

Fossil records and palaeoenvironmental implications of *Chloephaga picta* (GMELIN, 1789) (Magellan Goose) and *Cariama cristata* (LINNAEUS, 1766) (Seriema) from the Late Pleistocene of Uruguay

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With 2 figures

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Abstract: The first fossil records of the anseriform *Chloephaga picta* (Magellan Goose) and the gruiform *Cariama cristata* (Seriema) are described from the Sopas Formation (Late Pleistocene, northern Uruguay). According to the modern requirements of *Chloephaga picta*, its presence in the Sopas Formation would indicate: 1) a seasonal climate and 2) temperatures likely lower than those previously reported based on mammals. It could have occurred in response to rapid and short climatic changes with a drop of temperature not revealed by mammals. *Cariama cristata* is more euryoic than *Chloephaga picta* and suggests open woodlands, savannas and hilly grasslands with nearby woods coincident with the presence of some mammals also recorded from the Sopas Formation.

Zusammenfassung: Die ersten Fossilnachweise der Magellangans (*Chloephaga picta*) und der Seriema (*Cariama cristata*) werden aus der Sopas-Formation (Spät-Pleistozän, N Uruguay) beschrieben. Nach den rezenten Ansprüchen von *Chloephaga picta* würde ihr Nachweis auf ein saisonales Klima und niedrigere Temperaturen schließen lassen, als es bisher aus Säugerfunden gefolgert wurde. Dies könnte mit kurzfristigen Klimaschwankungen und Temperaturniedrigungen zu tun haben, die nicht durch Säuger belegt sind. *Cariama cristata* ist stärker euryök geprägt als *Chloephaga picta*; ihr Vorkommen deutet auf offene Wälder, Savannen und hügeliges Grasland mit nahen Wäldern, entsprechend dem Vorkommen einiger Säugertiere in der Sopas-Formation.

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1. Introduction

The Late Pleistocene Sopas Formation is a rich fossil deposit that crops out in northern Uruguay (UBILLA 1996, UBILLA & PEREA 1999). It has yielded a diverse Pleistocene fossil assemblage that includes vertebrates, mollusks, ichnofossils and plants (UBILLA et al. 2004). The vertebrates of the Sopas Formation are indicative of diverse environments (fluvial and lacustrine habitats, grasslands, wooded open areas and riparian forest) that could be related to the existence of a great ecotonic system (transitional zone between two different ecosystems) with influence of “Brazilian” forms existing in the region during the Late Pleistocene (UBILLA 1996).

The mammalian Sopas Formation assemblage suggests temperatures similar, or higher, than present day ones, and a warmer climate than that of the typical Lujanian association known from the Guerrero member of the Luján Formation, Buenos Aires Province (Lujanian Stage – Late Pleistocene – sensu CIONE & TONNI 1999). The association includes taxa such as the Brazilian tapir (*Tapirus terrestris*), a marsh rat (*Lundomys molitor*), nine-banded armadillo (*Dasypus novemcinctus*), and american porcupines (Erethizontidae) whose southern distributions are known to be constrained by the isotherms of 8° and 15° C in July and 22° to 25° C in January (UBILLA 1996, and references therein).

Fossil avian remains are helpful tools in paleoenvironmental reconstruction when extant species with well-known ecological requirements are recorded (TAMBUSSI & ACOSTA HOSPITALECHE 2002). This is especially the case because many South American mammalian taxa do not have living descendants to use as analogues. Two avian remains assignable to Anseriformes (screamers, ducks, and swans) and Gruiformes (rails, cranes, etc.) are included in the vertebrate collection excavated from the Late Pleistocene sediments of northern Uruguay (Malo and La California creeks, Tacuarembó department), mentioned by UBILLA & PEREA (1999). Here we provide a description of these materials and highlight their biogeographic and climatic significance in order to contribute to paleoenvironmental and paleoclimatic reconstructions of Late Pleistocene northern Uruguay.

