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SHORT COMMUNICATION

Mid-Holocene skua remains from King George Island, Antarctica

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Abstract Seven avian remains from Mid-Holocene strata of the southeastern coast of Potter Peninsula (King George Island: Isla 25 de Mayo, South Shetland Islands, Antarctica) are reported. They were described and assigned to the brown skua *Stercorarius antarcticus lonnbergi* (Aves, Laridae), a living species currently breeding in the area. The presence of penguins in the same sequence is in agreement with the current dynamics of the coastal ecosystems of Antarctica. Nowadays, penguins and skuas frequent these same environments.

Keywords Skuas · Laridae · Mid-Holocene · South Shetland Islands · Antarctica

Kurzfassung Aus dem mittleren Holozän der südöstlichen Küste der Potter-Halbinsel (King George Island: Isla 25 de Mayo, South Shetland Islands, Antarktis) werden sieben Rippen beschrieben, die dem Braunen Skua *Stercorarius antarcticus lonnbergi* (Aves, Laridae) zugeordnet werden. Diese Art kommt auch heute noch in der Region vor. Das gemeinsame Vorkommen von Pinguinen in der selben Fundschicht steht im Einklang mit der derzeitigen Dynamik der Ökosysteme der antarktischen Küsten. Heute leben auch noch Pinguine und Raubmöwen in derselben Umgebungen.

Schlüsselwörter Raubmöwen · Laridae · Mid Holozän · Süd-Shetland-Inseln · Antarktis

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Introduction

Skuas are marine birds related to gulls, waders, auks, and skimmers (Charadriiformes, Laridae). They have been classically divided into two genera; the smaller species were assigned to *Stercorarius* Brisson 1760, while the larger species were placed in *Catharacta* Brünnich 1764. Proposals based on genetic studies have included all species in the genus *Stercorarius* (Cohen et al. 1997; Andersson 1973, 1999). The latter systematic arrangement is followed here.

The fossil record of skuas (Aves, Laridae) is scant; only isolated remains have been found (mainly in Europe). A tarsometatarsus of *Stercorarius pomarinus* was found in the Upper Pleistocene of Spain (Sánchez Marco 2006). Remains of this species have also been reported in the Upper Pleistocene of the northern coast of Italy (Cassoli 1980) and the Middle Pleistocene of France (a tarsometatarsus of fossil subspecies *Stercorarius pomarinus philippi*, Mourer-Chauviré 1975).

Besides the above-mentioned records, at least three different species of jaegers and one of skua were recognized in Lee Creek Mine (North Caroline, USA), assigned

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probably to Yorktown Formation (Early Pliocene; Olson and Rasmussen 2001). The first one was identified as *Stercorarius aff. pomarinus*, and it is is represented by two fragmentary humeri, an ulna, and a coracoid very similar to those of living species. Also, an isolated coracoid from the Pliocene of Florida (USA) was assigned to an undescribed species of *Stercorarius*, slightly larger than *S. pomarinus* (Emslie 1995). The second species was identified as *Stercorarius aff. parasiticus* (two incomplete humeri and a carpometacarpus). The last species of jaeger is *Stercorarius aff. longicaudus*, represented by two humeral epiphyses and a carpometacarpus. The remains assigned to *Catharacta* are a fragmentary ulna, two carpometacarpi, and two tarsometatarsi, the first mention for the Northern Hemisphere (Olson and Rasmussen 2001).

The only extinct species is *Stercorarius shufeldti* Howard 1946, slightly smaller than *Catharacta*, from the Middle Pleistocene of Oregon, USA (Howard 1946). An ulna, a carpometacarpus, and three tarsometatarsi probably assignable to *C. skua hamiltoni* were described from Amsterdam Island (Indian Ocean). Although no radiocarbon datings were made, Worthy and Jouventin (1999) estimated the age at between a few hundred and a few thousand years old. In addition, *Stercorarius skua* was found in levels of the Holocene Nerja cave (Tyrberg and Hernández 1995).

