboderus Reiche, 1859

Diloboderus abderus Sturm, 1826
(Figures 4A-B)

Description. The fossil consists of a cephalic frontal horn of a male and the protoracic right tibiae and femur. The horn length is 17.49 mm, the tibiae length is 7.59 mm, and the femur is fragmented. The surface of the structures is smooth, glabrous, and black to brownish-black. It was possible to determinate the sex of the specimen, since sexual dimorphism in this species is shown by the presence of the cephalic frontal horn.
Label. "*Diloboderus abderus* MHM-PI 25/Col. Ramírez, L.C. 2013".

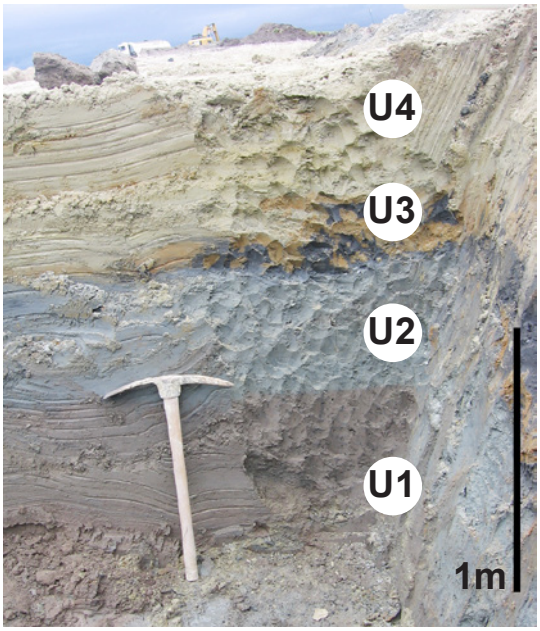

Figure 2. Sedimentary units recognized in the General Belgrano outcrop.

Figure 3. *Cyclocephala signaticollis* MHM–PI 24. **A**, pronotum; **B**, left elytron. Scale bar = 5 mm.

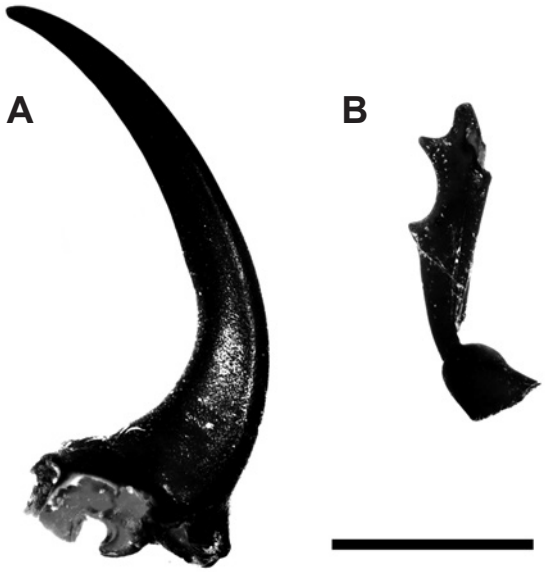

Figure 4. *Diloboderus abderus* MHM–PI 25. **A**, cephalic frontal horn; **B**, protoraxic right tibiae and femur. Scale bar = 5 mm.

DISCUSSION

Historically, the white grubs have been studied in order to achieve its effective biological control (*e.g.* Castelo & Capurro, 2000; Castelo & Corley, 2004). This study documents the presence of these two members of the white-grub complex 12,000 years BP and enables us to consider them as paleobio-indicators besides studying them as agricultural pests.

Current distribution of the species occupies much of the Argentinean territory. It is regularly collected in grasslands at shallow depths (larvae) in Buenos Aires Province, and it is very common to find adults flying into the lights at night (pers. obs.). The climate of the Pampas grassland where these species live is temperate, characterized by an east–west moisture gradient and increasing continentality toward the northwest (Burgos, 1968). This area can be classified as subhumid-humid in the east, with a NE humid border, and as subhumid-dry in the west, with a southern semi-arid border (Burgos & Vidal, 1951).

The presence of two species of white grubs and the large amount of rhizoconcretions in the studied deposits suggests a subhumid-humid climate and a mean annual precipitation close to modern levels, or higher water availability. Pasture grasses that support the white grubs are compatible with the development of the megafauna studied and discussed by many authors (*e.g.* Scanferla *et al*., 2013 and references therein), and does not reflect an arid climate.

The preservation of the original colors of the remains provides further information about the depositional environment; it could have been anoxic or hypoxic with very low energy.

Data discussed herein clashes with previous interpretations that indicate arid environmental conditions in the Pampas during the deposition of the Guerrero Member of the Luján Formation (ca. 21,000–13,000 yrs. BP) (Clapperton, 1993; Tonello & Prieto, 2010). Probably, the prevailing climatic conditions during the deposition of the paleopond sediments have been similar to those presently found. Current climate in the studied area is humid temperate with annual mean temperatures of 23°C in the hottest month (January) and 10°C in the coldest month (July) (National Weather Service, climate statistics, from 1951 to 2000). This could represent one of the first pulses of post-glacial climate recovery and the establishment of an insect fauna similar to that currently found in these environments.

This study is one of the first approaches to the Quaternary paleoentomology of Argentina, and highlights the potential of paleoentomological information, when evaluated in combination with previous knowledge on global climate conditions after the last glacial maximum.

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