2. Materials and methods

The fossil material belongs to the collection of the Museo de Geociencias de Tacuarembó (MGT), Uruguay. The skeletons used for comparisons are housed in the Colección Osteológica de Aves Actuales of the División Paleontología Vertebrados (PV-OR) of the Museo de La Plata (MLP), Argentina. Anatomical terminology is after BAUMEL & WITMER (1993). We follow the systematic criterion used by CARBONERAS (1992) in the case of the Anseriformes and that used by GONZAGA (1996) for the Gruiformes. Climatic data we use (precipitations, temperatures) are those published by the National Meteorological Service of Argentina between 1901 and 1970 (ESTADÍSTICAS CLIMATOLÓGICAS 1901-1950, 1951-1960, 1961-1970) and NATIONAL METEOROLOGICAL SERVICE OF URUGUAY, NMSU (1990 to 1999).

Our climatic classification is based on the hydric indexes of THORNTHWAITE (1948) that express the distribution of hydric and thermal effectiveness, based on hydric balances, temperatures and light-day durations. A negative index corresponds to an arid climate whereas a positive index corresponds to a humid climate (BURGOS & VIDAL 1951).

3. Geological and biostratigraphic setting

The Sopas Formation crops out in northern Uruguay, and in places is up to 10 m high in section. According to UBILLA & PEREA (1999) and UBILLA et al. (2004), the Formation is characterized by conglomerates with a muddy matrix (paraconglomerates), thin to fine coarse grained sandstones with a silty matrix, mudstones and wackes. Carbonate is very frequent as dust, concretions and pedogenic calcretes. In general, this unit has a predominantly brownish colour and unconformably overlies Mesozoic beds (Arapey and Tacuarembó formations).

Mammalian biostratigraphic criteria allow us to correlate the mammalian assemblage of the Sopas Formation to the Lujanian Stage/Age (Late Pleistocene-Early Holocene) of Buenos Aires province (UBILLA et al. 2004, UBILLA 2004a,b). These Late Pleistocene sediments of northern Uruguay show differences from those of the Guerrero Member of the Luján Formation (Buenos Aires Province, Argentina) which has yielded typical "Lujanian" faunas and is also associated with the Last Glacial Maximum. Radiocarbon ages of the Guerrero Member range from ^{14}C 21 to 10 kyrs BP (TONNI et al. 2003). UBILLA (1996) and UBILLA & PEREA (1999) provide ^{14}C ages of >43 and >45 kyrs BP (considered to be minimum ages) for the Sopas Formation, based on wood and fresh water mollusk shell samples. A discussion of the available ^{14}C ages for this unit is given by UBILLA (2001). Two TL/OSL (thermoluminescence and optically stimulated luminescence) ages for Malo

creek (Tacuarembó department) are also available: 58,3 +/- 7,4 and 200 +/- 25 kyrs BP, respectively (UBILLA 2004b, UBILLA et al. 2004).

4. Results

Analysis of the fossil avian samples found in the Sopas Formation demonstrates the presence of two living species. One complete right femur (MGT N° 804, Fig. 1B) from Malo creek, near Curtina town (Tacuarembó Department, 32°03' S, 56°07' W) (Fig. 2), excavated from a fluvial sandy-conglomerate of the Sopas Formation, is assigned to *Chloephaga picta* (GMELIN, 1789) (Anseriformes, Anatidae). This element has moderate craniocaudal curvature of the corpus femoris, scarce widening of both epiphysis; an almost straight angle between the caput femoris and the diaphysis, a conspicuous facies articularis acetabularis; deep fossa trochanteris; well marked impressiones obturatoriae on the diaphysis surface, and well developed tuberculum muscularis gastrocnemialis lateralis.

The second specimen, a fragment of a left distal tarsometatarsus (MGT-724), is assignable to *Cariama cristata* (Gruiformes, Cariamidae) (Fig. 1C). It was excavated from La California creek (Tacuarembó Department, 31°30' S, 65°00' W) (Fig. 2) and was found in the siltstones and sandy-siltstones of the Sopas Formation. This specimen has a trochlea metatarsi III that is more extended distally than the other trochleae; a rounded trochlea metatarsi II, that originates more proximally than trochlea IV, both trochleae extent to a similar distal level; the incisura intertrochlearis lateralis is wider than the incisura intertrochlearis medialis; the foramen vasculare distale is extended.