Others fossils of *Stercorarius* correspond to the Miocene and Pliocene of North Carolina, USA and the middle Holocene from the South Shetland Islands, Antarctica (Olson and Rasmussen 2001; del Valle et al. 2002). Finally, some Holocene remains from New Zealand (North and South Islands, Chatham Island) assigned to *Catharacta skua lonnbergi* (=*Stercorarius antarcticus lonnbergi*) were mentioned by Fordyce (1982) and compiled by Turbott (1990) and Millener (1991, 1999) and bibliography cited therein.

In this context, the goal of the present contribution is the study of new Holocene remains assigned to skuas found in the South Shetland Islands, Antarctica, including their systematic assignment and the descriptions of these bones. Additionally, some other comments concerning the geological and geographical context are made.

Materials and methods

Almost 3 m thick of fossiliferous sediments were excavated and bones were manually collected. Penguin bones were ^{14}C-dated at Weizmann Institute of Science, Rehovot (Israel). Recovered skua remains were measured and described following the terminology of Baumel (1993). Because the species are quite homogeneous concerning their qualitative characters, measurements have often been used in systematics (Worthy and Jouventin 1999; Acosta Hospitaleche et al. 2009). We determined the remains according to Remsen et al. (2009).

The study area

The Pingfo I locality (62°15′26.483″S, 58°37′08.530″W, 17.3 m a.s.l.) is located on the southeastern coast of Potter Peninsula, King George Island (Isla 25 de Mayo), South Shetland Islands, Antarctica (Fig. 1). It is within the Potter Peninsula Antarctic Specially Protected Area (ASPA 132).

The exposed depositional sequence shows a monotonous succession of sedimentary facies with high degree of conformity. It includes skuas, penguins, marine mammals, and seaweed, distributed in seven beds between 14.7 and 16.7 m a.s.l. Combined with the taphonomy of the fossil remains, it allows us to establish that bed 1 bearing skuas is older in geological terms than beds 3 and 5 from where radiocarbon-dated penguins were exhumed (Fig. 2). Reservoir correction ages are ca. 4540 and 4450 years BP for beds 3 and 5, respectively (see del Valle et al. 2002).

Bird remains recovered from these beds are complete, non-reworked, and free from erosion. They were probably accumulated in a marine beach environment without significant transport (del Valle et al. 2002). The taphonomical analysis of the remains suggests that bodies from a nearby breeding colony were deposited during mid-Holocene times (Montalti et al. 2009).

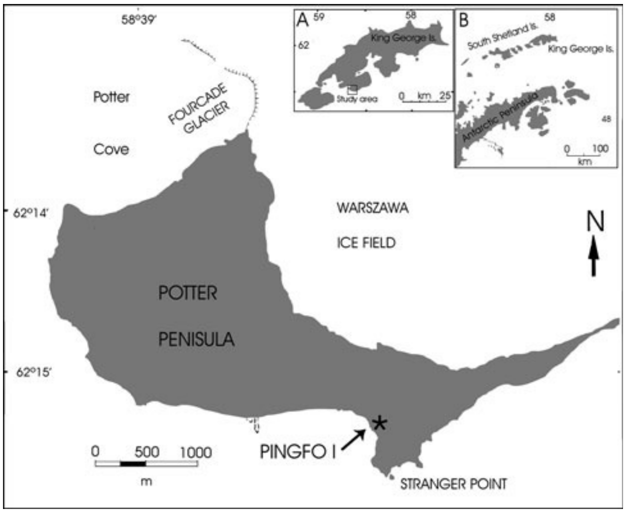

Fig. 1 Location map showing the Pingfo I locality, southeastern coast of Potter Peninsula (King George Island, South Shetland Islands, Antarctica)

