

Journal of Paleontology, 84(6), 2010, p. 1061–1070
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 0022-3360/10/0084-1061\$03.00

EOCENE BIRDS FROM THE WESTERN MARGIN OF SOUTHERNMOST SOUTH AMERICA

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ABSTRACT—This study presents the first record of Eocene birds from the western margin of southernmost South America. Three localities in Magallanes, southern Chile, have yielded a total of eleven bird remains, including Sphenisciformes (penguins) and one record tentatively assigned to cf. Ardeidae (egrets). Two different groups of penguins have been recognized from these localities. The first group is similar in size to the smallest taxa previously described from Seymour Island, *Marambiornis* Myrcha et al., 2002, *Mesetaornis* Myrcha et al., 2002, and *Delphinornis* Wiman, 1905. The second recognized group is similar in size to the biggest taxa from Seymour Island; based on the available remains, we recognize the genus *Palaeudyptes* Huxley, 1859, one of the most widespread penguin genera in the Southern Hemisphere during the Eocene. The stratigraphic context of the localities indicates a certain level of correlation with the geological units described on Seymour Island. The newly studied materials cast more light on the paleobiogeography of the group, extending the known ranges to the South American continent. In addition to the newly discovered birds, the presence of several taxa of elasmobranchs previously recovered exclusively from Eocene beds in the Southern Hemisphere help to clarify the age of the studied localities, widely discussed during the last decades. This paper verifies the presence of extensive Eocene sedimentary successions with fossil vertebrates along the western margin of southern South America, contrary to the previous assumption that such a record is lacking in Chile.

INTRODUCTION

A PART FROM isolated Late Cretaceous bird bones (Wetzel, 1930; Olson, 1992), the fossil bird record from Chile has been limited to strata that are Miocene in age or younger. This study describes the first Eocene materials collected from three localities in the Magallanes Region of Southern Chile. The remains are mainly fragmentary penguin materials (Sphenisciformes) and a proximal fragment of a tibiotarsus referred to an Egret (Ardeidae).

Fossil penguins have been widely studied during the last decades with discoveries from several localities exclusively in the Southern Hemisphere, ranging from the Paleocene (Slack et al., 2006) to the Recent. The Chilean fossil record of Sphenisciformes includes a rich diversity during the late Miocene-Pliocene (e.g., Walsh and Hume, 2001; Emslie and Guerra Correa, 2003; Acosta Hospitaleche et al., 2006; Walsh and Suárez, 2006; Chávez, 2007a; Chávez, 2007b). Regionally, the fossil record of Paleogene penguins in South America includes reports from Tierra del Fuego, Argentina (Clarke et al., 2003), where it is represented by a pelvic girdle and limb of undetermined affinities; Patagonia (Simpson, 1972) where two species were reported; and finally Ica, Peru (Clarke et al., 2007), with two identified species. Outside South America, the richest diversity of the group was recognized by several studies carried out on materials recovered from Seymour Island, Antarctica, particularly from the La Meseta Formation. Until the present, this locality has yielded seven genera with eleven species (Jadwiszczak, 2009). Other Eocene birds of the orders Falconiformes, Ciconiiformes, Phoenicopteriformes, Charadriiformes, and the families Pelagornithidae and Diomedidae were reported from Antarctica (Tambussi and Acosta Hospitaleche, 2007), most of them represented by fragmentary materials.

This study presents and describes the first Eocene Spheniscidae from the western margin of southernmost South

America, recovered in the Magallanes Region, southern Chile. Additionally, the presence of several recognized taxa of elasmobranchs previously recognized in the Weddellian Province (Zinsmeister, 1982) reinforce the Eocene age proposed by several authors for each studied locality, helping to clarify the stratigraphic situation of these units. These materials allow paleoenvironmental inferences and also extend the known paleodistribution of taxa previously reported in higher latitudes of the Southern Hemisphere, particularly Seymour Island, Antarctica.

MATERIALS AND METHODS

Vouchers were recovered by the group of Paleobotany and Paleozoology of the Antarctic Ring Bicentenary Project (Proyecto Bicentenario de Ciencia y Tecnología Anillo Antártico Conicyt-Chile) in January, 2008.

The anatomical nomenclature follows Baumel and Witmer (1993). The measurements of fossil penguin remains followed Jadwiszczak (2006a); we used the guidelines of Myrcha et al. (2002) for the tarsometatarsus. All measurements were taken with a digital calliper (± 0.01 mm). For the use of open nomenclature we follow the recommendations by Bengtson (1988). Lastly, we used extant species the osteological collection of birds of the Vertebrate Zoology Laboratory, Faculty of Sciences of Universidad de Chile for comparative purposes.

Institutional abbreviations.—SGO.PV: Collection of Vertebrate Paleontology Museo Nacional de Historia Natural, Santiago, Chile

LOCALITIES AND GEOLOGICAL SETTING

Three localities in Magallanes, Chile have yielded fossil bird remains. The southernmost locality is Río de las Minas (S53°80'18"; W71°03'32"), located 10 km west from Punta Arenas on the Brunswick Peninsula (Fig. 1, A). The host beds

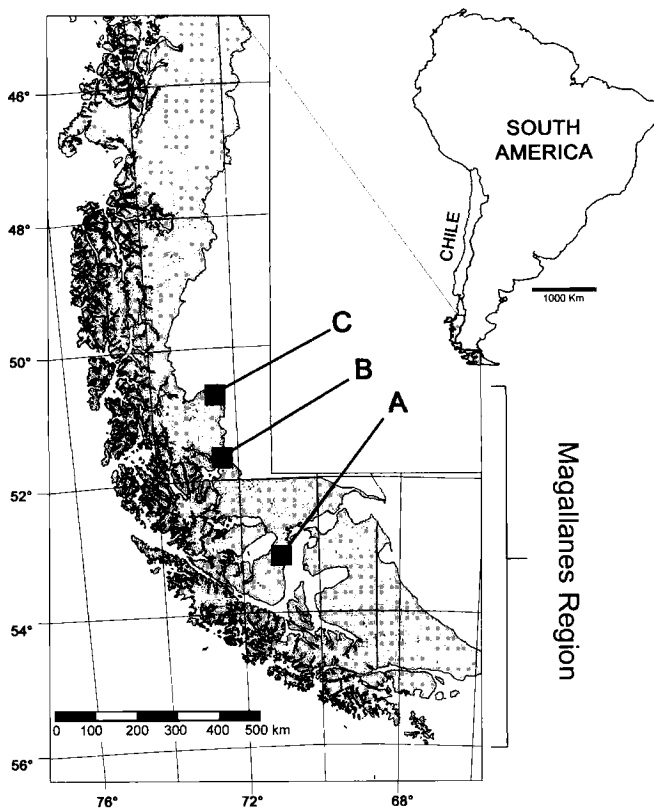


FIGURE 1—Map of the studied localities in the Magallanes Region of southernmost Chile, where fossil birds were recovered A) Río de Las Minas. B) Sierra Dorotea. C) Sierra Baguales.

