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BRACHYDELPHIS (PONTOPORIIDAE, ODONTOCETI, CETACEA) DO NEÓGENO DO PACÍFICO SUL ORIENTAL

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SUMÁRIO

RESUMO

Brachydelphis maseazi Muizon 1988, da Formação Pisco (Mesomiocene, Peru), corresponde a uma espécie de odontoceto conhecida por dois crânios incompletos e alguns elementos pós-cranianos associados. Uma revisão e estudo comparativo desta espécie foram realizados a partir de novos espécimes referidos a *B. mazeasi* provenientes dos depósitos neógenos da costa Sul-Pacífica do Peru e do Chile (Fms. Pisco e Bahía Inglesa respectivamente). Como dado complementar, nessa comparação, se estabeleceram hipóteses de correlações cronoestratigráficas para ambas as formações. Os fósseis aqui analisados ocorrem em rochas fosfáticas, cuja gênese ocorre sob condições muito específicas e está relacionada a eventos globais de variação de nível eustático. A presença dessas rochas em diversas formações neógenas do Pacífico, enfocando as Fms. Pisco e B. Inglesa, permitiu propor uma correlação cronoestratigráfica preliminar e constitui-se numa boa ferramenta para correlacionar eventos entre essas formações. Por outro lado, a tafonomia das mesmas é distinta, em um plano geral, com a Fm. B. Inglesa apresentando massiva quantidade de fósseis em uma camada retrabalhada de D-fosfato e a Fm. Pisco com amplos depósitos de sedimentos finos e fósseis esparsos. A fauna de vertebrados também já foi sugerida como sendo relacionada já que é notoriamente similar. A família Pontoporiidae está amplamente registrada em ambas as formações. A presença de *B. mazeasi* no Mesomioceno da Fm. Pisco reforçou a proposição da origem Pacífica para a família. Contudo, a paleobiogeografia, bem como a filogenia deste grupo, é confusa, podendo-se apenas precisar uma origem sul-americana para o clado. O estudo da variação morfológica em uma série ontogenética de exemplares de *B. mazeasi,* incluindo materiais provenientes de ambas as formações, contribui para uma visão mais integradora da diagnose da espécie, implicações filogenéticas para clados mais inclusivos e da correlação entre as duas áreas estudadas.

ABSTRACT

Brachydelphis maseazi Muizon 1988, of the Pisco Formation (Mesomiocene, Peru), corresponds to an odontocete known for two incomplete skulls and a few associated post-cranial elements. A revision and comparative study of this specie were carried out with new specimens, referred to *B. mazeasi*, from the Neogene deposits of the South-Pacific coast of Peru and Chile (the Pisco and the Bahía Inlgesa Formations respectively). As complementary fact, in that comparison, a hypothesis of chronostratigraphic correlation was established for both formations. The genesis of phosphatic rocks is ruled by specific conditions, however, also is related to global events of eustatic level variation. The presence of those rocks in diverse Neogene formations of the Pacific, focusing the Pisco and B. Inglesa Formations, permitted to propose a preliminary chronostratigraphic correlation for both deposits. The occurrence of phosphatic rocks was converted in a good instrument for correlate events between those formations. On the other hand, the taphonomy of both formations is distinctive, in a general view, with the B. Inglesa F. presenting massive quantity of fossils in a reworked layer of D-Phosphate, and to Pisco F. with broad deposits of thin sediments and scarce fossils. The vertebrate faunas also were suggested as related, since is notoriously similar. The Pontoporiidae family is broadly registered in both formations. The presence of *B. mazeasi* from Mesomioceno of the Pisco F. leads to the proposition of a Pacific origin for the family. However, the paleobiogeography as the phylogeny of this group is unresolved, only being able to designate a South American origin for the clade. The study of morphological variation of an ontogenetic series of specimens of *B. mazeas*i from both formations, contributes for a broader view of the species diagnosis, phylogenetic implications for more inclusive clades and for the correlation of both studied areas.