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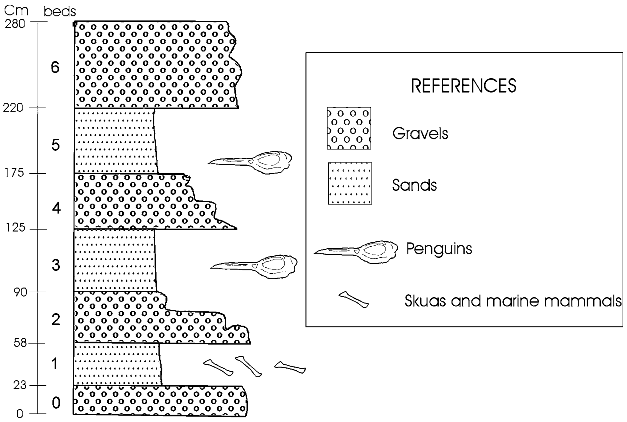


Fig. 2 Sedimentary sequence exposed at Pingfo I locality, Potter Peninsula (King George Island, South Shetlands Islands, Antarctica)

Systematic paleontology

Family Laridae Rafinesque, 1815
Genus *Stercorarius* Brisson, 1760
Species *Stercorarius antarcticus* Lesson, 1831
Subspecies *Stercorarius antarcticus lonnbergi* Mathews, 1912

Assigned materials

Femur (IAA 797), humerus (IAA 798), incomplete tibiotarsus (IAA 800), tarsometatarsus (IAA 799), carpometacarpus (IAA 801), mandible (IAA 802), pelvis (IAA 803).

Description

The mandible (Fig. 3a, b) is complete, and both rami mandibulae are articulated. A lateral deformation was caused during taphonomic processes (Fig. 3a, b). The processus mandibulae medialis is robust, and the processi mandibulae lateralis are small. The fenestra mandibularis cranialis is open, while the fenestra mandibularis caudalis is completely obliterated.

The humerus (Fig. 3c, d) has a subtriangular fossa pneumotricipitalis, and it is surrounded by a conspicuous tuberculum ventrale. Both crus dorsale fossae and crus ventrale fossae are well developed. The tuberculum dorsale is elongated and small. The crista deltopectoralis is widely expanded and its sharpened distal end projects cranially.

The processus supracondylaris dorsalis projects cranially and proximally. The epicondylus ventralis is rounded and slightly marked.

The sulcus humerotricipitalis is wide and connects to the fossa olecrani. The impression coracobrachialis is wide and shallow, and connects to the narrow and deep sulcus ligamentaris transversus. The fossa m. brachialis is very expanded.

The carpometacarpus (Fig. 3e, f) has a trochlea carpalis with a sharp end, and a broad notch joining it to the processus extensorius. The os metacarpale alulare is hook-shaped. The triangular sulcus interosseous is broad and connected with the sulcus tendinosus that reaches half of the os metacarpale majus. The fossa infratrochlearis is rounded.

The pelvis, os coxae, and synsacrum (Fig. 4a, b) are articulated in one piece. Fifteen vertebrae compose the synsacrum, whose processi transversi are joined so that the foramina intertransversaria open between them. The crista spinosi synsacri is uniformly developed along the vertebral column axis. The ala preacetabularis is notably longer than the ala postacetabularis. The foramen acetabuli is rounded and much smaller than the foramen ilioischiadicum, which is anteroposteriorly elongated. They are both divided by a prominent antitrochanter. The sulcus antitrochantericus is narrower at its posterior end.

The femur (Fig. 5a, b) has an extended crista trochanteris and a very well-developed impression iliotrochantericae. The sulcus intercondylaris is symmetrical with respect to both distal condyles. The epicondylus medialis and lateralis are weak. The trochanter femoris is small, and the fossa trochanteris is minimally developed. The crista supracondylaris medialis is weak and limits a fossa poplitea of irregular perimeter.

The tibiotarsus (Fig. 5c, d) belongs to a subadult specimen, as the proximal end is not fully developed.

The sulcus extensorius is broad, and its lateral and medial limits are represented by poorly defined crests. The pons supratendinosus is broad and runs obliquely to the axis of the diaphysis. The epicondylus medialis is not conspicuous, but more developed than the epicondylus lateralis.