outcrop on the upper slopes of the Las Minas River valley and the studied succession forms part of the Loreto Formation (Hoffstetter et al., 1957) assigned by these authors to the Eocene-Miocene, based on stratigraphic correlations, and later redefined and reassigned by Fasola (1969) to the Oligocene, based on palynomorphs. The Loreto Formation is about 800 m thick, and it is composed of well-sorted, marine sandstones containing glauconitic and concretionary horizons, intercalated with beds containing fossil flora and coal seams with variable thickness. The fossil content of bivalves, gastropods (Fasola, 1969) and vertebrates (this study) indicates that this unit was deposited in a marine environment, although wood fragments and leaf imprints are also present.

The second locality with fossil birds is Sierra Dorotea ($S51^{\circ}35'25''$; $W72^{\circ}22'17''$), Chile, about 20 km NE of Puerto Natales (Fig. 1, B). Fragmentary fossil vertebrates previously recovered from this locality included elasmosaurid plesiosaurs, collected from underlying Maastrichtian beds of the Dorotea Formation (Otero et al., 2009). The fossiliferous levels here are located near the border between Chile and Argentina and belong to a Chilean unit equivalent to the Río Turbio Formation (Feruglio, 1938, *sensu lato*.; emend. Hünicken, 1955; *sensu Malumián and Caramés, 1997*), which was originally defined in Argentina. The Río Turbio Formation is formed by sandstones, conglomerates and coquina horizons with intercalated continental clays. Following Feruglio's (1938) original definition, the unit can be divided into two sections: the lower marine and the upper continental. Hünicken (1955) also divided the formation into two sections, naming Sierra Dorotea as the type locality. The age of the Río Turbio Formation (*sensu stricto*, Hünicken, 1955) was originally assigned to the Paleocene–Eocene, based on

stratigraphic correlations and fossil marine invertebrates. Malumián and Caramés (1997) reinterpreted its age based on stratigraphic correlation and microfossils, reassigning it to the middle-late Eocene. Our observations indicate that the horizontal extension of the Río Turbio Formation can be estimated at 4,500 m (inside Chilean territory and only in N-S profile at the latitude of the studied area) and considering this fact and its dip attitude, the real thickness may reach more than 2 km. According to the measurements by Hünicken (1955) and Hoffstetter et al. (1957), the stratigraphic section described by these authors reaches approximately 550 m. These aspects of the formation indicate that an important section of the studied area remains unmapped by the original descriptions. We include a section reported here in the Río Turbio Formation based on the presence of horizons with fossil invertebrates which are recognized 1.5 km to the east (and thus stratigraphically overlying the studied section). Its fossil content includes the bivalves *Glycimeris* cf. *G. ibari* (Philippi, 1887), *Panopea* cf. *Pan. clausa* (Wilckens, 1910) and *Venericardia* (*Venericor*) *carrerensis* Griffin, 1991, all previously recognized by Griffin (1991) in outcrops of the Río Turbio Formation exposed in Argentina and assigned to the Eocene.

The last locality with fossil bird remains is Sierra Baguales ($S50^{\circ}43'59''$; $W72^{\circ}28'41''$), located 40 km NEE of the Torres del Paine National Park, Chile (Fig. 1, C). The host beds are interpreted to be part of the Río Baguales Formation (Cecioni, 1956; Le Roux et al., in press). According to Cecioni (1956), the type locality of the Río Baguales Formation is located at $S50^{\circ}57'$, $W72^{\circ}22'$, implying a distance approximately 25 km south of the studied beds. The strike of the units exposed in the region indicates that they crop out as N-S trending strips. This fact, together with the similar lithology between the observed conditions and those described in the definition of the unit, allow us to correlate them partially with the Río Baguales Formation. Specifically, we argue for a division of the formation into volcanic units exposed to the east, and sedimentary beds exposed to the west, with the presence of ammonoids and several typical Maastrichtian elasmobranchs recognized during the field campaign (Otero and Suárez, 2009).

SYSTEMATIC PALEONTOLOGY

Class AVES Linnaeus, 1758

Order SPHENISCIFORMES Sharpe, 1891

Family SPHENISCIDAE Bonaparte, 1831

gen. et sp. indet.

Figure 2.1–26

Materials.—SGO.PV.6587: Distal portion of left humerus. SGO.PV.6588: medial portion of right humerus. SGO.PV.6589: proximal portion of left femur. SGO.PV.6590: distal portion of left tibiotarsus. SGO.PV.6649: proximal portion of right humerus. SGO.PV.6650: proximal portion of left humerus with part of the diaphysis. SGO.PV.6652: Isolated ungual phalanx. SGO.PV.6653: incomplete left tarsometatarsus. SGO.PV.6655: two fragments of humerus, preserving only the diaphysis.

Locality, horizon and age.—SGO.PV.6587, SGO.PV.6588, SGO.PV.6589, SGO.PV.6590, SGO.PV.6649, SGO.PV.6650: Sierra Dorotea, Puerto Natales, southernmost Chile. Río Turbio Formation (*sensu Malumián and Caramés, 1997*), middle to late Eocene. SGO.PV.6652, SGO.PV.6653: Río de Las Minas, Punta Arenas, southernmost Chile. Loreto Formation (Hoffstetter et al., 1957), middle to late Eocene. SGO.PV.6655: Sierra Baguales, northern Magallanes Region,