Onto the distribution map of *Chloephaga picta* and *Cariama cristata* we overlaid the January and July isotherms and the mean annual precipitations for Uruguay (Figure 2). This procedure enabled us to establish that the present northernmost range of *Chloephaga picta* is constrained by the 21.3°C January isotherm and 7.1°C July isotherm. It should be pointed out that the recent distribution of species of *Chloephaga* does not include Uruguay but reaches its eastern limit in Buenos Aires Province, Argentina

Fig. 1. *Chloephaga picta*, femur in anterior view: **A** – Recent specimen PV-OR 87; **B** – fossil remain MGT-804. *Cariama cristata*, tarsometatarsus in anterior view: **C** – fossil remain MGT-224; **D** – Recent specimen PV-OR 533. Scale bar: 10 mm.

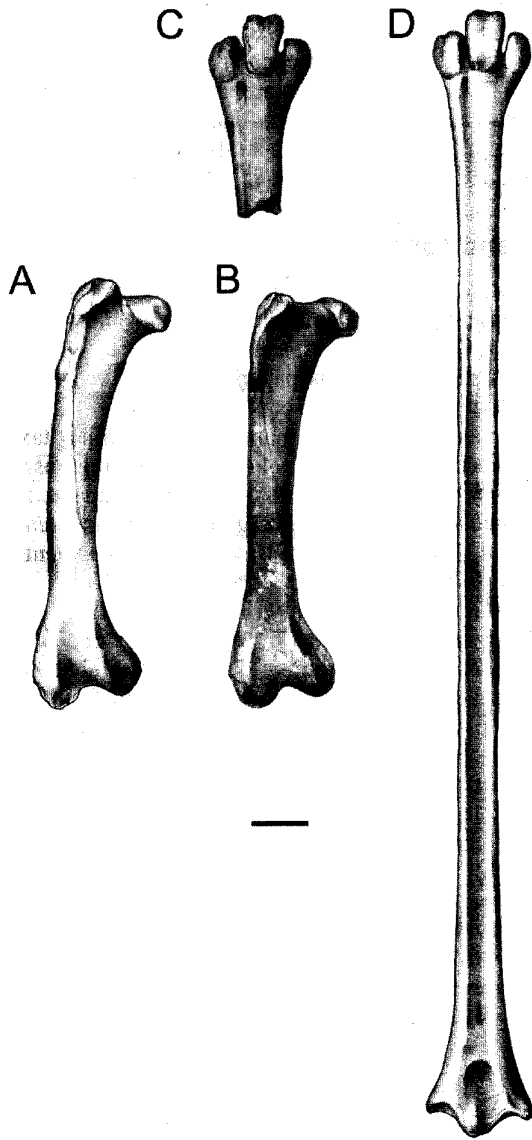


Fig. 1 (Legend see p. 260)

(*Chloephaga picta* exceptionally reaches the south-west and south-east coast of Uruguay) (ARBALLO & CRAVINO 1999, DE LA PEÑA & RUMBOLL 1998). At the northern most limit of the recent distribution of *Chloephaga picta* (nearly 37°S), the environment is characterized by annual precipitations not greater than 800 mm and a hydric index of 10. Consequently, the higher limit of hydric tolerance of the species corresponds to a humid-subhumid climate (BURGOS & VIDAL 1951).

5. Discussion and conclusions

Pleistocene vertebrate faunas have bearing a number of issues, such as (1) the time of their onset, (2) megafaunal extinctions, (3) non-analogue assemblages (see below), (4) paleoclimates, and (5) changes on their distributions. The avian remains analyzed in this paper are directly related to issues 3, 4 and 5, which will be treated in this section.