The tarsometatarsus (Fig. 5e, f) has a sturdy and rounded eminentia intercotylaris aligned with the trochlea metatarsi III. The cotyla medialis is displaced medially towards the trochlea metatarsi II, while the cotyla lateralis is aligned with the trochlea metatarsi IV. The fossa infracotylaris dorsalis is deep, and the tuberositas musculi tibialis cranialis is elongated. Both foramina vascularia proximalia open in both faces, caudal and cranial. The elongated and large foramen vasculare distale opens into the fossa supratrochlearis plantaris. The sulcus extensorius extends becoming shallower and narrower from the foramina vascularia proximalia to the foramen vasculare distale. The crista medialis hypotarsi is very well developed.

Measurements. Femur: total length 66 mm, proximal width 14.6 mm, distal width 19 mm. Humerus: total length 141 mm, lateromedial anterior width 28 mm, distal width 20 mm. Tibiotarsus: total length 18.5 mm, distal width

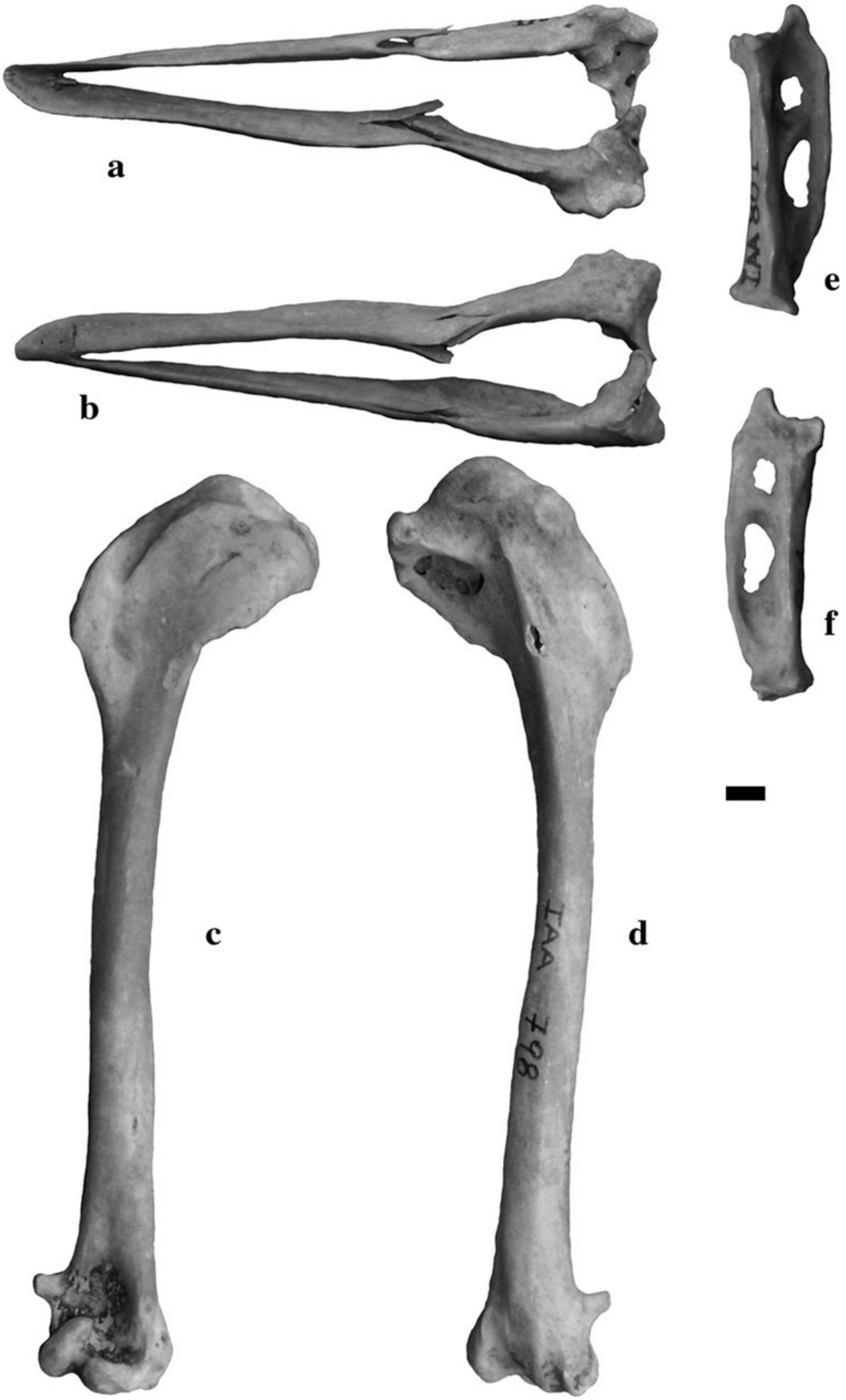


Fig. 3 Mandible and elements of the wing of *Stercorarius antarcticus lonnbergi*: **a** mandible IAA 802 (*dorsal view*), **b** mandible IAA 802 (*ventral view*), **c** carpometacarpus IAA 801 (*anterior view*), **d** carpometacarpus IAA 801 (*posterior view*), **e** humerus IAA 798 (*anterior view*), **f** humerus IAA 798 (*posterior view*). Scale bar: 10 mm