1. OBJETIVOS

- Revisar a definição da espécie *B. mazeasi* Muizon, 1988a com base em novos espécimes da Fm. Bahía Inglesa, Chile e da Fm. Pisco, Peru;
- Avaliar os caracteres de *B. mazeasi* no contexto dos demais Inioidea, enfatizando os Pontoporiidae;
- Detectar a variação morfológica dos exemplares referidos a *Brachydelphis*, holótipo e parátipo de *B. mazeasi,* tendo como base de comparação a espécie vivente *Pontoporia blainvillei*;
- Verificar correlação cronológica entre os estratos onde foram coletados os diferentes espécimes aqui estudados.

2. OS CETÁCEOS

A Ordem Cetacea é formado pelas baleias antigas, baleias com barbatanas e baleias dentadas (golfinhos e cachalotes), que correspondem às três tradicionais subordens: Archaeoceti, Mysticeti e Odontoceti, respectivamente. (Van Valen, 1968).

Dentro das muitas modificações anatômicas sofridas por esse clado, a partir de um ancestral terrestre (perda das extremidades posteriores, transformação da cauda e membro anterior nem nadadeiras) sem dúvida a mais conspícua é a telescopização do crânio (Miller, 1923). A telescopização é a sobreposição das suturas ósseas, que ao invés de apresentar um contato simples entre os ossos, apresentam-se em laminas sobrepostas (Miller, 1923). Essa característica permite a extrema modificação observada em crânios de cetáceos, sendo presente ainda que pouco marcada nos arqueocetos e misticetos e notavelmente desenvolvida em odontocetos modernos, como os Delphinida (Muizon, 1988b).

Os Delphinida, concomitantemente com a telescopização, adquirem um alto grau de assimetria e elevação do vertex craniano (Kellogg, 1928). Os nasais também aparecem modificados. Em misticetos, arqueocetos e odontocetos primitivos esses se sobrepõem à narina óssea, diferentemente do que ocorre nos Delphinida, por exemplo, onde os nasais estão posicionados posteriormente, reduzidos e bastante elevados, juntamente com o vertex (por exemplo, Iniidae, Delphinidae e Ziphiidae; Heyning e Mead, 1990). Mesmo que em Archaeoceti muitas dessas características não estejam presentes, as modificações na região ótica do crânio (relacionadas à ecolocalização) são as características que sustentam as formas fósseis (desde Pakicetidae) como Cetacea (Mesoeoceno, Gingerichet al., 1983).

As relações filogenéticas de Cetacea dentro de Mammalia, bem como dos clados dentro de Cetacea vêm sendo constantemente debatidas na literatura (Milinkovitch et al. 1993; 1994 e 1995; Geisler e Sanders, 2003; Gatesy et al. 1999; Gingerich et al., 1983; Kellogg, 1928)

Caracteres morfológicos e moleculares já foram interpretados por diferentes autores sugerindo relação entre Archaeoceti (Cetacea) e Mesonychia (condilartros extintos), como grupos-irmãos relacionados à Artyodactyla; ou entre Archaeoceti e Artyodactyla, como grupos irmãos (Gingerich et al., 1983; O'Leary & Geisler, 1999; Thewissen et al., 1998; Thewissen & Madar, 1999). Gingerich (2001) e Thewissen et al. (2001) parecem ter concordado em considerar Cetacea como um grupo monofilético e irmão de Artyodactyla, devido à estreita relação entre Archaeoceti e *Diacodexis* (um artiodáctilo primitivo). Por outro lado, o clado Hippopotamidae também tem sido proposto (Gatesy et al. 1997, 1999) como grupo irmão de Cetacea, formando o clado Cetartyodactyla e, consequentemente, caracterizando Artyodactyla como parafilético. Essa hipótese foi baseada principalmente em análises filogenéticas moleculares, porém vem sendo discutida, também, com base em caracteres morfológicos (Geisler e Uhen, 2003). Não obstante, Cetacea tem sido considerado um grupo monofilético pela maioria dos autores.

Já a questão filogenética dentro de Cetacea é confusa. Os únicos consensos parecem estar relacionados aos grupos com grande parte dos seus representantes viventes, como Delphinidae consensualmente considerado derivado e monofilético (Fig. 1).