The Sopas Formation includes remains of mammalian taxa typical of tropical to subtropical areas and tropical to temperate regions such *Tapirus* (tapir) and *Lundomys* (marsh rat), along with taxa adapted to arid and semiarid environments such *Microcavia* (guinea pig) and *Reithrodon* (field mice) (UBILLA et al. 1999). However, *Microcavia* is represented by an extinct species, *M. criolloensis* (UBILLA et al. 1999), which could have had different ecological requirements than its recent counterparts. Fossil assemblages that contain taxa that would be considered “ecologically incompatible” today, are known as “disharmonious” or “non-analogue”. This is characteristic of several Pleistocene sites (see LUNDELIUS et al. 1983, GRAHAM et al. 1996). In the Sopas Formation, such a non-analogous association could be related to the presence of mixed vegetation, mixed environments or even alternating seasonality. The information provided by the mammalian assemblage alone allows us to tie the Sopas Formation to a climatic period of similar, or higher, temperatures and humidity to those registered around 32°S today (UBILLA & PEREA 1999). Nowadays, the area of Tacuarembó Department (Uruguay) is characterized by temperatures of 23,3°C for January and 11,3°C for July, and annual precipitations of 950 mm (NMSU 1990-1999).

South American endemic geese of the genus *Chloephaga* EYTON, 1838 are medium sized migratory continental birds. They frequent dry pastures and are not necessarily associated to water except during their breeding periods. *Chloephaga* includes five living species: *C. picta* (GMELIN, 1789); *C. rubidiceps* SCLATER, 1861, *C. poliocephala* SCLATER, 1857, *C. melanoptera* (EYTON, 1838) and *C. hybrida* (MOLINA, 1782). The first three species migrate during the austral winter (from April to August) from southern Argentina to southern and eastern Buenos Aires Province (Bahía Blanca and

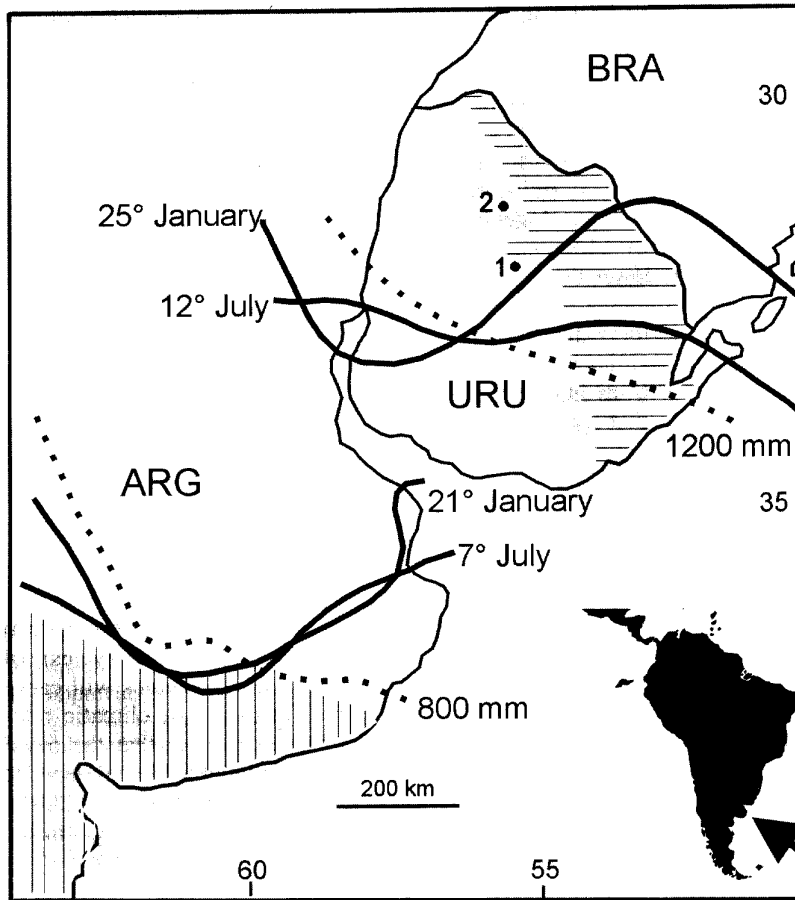


Fig. 2. Map of southern Brazil (BRA), central Argentina (ARG) and Uruguay (URU) with recent distribution of *Chloephaga picta* in Argentina (vertical lines) and *Cariama cristata* in Uruguay (horizontal lines). Dots indicate localities where the specimens reported herein were found (1) *Chloephaga picta*, Malo Creek (Tacuarembó department), (2) *Cariama cristata*, La California Creek (Tacuarembó department). January and July isotherms (in °C), and mean annual precipitations (in mm) are indicated (modified from HOFFMAN 1975).