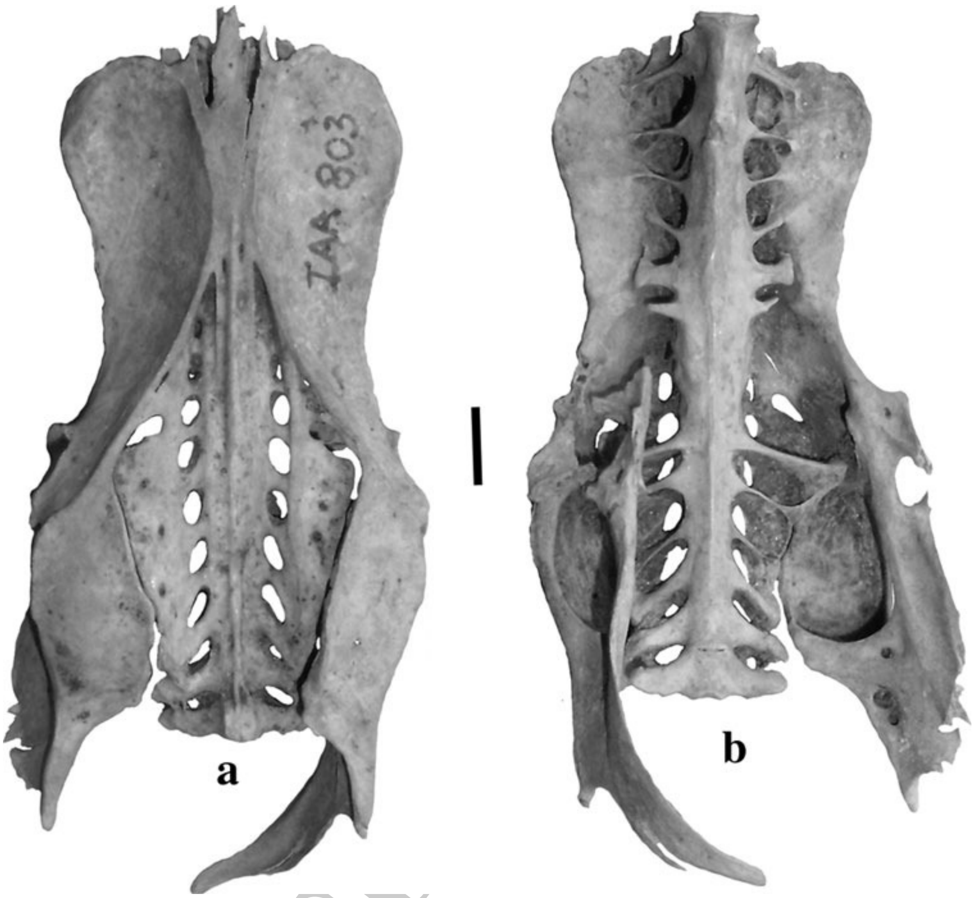


Fig. 4 Pelvis of *Stercorarius antarcticus lonnbergi*: **a** Os coxae and synsacrum IAA 803 in *dorsal view*, **b** in *ventral view*. Scale bar: 10 mm

12.7 mm. Tarsometatarsus: total length 73 mm, proximal width 14 mm, distal width 13.5 mm.

Paleoenvironmental context

Because the sea level reached its present height between 5,000 and 6,000 ^{14}C-calibrated year BP (Lambeck and Chappel 2001), most of the observed Holocene uplift in the South Shetland Islands is due to glacio-isostasy (Pallàs et al. 1997). This suggests that the sedimentary sequence may allow quantification of the glacio-isostatic uplift of the coast since deposition (del Valle et al. 2002).