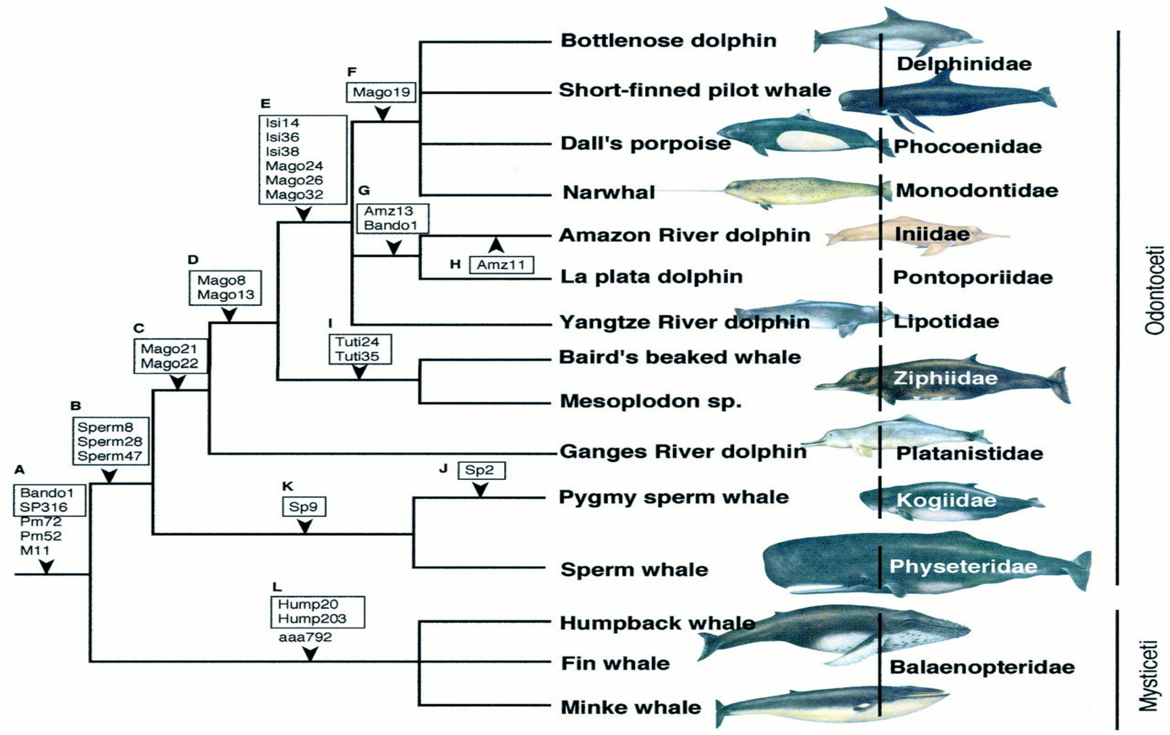

Fig. 1. Relações filogenéticas entre linhagens mais abrangentes de cetáceos. As caixas correspondem aos *loci*. (Extraído de Nikaido et al. 2001)

Os Inioidea formam um grupo com histórico complexo. Inicialmente faziam parte de Platanistidae ou "golfinhos de rio" *(river dolphins)* como eram conhecidas as espécies que atualmente habitam os rios Ganges, Indus e Brahmaputra, na Índia (Platanistidae: *Platanista gangetica* e *P. indica*), rio Yangtzé, na China (Lipotidae: *Lipotes vexliffer*), rios da região Amazônica, em diversos países da América do Sul (Iniidae: *Inia geoffrensis* e *I. bolivienesis*) e regiões costeiras-estuarinas da costa Atlântica da América do Sul (Pontoporiidae: *Pontoporia blainvillei*; Fordyce e Muizon, 2001; Fordyce e Barnes, 1994).