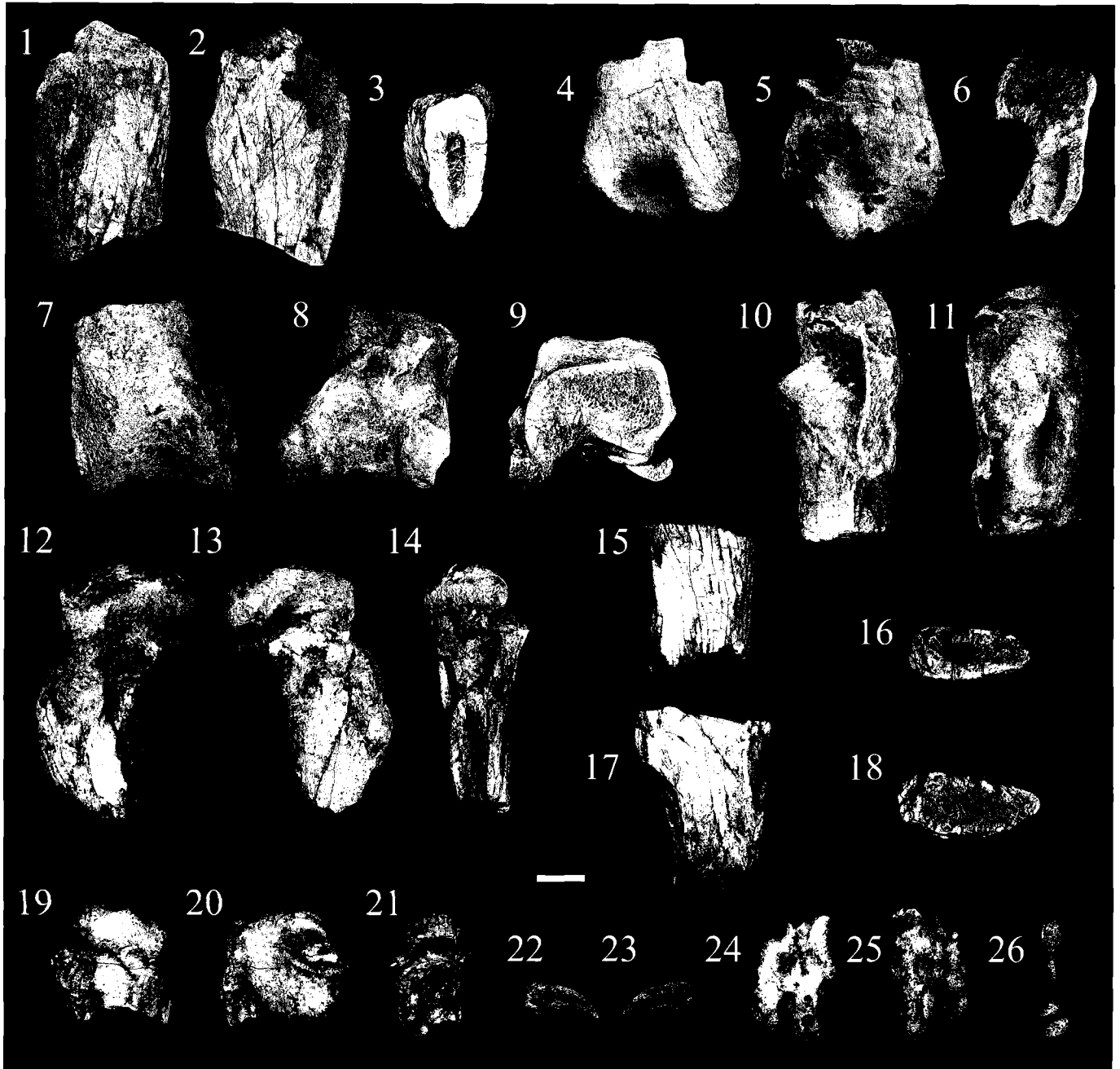


FIGURE 2—Spheniscidae gen., et sp. indet., medial portion of right humerus (SGO.PV.6588). 1, dorsal view; 2, ventral view; 3, cross section, distal portion of left humerus (SGO.PV.6587); 4, dorsal view; 5, ventral view; 6, cross section, distal portion of left tibiotarsus (SGO.PV.6590); 7, posterior view; 8, anterior view; 9, cross section, proximal portion of left femur (SGO.PV.6589); 10, anterior view; 11, lateral left view, proximal portion of left humerus with part of the diaphysis (SGO.PV.6650); 12, dorsal view; 13, ventral view; 14, cranial view, two fragments of humerus, preserving only the diaphysis (SGO.PV.6655); 15, lateral view; 16, cross section; 17, lateral view; 18, cross section, proximal portion of right humerus (SGO.PV.6649); 19, dorsal view; 20, ventral view; 21, cranial view, isolated unguis phalanx (SGO.PV.6652); 22, 23, incomplete left tarsometatarsus (SGO.PV.6653); 24, plantar view; 25, dorsal view; 26, lateral view. Scale bar = 1 cm.

southernmost Chile. Río Baguales Formation (Hoffstetter et al., 1957), middle to late Eocene.

Description.—SGO.PV.6588 is similar to SGO.PV.6655 in its general characteristics, with a flattened oval in cross section and evidence for part of the fossa pneumotricipitalis, but it lacks the rim, which makes it impossible to establish its size. The distal part of the facies musculi pectoralis is full of sediment, but it is possible to distinguish. SGO.PV.6587: cross section is a flattened oval, both distal condyles are observed (condylus ventralis and condylus dorsalis) as also both sulci

musculus. The scapulotricepitis and humerotricepitis condylus ventralis reach a more distal position than the condylus dorsalis. SGO.PV.6589: poorly preserved fragment, with the caput femori and crista trochanteris both absent. Part of the fossa trochanteris and part of the linea intermuscularis cranialis are also preserved. SGO.PV.6590: both distal condyles are preserved, but are strongly eroded so that no measurements could be evaluated except the distal width, between cranial (distal) portions of outer edges of both condyles, which were 29.56 mm. The incisura intercondylaris

TABLE 1—Comparative measurements of Eocene Spheniscidae. All measurements shown in millimeters.