Additionally, the values of age versus altitude a.s.l. fall between the predicted relative sea-level curve, according to the ICE-3G glacial rebound model (Tushingham and Peltier 1992), and the expected relative sea-level curves corresponding to Maxwell Bay (Bahía Guardia Nacional) area (King George Island: Isla 25 de Mayo) (Pallàs et al. 1997; del Valle et al. 2002; Fig. 3).

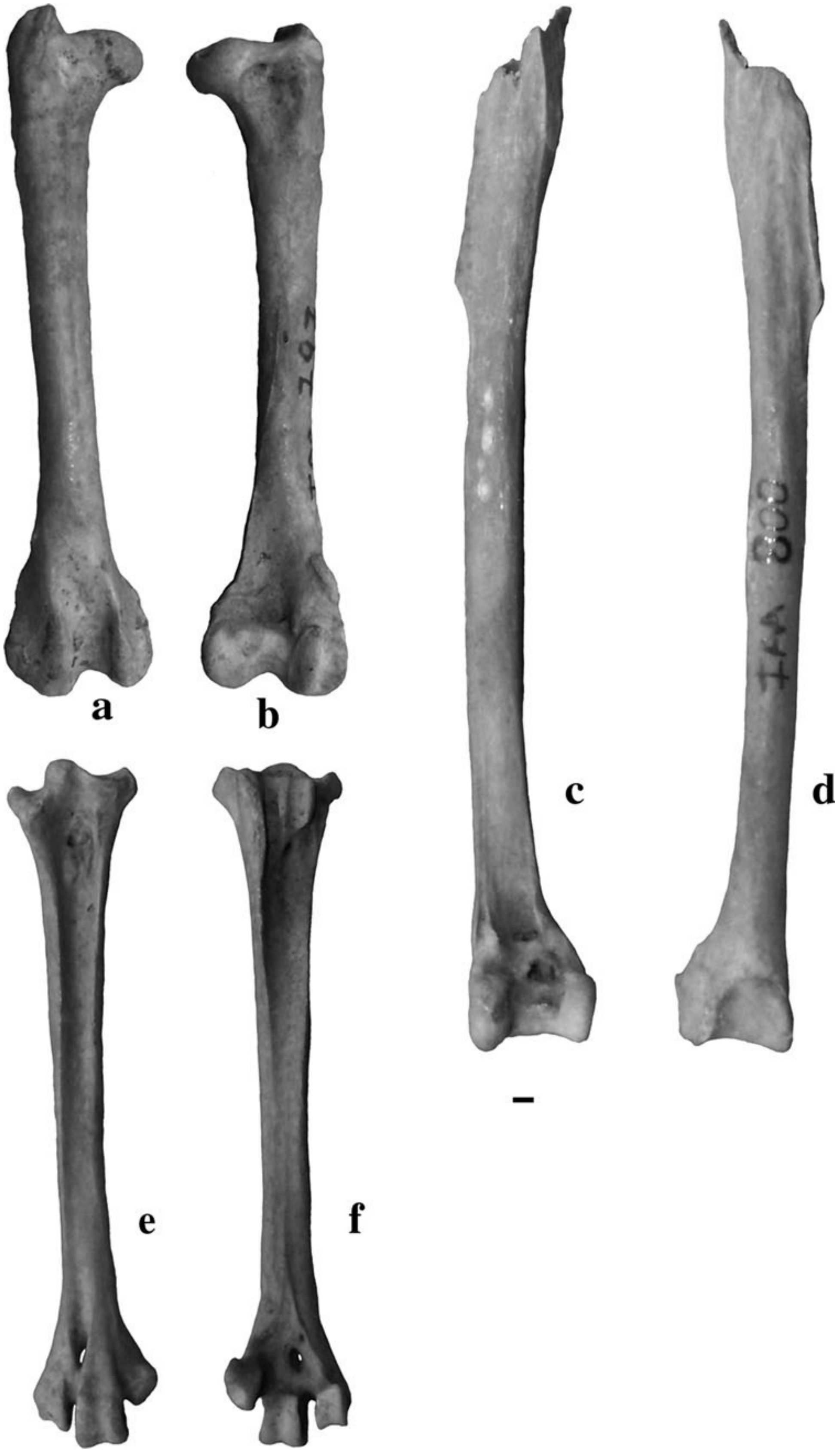
The recorded birds probably inhabited King George Island before the “climate optimum” of the Antarctic Peninsula (between 4,000 and 3,000 years BP; see, e.g., Ingólfsson et al. 1998). Moreover, the coastal occupation period, reported by del Valle et al. (2002), might match the cooling period in Antarctica, from 8,000 to 4,000 years BP (Lorius et al. 1979; Cias et al. 1992).