Estudos moleculares recentes (Cassens et al. 2000, Hamilton et al. 2001, Nikaido et al. 2001), entretanto, apontam a polifilia desse grupo. Por outro lado, estudos morfológicos e filogenéticos reconhecem a superfamília Inioidea, que inclui Pontoporiidae e Iniidae (Muizon 1988a, 1991; Arnason e Guldberg, 1996; Yang e Zhou 1999). Porém, a relação dessas com Lipotidae é controversa, podendo ser interpretados como grupos irmãos (Heyning 1989; Yang e Zhou 1999) ou basalmente relacionados à Delphinoidea e Inioidea, conformando Delphinida descrito por Muizon (1988b; corroborado por Messenger e McGuire, 1998), enquanto Platanistidae não possui relação direta com nenhuma das anteriores (Barnes, 1985).

Independente das relações de Inioidea com os demais táxons, essa superfamília vem sendo aceita como um clado monofilético (Muizon, 1988b; Hamilton et al. 2001) constituindo-se, pelo menos, de

Pontoporiidae e Iniidae. Relações de grupo-irmão foram propostas para Lipotidae (*Lipotes vexllifer*) por Cassens *et al.* (2000), com base em filogenia molecular.

3. ANTECEDENTES GEOLÓGICOS

O Neógeno marinho da América do Sul tem sido amplamente estudado sob diferentes enfoques. Estudos envolvendo invertebrados (moluscos), diatomáceas e foraminíferos (DeVries, 1998, DeVries e Frassinetti, 2003, Guzmán, 2000; Ibaraki, 1990; Marchant et al., 2000; Tsuchi, 1992) tem sido usados para desvendar a bioestratigrafia, paleoecologia e correlação cronológica dessas áreas. Registros de mamíferos marinhos também foram amplamente reportados, principalmente na costa do Peru (Muizon, 1983, 1984, 1988a; Muizon e Domming, 2002).

O registro do Neógeno marinho foi altamente influenciado pela variação do nível eustático global e a maioria das formações correspondem a sistemas transgressivo-regressivos como é o caso das Fms. Pisco (Peru; DeVries e Schrader, 1997) e Bahía Inglesa (Chile; Walsh e Hume, 2001; Achurra, 2002). Essas variações, sobretudo durante o Mioceno tem sido consideradas como responsáveis pela presença de camadas de rochas fosfáticas em diferentes localidades do Pacífico (p. ex: Fm. Monte Rey, na Alta Califórnia e na costa offshore do Peru) já que são rochas que se formam somente sob determinadas condições, entre elas formação em zonas profundas (Garrison, 1992).

Os materiais atribuídos ao odontoceto *B. mazeasi* (Gutstein et al., este volume) são provenientes de diversas localidades da Formação Pisco, no Peru e da localidade de Mina Fosforita da Formação Bahía Inglesa, Caldera, Chile. Sendo associados a rochas fosfáticas no topo da seqüência da localidade de Cerro La Bruja e na localidade de Mina Fosforita, provém somente do "bonebed" (conglomerado ossífero fosfático consolidado).

3.1- Formação Pisco

A Fm. Pisco é localizada ao Sul de Lima abrange uma área de 350 Km desde Pisco até Yauca no Sul do Peru. Foi primeiramente descrita por Adams (1908, *apud* Muizon e DeVries, 1985) e já foi posicionada em diferentes amplitudes temporais, desde totalmente Plioceno a totalmente Mioceno. Nos últimos 20 anos, porém, vem sendo revisada e geralmente é atribuída ao intervalo Mesomioceno-Plioceno (Muizon e DeVries, 1985; DeVries, 1998).

Litologicamente, é caracterizada pela presença de arenitos e diatomitos, intercalados com cinzas vulcânicas de tons amarelo a branco. Representa um grande sistema transgressivo (Muizon e DeVries, 1985). Sendo que DeVries e Schrader (1997) propõem que a base da Fm. Pisco corresponde a uma transgressão mesomiocênica, começando entre 16 a 14 Ma, o que resultou na deposição de 150m de sedimento na porção norte da Bacia de Pisco, tendo apenas metade dessa espessura na porção central da mesma. Por isso, a base da Fm. Pisco é considerada diacrônica ao longo da Bacia de Pisco, variando de 14Ma no Norte a 10Ma no Sul.