Humeri	1	2	3	4
SGO.PV 6585	36.05	28.20	26.33	14.42
<i>Anthropornis nordenskjoldi</i> (IB/P/B 0019) (*)	44.4	27.2	36.7	18.5
<i>Anthropornis nordenskjoldi</i> (IB/P/B 0478) (*)	45.6	31.2	34.6	18.4
<i>Anthropornis grandis</i> (IB/P/B 0179) (*)	36.7	21.6	32.1	17.9
<i>Palaeudyptes gunnari</i> (IB/P/B 0066) (*)	31.9	20.9	25.3	14.2
<i>Palaeudyptes gunnari</i> (IB/P/B 0126) (*)	35.6	22.6	25.9	13.2
<i>Palaeudyptes gunnari</i> (IB/P/B 0371) (*)	36.1	21.7	26.7	13.1
<i>Palaeudyptes gunnari</i> (IB/P/B 0472) (*)	37.0	22.3	26.6	15.1
<i>Palaeudyptes</i> sp. (IB/P/B 0379) (*)	29.7	18.4	22.6	13.1
Tarsometatarsi	5	6	7	8
SGO.PV 6653	4.63	8.43	6.52	13.24
<i>Mesataornis polaris</i> (IB/P/B-0278) (**)	6.3	11.5	8.2	16.1
<i>Delphinornis gracilis</i> (IB/P/B-0279a) (**)	6.5	8.8	7.1	13.6
<i>Delphinornis larseni</i> (IB/P/B-0062) (**)	8.3	10.3	8.9	16.8
<i>Delphinornis larseni</i> (IB/P/B-0547) (**)	7.1	10.6	8.1	14.8
<i>Delphinornis larseni</i> (IB/P/B-0548) (**)	7.2	11.0	8.1	15.7
<i>Delphinornis larseni</i> (MLP 84-II-1-79) (**)	7.6	12.0	9.0	15.5
<i>Delphinornis larseni</i> (MLP 84-II-4-174) (**)	7.9	11.3	8.5	17.0
<i>Delphinornis arctowskii</i> (IB/P/B-0484) (**)	7.3	10.6	7.8	16.0
<i>Delphinornis</i> sp. (IB/P/B-0283) (**)	6.5	9.7	6.6	14.7
<i>Marambiornis exilis</i> (IB/P/B-0490) (**)	6.1	10.5	7.0	15.0
<i>Marambiornis exilis</i> (MLP 93-X-1-111) (**)	6.3	10.0	8.0	15.0

1: Extreme length of the articular surface of caput humeri.

2: Dorso-ventral diameter of fossa pneumatica (between outer sides of its rim).

3: Cranio-caudal width of the shaft in the narrowest part of its proximal fragment.

4: Dorso-ventral thickness of the shaft at right angles to the measurement 5.

5: Dorso-plantar thickness of the bone from the central point of tuberositas musculi tibialis cranialis to the corresponding point of the plantar side.

6: Dorso-plantar thickness of trochlea III.

7: Maximal width of trochlea III between its lateral and medial edges.

8: Medial width between margo medialis and lateralis, in the narrower point of the shaft.

(*) = Data published in Jadwiszczak, 2006a.

(**) = Data published in Myrcha et al., 2002.

IB/P/B = Institute of Biology, University of Białystok, Poland.

MLP = Museo de La Plata, Argentina.

is low. The condylus medialis is diagonally projected, and reaches the most distal position of both condyles. SGO.PV.6649: The caput humeri is well preserved. Part of the fossa pneumotricipitalis is clearly distinguished. The facies musculi pectoralis is recognized as well as the incisura capitis. SGO.PV.6650: This fragment preserves part of the facies

ventralis of the diaphysis. The facis dorsalis is strongly eroded; the fossa tricripitalis can be recognized; the incisura capitis is wider than the other humerus. SGO.PV.6652: The unguis phalanx is robust, recurved, with a slender distal end and it lacks a sharp cutting edge. It is grooved on both sides, with the lateral groove occupying a more dorsal position than the



FIGURE 3—*Palaeudyptes* sp. Right humerus (SGO.PV.6585): 1, caudal view; 2, cranial view; 3, side view; 4, proximal view of the articular head; 5, cross section view of the diaphysis. Sierra Dorotea, southernmost Chile. Rio Turbio Formation, middle to late Eocene. Scale bar = 1 cm.

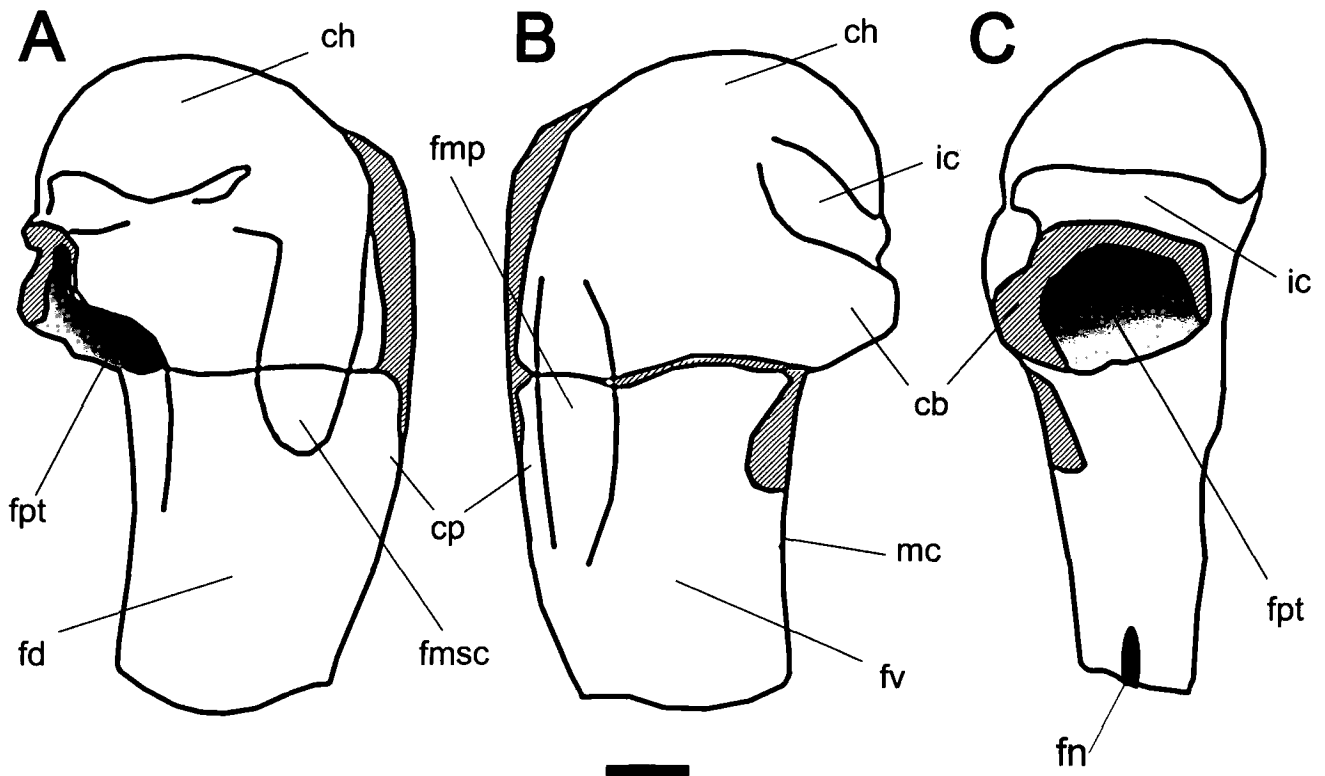


FIGURE 4—Anatomical nomenclature of penguin humerus. cb: crista bicipitalis. ch: caput humeri. cp: crista pectoralis. f: foramen. fd: facies dorsalis. fmsc: facies musculi supracoracoideus. fn: foramen nutricium fpt: fossa pneumotricipitalis. ic: incisura capitis. mc: margo caudalis.