General Lavalle), La Pampa Province and Río Negro Province (Argentina). Their migration is strongly influenced by climatic factors (MARTÍN 1984). The fossil record for this genus is restricted to an indeterminate species from the Paso de Otero locality (Late Pleistocene, TONNI & LAZA 1980), *C. picta* from Sauce Grande Valley (Late Pleistocene, DESCHAMPS & BORROMEI 1992) and *C. robusta* TAMBUSI, 1998, found in Cascada Grande, Quequén Salado River (Middle and Late Pliocene, TAMBUSI 1998) all of them of Buenos Aires Province, Argentina.

Occurrence of *Chloephaga picta* indicates that temperatures in January and July were lower than those that UBILLA & PEREA (1999) suggested for the same area based on fossil mammals. This could indicate that this species had a more northern distribution during the late Pleistocene in Uruguay than today, which implies a very different climatic regime in the area with cold and arid conditions at least similar to that of northern part of Patagonia (Argentina) or that some error is associated to the use of fossils for palaeotemperatures estimation. Nevertheless, as *Chloephaga picta* is migratory, its presence in the late Pleistocene of Uruguay could be interpreted merely as an evidence of a displacement of the northern limit of its migratory process.

On the other hand, the presence of this species in northern Uruguay in the late Pleistocene could have been caused by rapid changes of climate; strong and rapid cooling that are events undetected by the mammalian record. It is accepted that short and high amplitude climatic changes occurred in glacial and interglacial periods (Dansgaard-Oeschger or "flickers" cycles) of millennial scale (ROY et al. 1996). These geographical changes will cause responses in biotas, which could explain the formation of climatic non-analogue assemblages. Incidentally, it is important to note that the fossil remains of *Chloephaga* were deposited in fluvial sediments. Fluvial deposits could be usually affected by time averaging (UBILLA & LORENZO 2001), which implies the existence of temporal mixing of skeletal elements in the fossiliferous association. In fact, there are estimated limits on time averaging of fluvial attritional vertebrate assemblages ranging from 10 years to 100 kyrs (BEHRENSMEYER et al. 2000). Even though a measure of this process on the outcrop is not available, there is no reason to reject some influence on the observed pattern. In a preliminary taphonomic study, UBILLA & LORENZO (2001) state that there is a low incidence of time-averaging at this place according to available information. Finally, based on the ecological requirement of *C. picta*, the record of this avian species at the late Pleistocene of Uruguay indicates a well-defined seasonally climatic regime.

The endemic South American Cariamidae live in open woodlands, thorny scrub savannah and ranchland with moderate to tropical climate (GONZAGA 1996). They nest in trees and only occasionally fly. They are represented by two living species of running birds: *Cariama cristata* (LINNAEUS, 1766)

that is distributed in central and eastern Brazil, eastern Bolivia, northern Paraguay, north, east and central Uruguay and central Argentina, while *Chunga burmeisteri* (HARTLAUB, 1860) occurs in southern and southeastern Bolivia, western Paraguay and central Argentina (GONZAGA 1996) (Fig 2). *Chunga* includes a single extinct species, *Chunga incerta* from Monte Hermoso, Buenos Aires Province (Middle-Late Pliocene, TONNI 1974). The neospecies are represented in the Quaternary of Brazil and Argentina (BRODKORB 1967). Up to date, no fossil Cariaminae has ever been recorded in Uruguay.

As stated above, *Cariama cristata* occurs in the area today and does not appear to be a climate indicative. However, it should be pointed out that this species reveals the presence of open woodlands, savannas and also hilly grasslands with nearby woods and this is coincident with the presence of fossil mammals adapted to this kind of habitats such as the deer *Ozotoceros bezoarticus*, the cavies *Cavia* sp. and *Galea* sp. and the grassland fox *Dusicyon gymnocercus* in the same unit (UBILLA & PEREA 1999, UBILLA & RINDERKNECHT 2001). So, we can point out that the record of *Cariama cristata* shows that seriemas could have remained in essentially the same type of habitat since the Late Pleistocene.

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