Pela sua grande extensão e, em alguns casos, pouca exposição dos sedimentos, torna-se difícil correlacionar as camadas nas diferentes localidades expostas. O zoneamento com moluscos obteve menor resolução que as datações radiométricas (Muizon e Belon, 1980; 1986), já que camadas de cinzas vulcânicas são abundantes nessa Formação (Muizon e DeVries, 1985). Em uma tentativa de ordenar biostratigraficamente as camadas de localidades afastadas, Muizon e DeVries (1985) criaram níveis de vertebrados dentro das localidades estudadas até aquele momento (Sacaco, Sudsacaco, Montemar, Aguada de Lomas, El Jahuay e Cerro la Bruja). Esses níveis teriam o papel de ordenar camadas isoladas dentro da mesma formação e foram propostos com base na presença/ausência de restos de tubarões, peixes ósseos (Teleósteos), quelônios, crocodilos, aves e mamíferos, incluindo cetáceos (odontocetos e Mysticetos), focas e edentados (Tab. 1).

Muizon e DeVries (1985) identificaram um táxon endêmico, cf. Pontoporiidae nov. gen. nov. sp.1, para a localidade de Cerro la Bruja (CLB), que seria portanto, fóssil guia para o nível vertebrado CLB, identificado a partir dessa localidade, que corresponderia a Mioceno. Essa nova espécie foi posteriormente descrita como *B. mazeasi* por Muizon (1988a). Essa localidade não foi incluída no perfil composto de Muizon e DeVries (1985; Fig. 2), mas estaria abaixo da coluna já que, na opinião dos autores, seria a localidade mais antiga, correspondendo ao Meso-Neomioceno. Posteriormente, DeVries e Schrader (1997) atribuíram essa localidade ao Mesomioceno e descreveram uma camada fosfática consolidada (hardgrounds) que poderia corresponder ao episódio de baixo nível eustático e compressão regional ocorridos entorno dos 10Ma. Essa hipótese é contrária ao observado por Garrison (1992) que relaciona a deposição de rochas fosfáticas com os períodos de alto nível eustático.