medial one. SGO.PV.6653: Incomplete tarsometatarsus lacking its proximal portion. The distal end only preserves the articular facets of the trochlea metatarsi III and IV, each having a softly excavated incisura intertrochlearis medialis. The margo medialis is partially preserved, being moderately curved, while the margo lateralis is straighter. In plantar view, the foramen vasculare distale is placed centrally over the tarsal III trochlea. SGO.PV.6655: Compressed bones with very striated surface, caused by weathering. The cross sections are flattened ovals, similar to those observed on the material SGO.PV. 6585.

Discussion.—From the list of recovered fragmentary specimens referred to Spheniscidae, SGO.PV 6586, SGO.PV 6587, and SGO.PV 6655 do not resemble *Palaeedyptes* or SGO.PV

6585 in general size, mostly because the fragmentary nature of the remains make further comparisons impossible. The preservation of SGO.PV 6589 does not allow a more definitive identification, but considering its size, it can be tentatively grouped with the other large-sized remains. Despite the fact that the tibiotarsus of SGO.PV.6590 is similar in size to those described for the other genus *Palaeedyptes*, no diagnostic features are preserved sufficient for a more accurate identification. SGO.PV.6652 is assigned to the family Spheniscidae, mainly because it is the only bird taxon present at the locality, but also because it corresponds in general form and size to the expected unguis phalanx of the penguins from this locality. More specifically, it resembles in form and size the unguis phalanx described as that from a Spheniscidae by Jadwyszczak

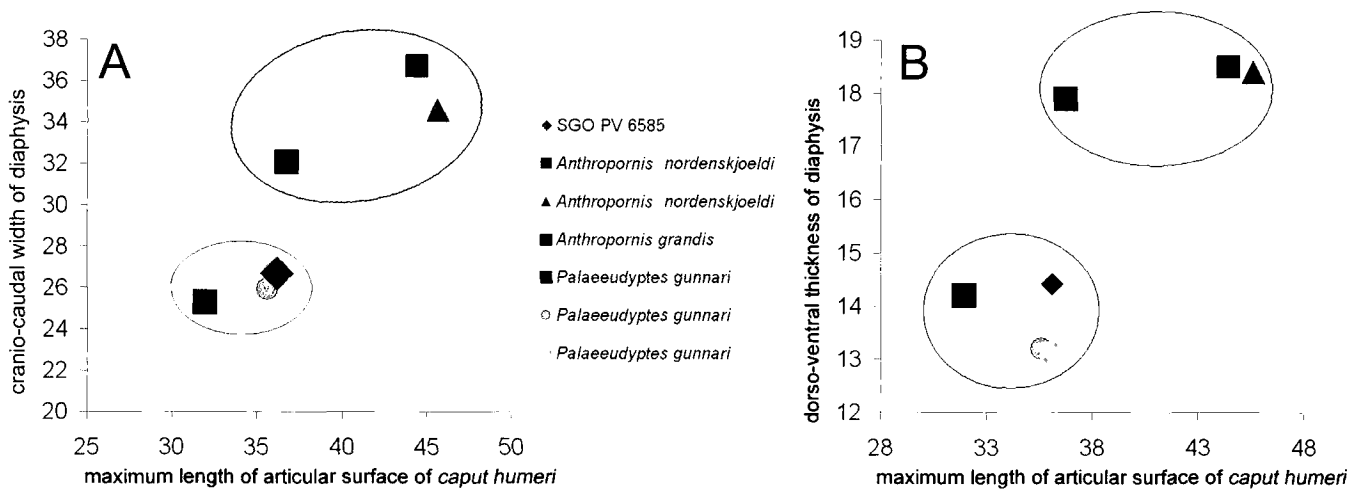


FIGURE 5—Morphometric analysis, comparing the known species of *Palaeedyptes* and *Anthropornis* with the material SGO.PV.6585.