The fossiliferous sediments were assigned to a depositional environment, which is in agreement with the seasonally open marine conditions proposed for the Antarctic Peninsula between 8,000 and 4,000 years BP (e.g., Ingólfsson et al. 1998). The sedimentary, paleontological, and chronological data reported herein are in agreement with the quaternary paleoenvironmental chronology known for the region (del Valle et al. 2002).

Results and conclusions

The brown skua is the largest and heaviest of all the southern skuas, and its identification is partially based on size measurements. However, osteological features represent a legitimate and necessary tool for taxonomic determinations (Acosta Hospitaleche et al. 2009). The presence of the following characters allows its assignment to species level as well as the distinction of this species from *Stercorarius maccormicki*, the most similar in morphological terms. The processi mandibulae medialis of the mandible

Fig. 5 Elements of the leg of *Stercorarius antarcticus lonnbergi*: **a** femur IAA 797 (*anterior view*), **b** femur IAA 797 (*posterior view*), **c** tibiotarsus IAA 800 (*anterior view*), **d** tibiotarsus IAA 800 (*posterior view*), **e** tarsometatarsus IAA 799 (*anterior view*), **f** tarsometatarsus IAA 799 (*posterior view*). Scale bar: 10 mm



are robust. In the humerus, the tuberculum ventrale is clearly defined, the crus dorsale and ventrale fossae are well developed, and the fossa m. brachialis is extensive. In the tarsometatarsus, the trochlea carpalis has an acute proximal end, the os metacarpale alulare is hook-shaped, the sulcus interosseous is wide, the fossa infratrochlearis is proximodistal, and the end of the processus pisiformis is sharper. In the femur, the crista trochanteris is well extended, and the sulcus intercondylaris is shallow and symmetric with respect to the condyles. In the tibiotarsus the pons supratendinosus is broad. In the tarsometatarsus the eminentia intercotylaris is rounded and sturdy, the tuberositas musculi tibialis cranialis is notable, the edges of the trochlea metatarsi III are weak, and the sulcus extensorius is deep.

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