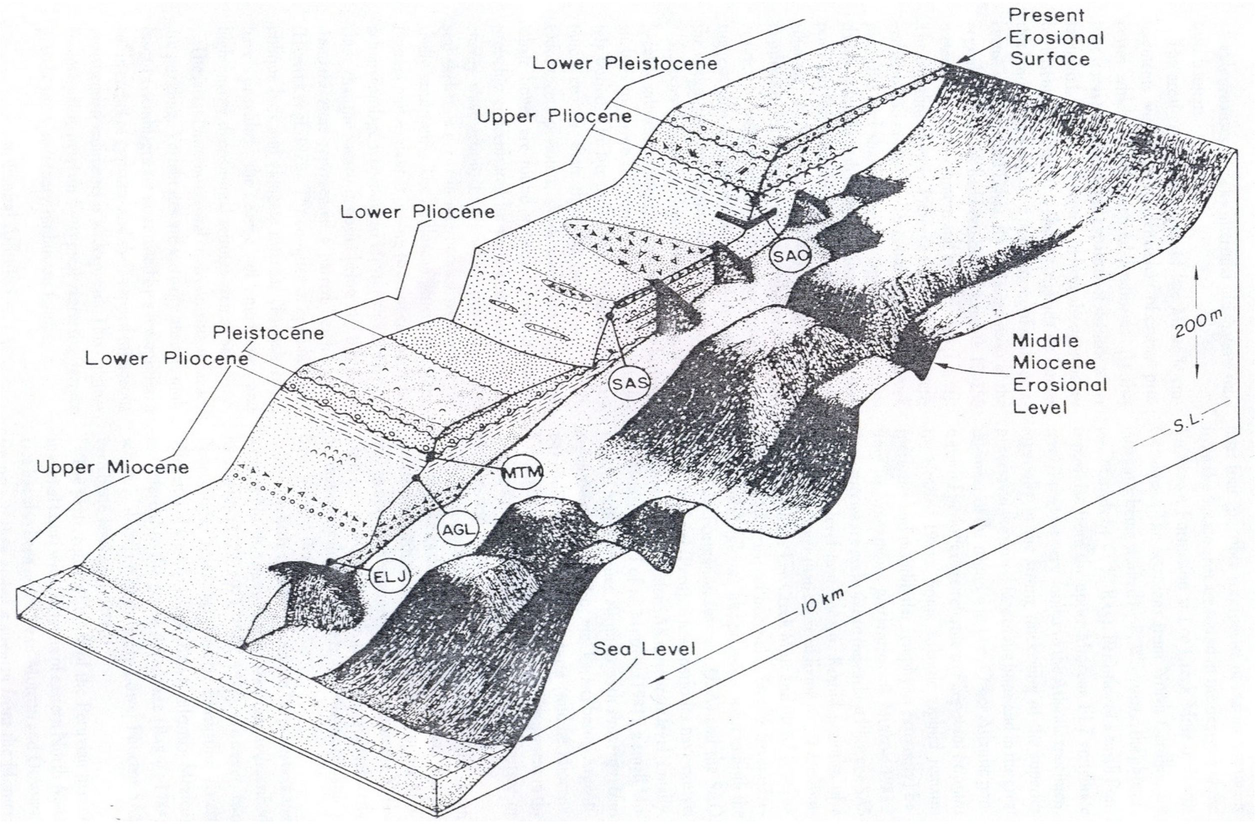

Fig. 2 – Reconstrução generalizada da topografia da Formação Pisco. Litologias principais e inconformidades são indicadas, com uma posição estratigráfica aproximada dos níveis vertebrados. Extraído de Muizon e DeVries (1985). ELJ, El Jahuay; AGL, Aguada de Lomas; MTM, Montemar; SAS, Sud-Sacaco; SAO, Sacaco. O nível de vertebrados Cerro la Bruja (CLB) não foi incluído, porém estaria abaixo de El Jahuay (ELJ) segundo os autores.

Pelo menos a localidade de Corre Viento (Ocucaje, Ica), onde alguns dos materiais estudados aqui foram encontrados, seria aproximadamente correlato a base do Cerro la Bruja (L. Brand com. pess., 05/2005), porém estudos mais detalhados de correlação das camadas e afloramentos são necessários para corroborar as correlações com as demais localidades.

Aspectos tafonômicos da Fm. Pisco. - Brand et al. (2004) estudaram a tafonomia de níveis mais recentes (do que os referidos em Gutstein et al., este volume) para a Fm. Pisco. Para os níveis miocênicos, somente se pode observar o estado de preservação dos materiais estudados, apresentando tanto a excelente preservação de fósseis de algumas localidades, como a total deformação de outros pela precipitação de sais quando esses entram em contato com a umidade e ficam expostos aos intempéries do deserto (R. Salas, com. pess.). Essa reação deforma a superfície externa dos materiais ósseos, tornando-a rugosa, com nódulos e protuberâncias (Ver Gutstein et al., este volume: Fig. 7D). Um dos espécimes de *B. mazeasi* (MUSM 887), da localidade de Corre Viento (Ica) está articulado e apresenta fossilização semelhante ao observado por Brand et al. (2004) para as baleias da localidade de Cerro Blanco (Ocucaje, Ica) que corresponde a níveis mais recentes (Mioceno-Plioceno).

Os diatomitos claros, abundantes nessa área (Cerro Blanco), bem como na maior parte da Formação Pisco, sugerem um mar raso e com grande aporte de nutrientes, com eventuais tempestades (estruturas hummochy), que traziam um massiva quantidade de plâncton (diatomáceas) que se depositava em uma taxa extremamente elevada (Brand *et al.*, 2004). A deposição desses diatomitos possibilitou, por exemplo, a extrema preservação de baleias (*Baleonoptera* sp.) em Cerro Blanco, Ica; inclusive com um caso de conservação de tecido de barbatana (baleen) de baleia (Brand *et al.*, 2004).