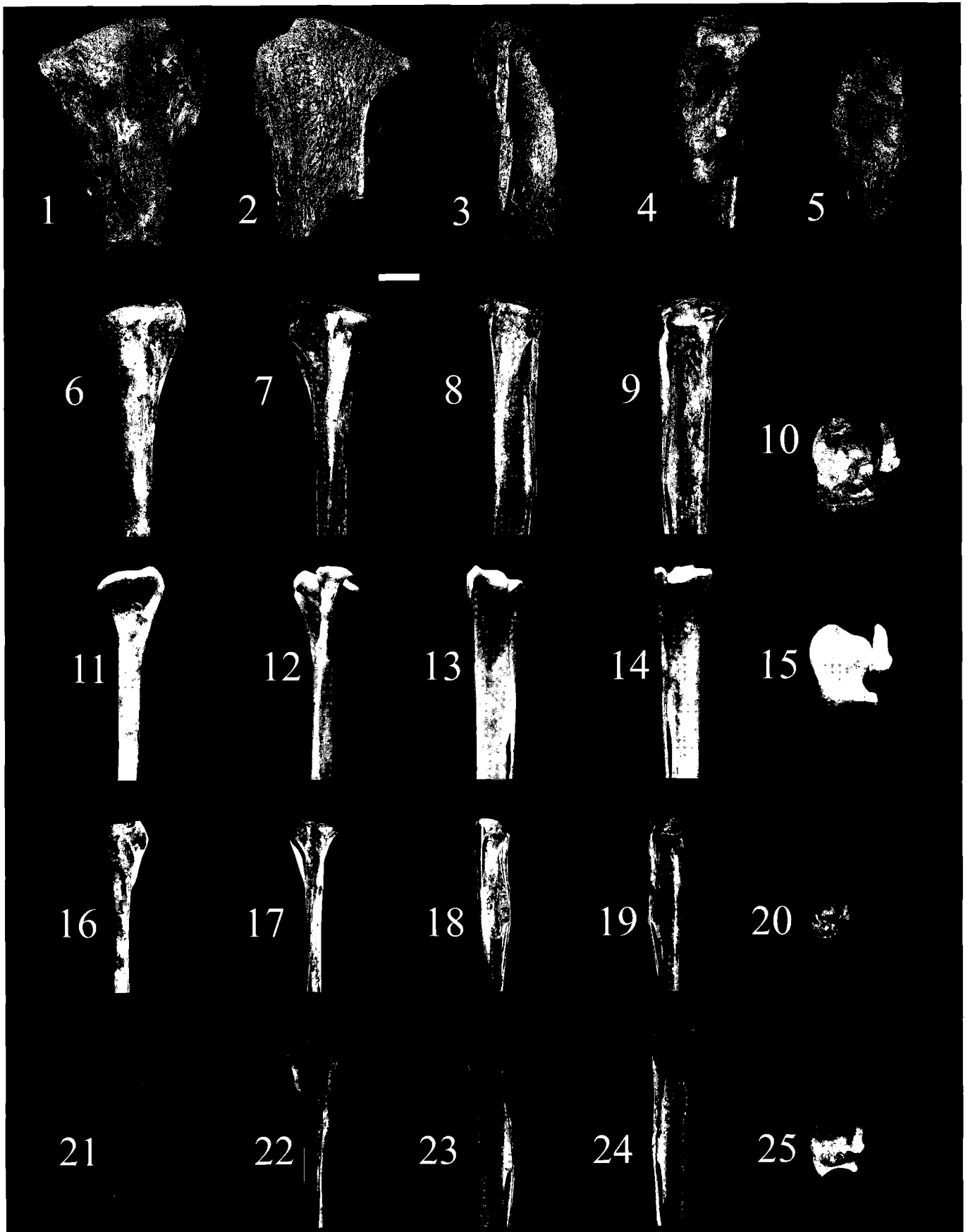


FIGURE 6—Comparison between fossil Egret from Sierra Dorotea and the extant egrets and herons present in Chile. Ardeidae gen. et sp. indet. Proximal portion of left tibiotarsus (SGO.PV.6584); 1, lateral internal view; 2, lateral external view; 3, cranial view; 4, caudal view; 5, proximal view; left

(2006a). SGO.PV.6653 corresponds to a very incomplete tarsometatarsus, no diagnostic character could be observed, comparison measurements are shown in Table 1.

Genus *Palaeodyptes* Huxley, 1859

Palaeodyptes sp.

Figure 3.1–5

Materials.—SGO.PV.6585: Incomplete right humerus.

Locality, horizon and age.—Sierra Dorotea, Puerto Natales, southernmost Chile. Río Turbio Formation, middle to late Eocene.

Description.—The humerus of SGO.PV.6585 preserves the proximal and medial portions. Its general aspect is thick, with massive and rounded caput humeri. The shaft shape is elongated and slightly sigmoidal, with a relatively constant thickness through the diaphysis. The fossa pneumotricipitalis is wide and without internal division, with a rounded perimeter and a well developed but poorly preserved crista bicipitalis. In the cranial surface it shows a wide fossa capitalis caudalis, with a foramen extended over the crista bicipitalis, forming the incisura capitis. In the caudal surface, the facies musculi supracoracoideus is located near the dorsal margin and is extended beyond the position of the fossa pneumotricipitalis. The crista pectoralis is poorly preserved at its proximal end. The margo caudalis shows a well marked constriction near the middle of its length. The facies musculi latissimus dorsi is distally twisted with respect to the humerus head, and the foramen nutricium is located over the facies ventralis, close to the margo caudalis. The facies musculi supracoracoideus appears subparallel to the shaft axis (Fig. 4).

Discussion.—SGO.PV.6585 preserves enough morphological characters to enable generic identification. Compared with other known Eocene penguins, we note a closer morphological affinity and size with those species of the genus *Palaeodyptes*. The gracile diaphysis observed in SGO.PV.6585 differs from that observed in the genus *Anthropornis* Wiman, 1905, where this bone has a more massive aspect. The margo caudalis has a pronounced constriction that allows it to be differentiated the SGO.PV.6585 material from *Anthropornis*, as the latter lacks this characteristic.

The facies musculi latissimus dorsi is distally separated from the humeral head, while in *Anthropornis* it is closer, as is described in Jadwiszczak (2009). The foramen nutricium is located in the facies ventralis, near the margo caudalis, this being a diagnostic characteristic of the genus *Palaeodyptes*. Additionally, the subparallel condition of the facies musculi supracoracoidei with respect to the shaft axis is also different compared with *Anthropornis* and *Archaeospheniscus* Marples, 1952, where this is disposed in a more oblique sense. The graphic results of the comparison of the cranio-caudal width of diaphysis (Fig. 5, A) and dorso-ventral thickness of the diaphysis (Fig. 5, B) against the maximum length of articular surface of caput humeri and group together SGO-PV 6585 within *Palaeodyptes*, distinguishing it from *Anthropornis*. Measurements are shown in Table 1.

Order CICONIIFORMES Sharpe, 1891

Family ARDEIDAE Leach, 1820

cf. Ardeidae gen. et sp. indet.

Figure 6.1–5

Materials.—SGO.PV.6584: Proximal portion of left tibiotarsus.

Locality, horizon and age.—Sierra Dorotea, Puerto Natales, southernmost Chile. Río Turbio Formation, middle to late Eocene.

Description.—Proximal end with its lateral external half absent, revealing the internal trabeculae of the bone. The crista cnemialis cranialis is well developed, but incomplete, with its distal limit preserved. The sulcus intercostalis is slightly deeper than the fossa flexoria, and both have a rounded surface. The facies articularis medialis is quite flattened, but part of the area interarticularis is preserved. The fossil belongs to a large size bird, compared with extant species of the family Ardeidae (Figure 6), some measurements could be considered, the width between the crista cnemialis cranealis and the caudal margin of articulation is 35.6 mm, the width of the crista cnemialis cranealis is 38.7 mm, the diaphysis thickness (caudal-cranial) is 19.1 mm, the length between area interarticularis and caudal callosity is 26.6 mm and the articular surface length is 23.1 mm.

Discussion.—As concerns SGO.PV.6584, the flattened facies articularis medialis forms a low angle with the shaft, and near the cranial margin it shows a change of inclination. In other seabirds, a prominent extension of the crista cnemialis cranialis is developed in the proximal direction (Figure 7). Such is the case of several Gruiformes, Anseriformes, Podicipediformes, Charadriiformes, and Pelecaniformes. However, this is not the case of Ardeidae, as observed in *Egretta thula* (Molina, 1782), *Ardea cocoi* Linnaeus, 1766, *Ardea alba* (Linnaeus, 1758), and *Nycticorax nycticorax* (Linnaeus, 1758) (used for comparison). In all of these latter taxa, the distal margin of the crista cnemialis cranealis is not extended in a distal direction, as is also seen in SGO.PV.6584.

DISCUSSION

The materials collected in the Loreto Formation were associated with abundant elasmobranch teeth in the same stratigraphic level. Although this assemblage is still in the process of being studied, several taxa with good chronostratigraphic value have been recognized already, including the species *Striatolamia macrota* (Agassiz, 1843) and *Ischyodus dolloi* Leriche, 1902 (Otero et al., 2007). These taxa suggests an Eocene age for the host beds, and considering the Oligocene age proposed by Fasola (1969) based on palynomorphs, the assemblage probably corresponds to the late Eocene or Eocene-Oligocene boundary.

A similar situation is noted in the studied beds at Sierra Dorotea. The presence of fossil penguins of the genus *Palaeodyptes* associated with elasmobranch teeth of the species *Striatolamia macrota* and abundant teeth of *Carcharias* sp. allow these beds to be correlated with outcrops of the La Meseta Formation (Rinaldi et al., 1978). *S. macrota* was

←
tibiotarsus of Cocoi Heron, *Ardea cocoi*: 6, lateral internal view; 7, lateral external view; 8, cranial view; 9, caudal view; 10, proximal view; left tibiotarsus of Great Egret, *Ardea alba*: 11, lateral internal view; 12, lateral external view; 13, cranial view; 14, caudal view; 15, proximal view; left tibiotarsus of Snowy Egret, *Egretta thula*: 16, lateral internal view; 17, lateral external view; 18, cranial view; 19, caudal view; 20, proximal view; left tibiotarsus of Black-crowned Night Heron, *Nycticorax nycticorax*: 21, lateral internal view; 22, lateral external view; 23, cranial view; 24, caudal view; 25, proximal view. Scale bar = 1 cm.

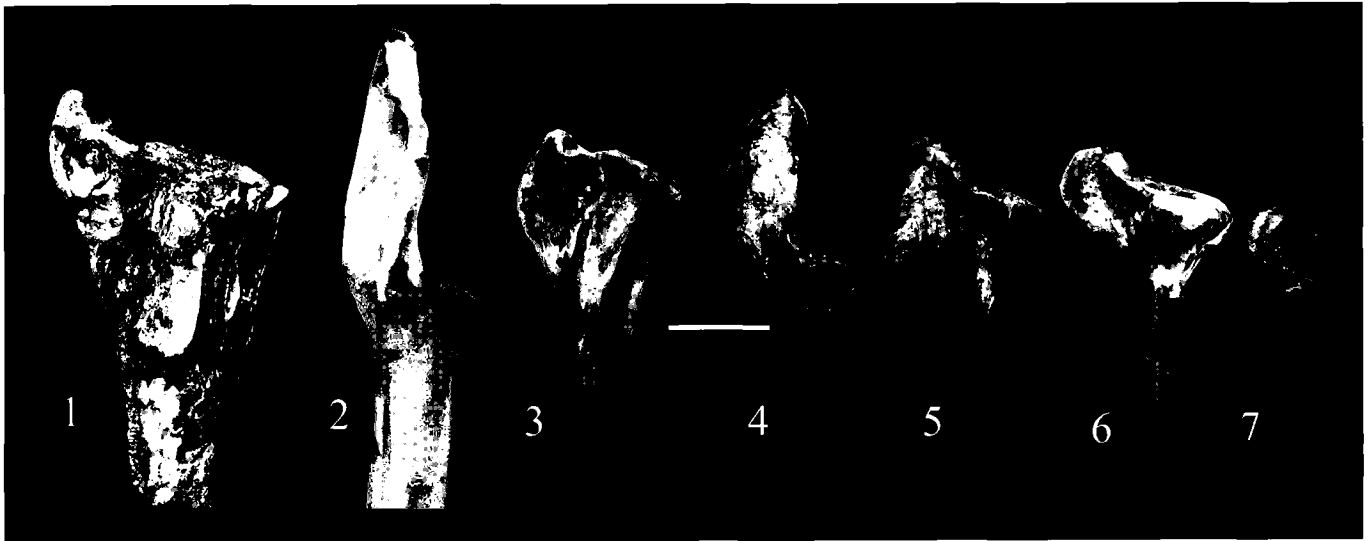


FIGURE 7—Differences in the tibiotarsi from some aquatic birds. 1, Humboldt Penguin, *Spheniscus humboldti* (Spheniscidae, Sphenisciformes); 2, Great Grebe, *Podiceps major* (Podicipedae, Podicipediformes); 3, Peruvian Booby, *Sula variegata* (Sulidae, Pelecaniformes); 4, Sooty Shearwater, *Puffinus griseus* (Procellariidae, Procellariiformes); 5, Red-fronted Coot, *Fulica rufifrons* (Rallidae, Gruiformes); 6, Crested Duck, *Lophonetta specularoides* (Anatidae, Anseriformes); 7, Franklin's Gull, *Larus pipixcan* (Laridae, Charadriiformes). Scale bar = 1 cm.

mentioned by Kriwet (2005) as the predominant taxon of elasmobranchs in all the strata and associations of the La Meseta Formation. In addition, the genus *Palaeudyptes* was reported from lithofacies Telm 4, 5 and 7 (sensu Sadler, 1988), and mentioned as a particularly abundant taxon in Telm 7 (Jadwiszczak, 2006b). Tambussi et al. (2006) indicate for the *Anthropornis nordensjoeldi* Biozone (indicated as the *Palaeudyptes klekowskii* Biozone by Jadwiszczak, 2006b) an age of 36.13 to 34.2 Ma, i.e., late Eocene. According to our observations at Sierra Dorotea during the present field campaign, the strata assigned to the Río Turbio Formation show a high degree of lithological and faunal coincidence with lithofacies Telm 1 to Telm 7, both containing fossiliferous sandstones and limestones with intercalations of coquina. Lithofacies Telm 7 of Seymour Island can be partially correlated with equivalent strata of the Río Turbio Formation that crop out on the Chilean side of Sierra Dorotea, being composed of sandstones and limestones that include the species *S. macrota* and the genus *Palaeudyptes*, respectively. In addition, coquina beds are seen in the Río Turbio Formation, similar to those reported from Seymour Island. Considering this evidence, the middle-late Eocene age proposed for the studied section seems to be supported.