3.2- Formação Bahía Inglesa

A Fm. B. Inglesa foi primeiramente descrita por Rojo (1985) quem designou que sua seção tipo corresponde à área em frente à praia de Bahía Inglesa, próxima à cidade de Caldera (localidade “Mina fosforita”). Foi recentemente revisada e emendada por Marquardt et al. (2000), correspondendo a sedimentos marinhos depositados durante o Neógeno. A gênese e o sistema deposicional da Fm. B. Inglesa foram estudadas recentemente por Achurra (2004) que propôs 3 seqüências transgressivo-regressivas desde o MesoMioceno até o Neoplioceno.

Achurra (2004) descreveu 9 unidades litológicas para o Neógeno da Bacia de Caldera, das quais oito (1-8) seriam parte da FBI e a nona corresponderia aos estratos de Caldera (Pleistoceno) descrita por Marquardt (1999). A seqüência 2 pôde ser observada na localidade de “Mina Fosforita”, já que apresenta uma sucessão de fácies bem marcadas: coquinas intercaladas por arenitos, seguidos por arenitos fosfáticos, conglomerados fosfáticos não consolidados e conglomerados fosfáticos cimentados com nódulos, formados em profundidades entre 45 e 180m (Blatt *et al.* 1972 apud Achurra, 2004), também seguidas de sedimentos finos (siltitos, diatomitos) (Gutstein et al, este volume:Fig.1).

Garrison (1992) classificou as rochas fosfáticas em três tipos: F-, P- e D-fosfato, de acordo com a sua origem e processo diagenético. O “bone-bed” ou “fosforita” da Fm. B. Inglesa (Walsh and Hume, 2001) teria três tipos de fosfatos, como descrito acima. Dois dos tipos descritos por Garrison (1992), P- e D-fosfatos, foram identificados para a esses níveis na F. B.Inglesa (Achurra, 2004). Esses foram identificados para a localidade “Mina Fosforita” (Unidade 5 de Achurra, 2004) e corresponderiam ao conglomerado não consolidado e ao conglomerado cimentado com nódulos, respectivamente (Gutstein et al, este volume:Fig.1). O arenito fosfático possui características intermediárias aos tipos F- e P-fosfatos, sendo mais semelhante ao F-fosfato. Entretanto, existe a possibilidade de que alguns elementos tenham sofrido transporte, já que ocorrem bioclastos e não ocorre nenhuma estrutura sedimentar bem definida. Portanto, não se exclui a possibilidade de que essa camada corresponda a algum tipo litológico diferente, do qual não se poderia precisar a história genética.

É importante ressaltar que o D-fosfato, em geral, é formado por outros tipos de fosfatos retrabalhados, o que é corroborado por características (p. ex., o tipo de fraturas) que sugerem retrabalhamento dos fósseis, tanto nos observados em campo quanto nas coleções científicas.

Cabe ressaltar que o ciclo de fosfogênese de Garrisson (1992) foi montado com base em materiais de poços de perfurações da costa do Peru e da Alta Califórnia, podendo estar geneticamente ligados aos fosfatos da Fm. B. Inglesa, tendo em vista a singularidade das condições para formar esse tipo de rocha. Além disso, essas provavelmente foram formados em ciclos transgressivo-regressivos que acompanham níveis eustáticos globais (com algumas variações; Achurra, 2004) e as rochas fosfáticas da Fm. B. Inglesa parecem ser sincrônicas com o pico de formação de D-Fosfato na Formação Monte Rey (Messiniano-Tortoniano; Garrisson, 1992).

A antiguidade dos sedimentos em questão tem sido discutida recentemente. Marquardt (1999) realizou uma datação, através do método de K-Ar, numa camada de cinza retrabalhada acima do “bone-bed”, na localidade Morro Copiapó (Gutstein et al, este volume: Fig.1) de 7,6±1,3. Achurra (2004) considera essa idade inválida porque corresponderia à idade de camadas abaixo dessa, já que as cinzas utilizadas para a datação seriam retrabalhadas. Achurra (2004) também propôs uma série de datações, com o método de isótopos de Sr, que utiliza curvas de concentrações de Sr nos oceanos durante o Neógeno (ver

Achurra, 2004). A unidade 5 proposta por aquele autor, corresponde a unidade que abrange a fosforita e foi datada em 6,8 milhões de anos em sua porção médio-superior (Messiniano, Neomioceno), para a localidade Morro Copiapó. Estudos bioestratigráficos com moluscos (Guzmán et al. 2000), e microfósseis (Tsuchi, 1992) parecem concordar com essa idade. As associações de vertebrados indicam que esses níveis correspondam ao Neomioceno, Tortaniano-Messiniano (Walsh e Hume, 2001; Walsh e Naish, 2002; Suárez e Marquardt, 2003; Walsh e Suárez, 2005).