The materials recovered at Sierra Baguales were also associated with abundant elasmobranch teeth that indicate the richest regional diversity of these fishes recognized until now. The frequent presence of the species *S. macrota*, scarce teeth of the genus *Abdounia* Cappetta, 1980 and plates of the holocephalian fish *I. dolloi*, strongly suggest an Eocene age for these strata. All three studied localities can be partially correlated, based on their similar faunal assemblage, lithology and suggest an Eocene age.

Considering the known stratigraphic resolution of the recognized penguin taxa and their occurrence association with teeth of the elasmobranch *Striatolamia macrota*, these facts support an Eocene age for the studied beds exposed at the three localities. In the case of the beds of the Loreto Formation, the additional stratigraphic information available from previous studies allows the age to be constrained to the middle to late Eocene. In the case of the beds from Sierra

Dorotea, stratigraphic correlation with similar successions exposed on Seymour Island suggests middle to late Eocene age for the host beds. Finally, for the studied beds in Sierra Baguales, considering the geological context and distribution of the regional units and the presence of several shark taxa with good chronostratigraphic value associated with the bird remains, an undifferentiated Eocene age is indicated for the fossiliferous outcrops. Nevertheless, further stratigraphic studies are needed in order to clarify the stratigraphic location of this unit.

The presence of *Palaeudyptes* in the Magallanes Region of southernmost Chile constitutes the first record of this genus in South America, and the first generic identification of Eocene penguins in Chile. Regionally, this constitutes the seventh record of spheniscids in South America during the Eocene. Previous reports mentioned fragmentary postcranial remains identified as Sphenisciformes indet. (Clarke et al., 2003) recovered from the Leticia Formation of Tierra Del Fuego. Two species are recognized in the Eocene San Julián Formation of Argentinian Patagonia: *Arthrodytes andrewsi* (Ameghino, 1901) and *Parapterodytes robustus* (Ameghino, 1895) both strongly differ from the Sierra Dorotea humerus, the humeral head of *Arthrodytes* being less robust than SGO.PV.6585 and in *Parapterodytes* having a much straighter diaphysis. They are also very different in the configuration of the caput humeri and the sulcus ligamentosus transversus. Two additional species are known from the Eocene of Peru: *Perudyptes devriesi* Clarke et al., 2007 and *Icadyptes salasi* Clarke et al., 2007.

The previous reports of *Palaeudyptes* includes New Zealand, with the species *Palaeudyptes marplei*, Brodkorb, 1963 and other remains assigned to *Palaeudyptes* sp. (Simpson 1971, 1975). The genus was furthermore reported from southern Australia (Simpson, 1975) and numerous records are known from Seymour Island, Antarctica, where the species *Palaeudyptes gunnari* (Wiman, 1905) and *Palaeudyptes klekowskii* Myrcha et al., 1990 (Jadwiszczak, 2009) have been reported. Recently an articulated skeleton of *Palaeudyptes gunnari* was recovered that can clarify the previous doubtful assignation of materials different in the

tarsometatarsi (as humeri) to this genus. This was based on criteria of controversial taxonomic value such as size (Acosta Hospitaleche and Reguero, 2009).

Finally, cf. Ardeidae gen. et sp. indet. constitutes the oldest and unique record of fossil herons in Chile, and the recovered material probably belongs to a large bird. The known fossil record of Ardeidae is scarce and incomplete, being mostly represented by isolated bony fragments. The species *Calcardea junnei* Gingerich, 1987, was reported from the early Eocene of Wyoming, constituting the oldest record of the group. Mayr (2005) mentioned the presence of *Proardea amissa* Milne-Edwards, 1892 in Oligocene beds of France, and "*Anas*" *basaltica* Bayer, 1883 in the early Oligocene of the Czech Republic. Rasmussen et al. (1987) mention the presence of bones referred to Ardeidae in the Oligocene of Egypt.

These materials are important in presenting three new Eocene localities of interest, contrary to the previous assumption of a lack of Eocene fossils in Chilean strata (Clarke et al., 2003; Chávez, 2007a). The present records of Eocene birds in southernmost Chile, in particular spheniscids, reveal a number of interesting localities where two groups of large- and medium-sized penguins are represented. The most abundant remains were found at Sierra Dorotea, including the larger types described here, whereas at Río de Las Minas, Punta Arenas, medium-sized, fragmentary remains of penguins which are comparable to *Mesetaornis*, *Delphinornis* and/or *Marambiornis* were recovered. Despite the fact that the locality of Sierra Baguales was explored in little detail during our field campaigns, the fragmentary and poorly preserved remains recovered clearly indicate the potential of discovering more complete bird remains, which indicate an important extension of the paleobiogeography of the group. Beside penguins, the record of a fossil herons is interesting in that it does not constrain the bird record of Sierra Dorotea to a strictly marine environment, suggesting the proximity of the coast during sedimentation.

ACKNOWLEDGMENTS

This study was supported by the Antarctic Ring Bicentenary Project (Proyecto Bicentenario de Ciencia y Tecnología Anillo Antártico, PBCT-ARTG-04, Conicyt, Chile), directed by Dr. T. Torres. Our special thanks to J. Maclean for his assistance with logistics, access to the outcrops and goodwill that allowed us to study Sierra Baguales. J. L. Oyarzún (Puerto Natales) is also thanked for his valuable support in the field, organizing the logistics and access, and for the collection of part of the materials. We thank C. Acosta Hospitaleche (Museo de la Plata) for sharing information and literature with us. J. P. Le Roux (Departamento de Geología, Universidad de Chile) is thanked for checking the English of the manuscript. We are grateful to N. D. Pyenson (University of British Columbia) who made comments that significantly improved the manuscript. The comments of P. Jadwiszczak, C. P. Tambussi, G. Dyke and one anonymous reviewer were invaluable.

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ACCEPTED 25 MAY 2010