Análises bio e cronoestratigráficas com foraminíferos também foram feitas para a F. B. Inglesa, sendo que Marchant et al. (2000) obtiveram idade Eoplioceno em camadas abaixo do "bone-bed", correspondente à zona de foraminíferos N19, caracterizada pela presença de *Globigerina calida*, enquanto que Achurra (2004) não obteve zonas muito refinadas para esse intervalo (biozona com amplitude entre 10 e 2 M.a.). Marchant et al. (2000) também propõem apenas uma seqüência transgressivo-regressiva no Neógeno Superior, em desacordo com o proposto como modelo geral para a costa do Chile e do Peru (Marchant et al.2000), diferente das três seqüências propostas por Achurra (2004).

Walsh e Suárez (2005) propuseram a subdivisão da Fm. B. Inglesa em três membros. Essa divisão foi baseada em 3 unidades descritas anteriormente (Walsh e Hume, 2001) para a localidade do Morro Copiapó: Membro Morro (Unidade 1); membro "bone-bed" (Unidade 2), e Membro Lechero (Unidade 3), que estaria dentro do Plioceno 4,5 a 2,6 Ma., baseado em estudos de diatomáceas e foraminíferos (Tsuchi et al. 1988 e Ibaraki 1995, apud Walsh e Naish, 2002). Segundo Walsh e Suárez (2005) o "bone-bed" corresponde a uma fosfatita (*sensu* Slansky 1986 *apud* Walsh e Suárez, 2005) com extensão lateral de 4 km, e conforma a base do Membro Bonebed, que apresentaria 77% (em sua maioria fragmentário) dos restos de vertebrados da Fm. Bahía Inglesa. As subdivisões descritas acima, não concordam com o modelo proposto por Achurra (2004), sendo que separam a seqüência transgressivo-regressiva 2 (e principalmente da unidade 5; deste autor). Tendo em vista que o modelo do último autor é mas, foi esse o adotado no presente trabalho para referir-se à Fm. B. Inglesa.

Embora as datações de Achurra (2004) apontem uma idade mais jovem a formação, Neomioceno – Eoplioceno, e tenha datações de 3,7 M.a. na localidade "Mina fosforita", essa corresponderia a unidade 6. A datação com Sr na unidade 5, que contém as camadas de fosfatos (bone-bed) de 6,8 M.a sugere uma idade miocênica para os fósseis do “bone-bed” na localidade Morro Copiapó, que é correlato com o “bone-bed” da localidade “Mina Fosforita”. Isso porque o Morro Copiapó foi levantado (soerguido) durante o período de deposição da Fm. B. Inglesa (Walsh e Suárez, 2005, Achurra, 2004), ou seja, a falha localizada na base do Morro Copiapó estava ativa durante o Neomioceno (Fig. 3). Os materiais referidos a *B. mazeasi* e cf. *Brachydelphis* (nova forma; Gutstein et al., este volume) coletados no Chile, bem como todos os taxa citados na Tabela 1 como pertencentes à Fm. B. Inglesa, provém desse “bone-bed”.

Aspectos tafonômicos da Fm. B. Inglesa. - Na Fm. B. Inglesa há uma abundância maior de fósseis concentrados em sua maioria em uma camada de 40cm (com grande variação horizontal de espessura). A presença de indivíduos adultos e juvenis poderia ser utilizado para uma argumentação catastrofista, porém indivíduos jovens de *P. blainvillei* são comumente encontrados mortos nas praias. Além disso, um estudo tafonômico preliminar realizado para o “bone-bed” revelou uma alta taxa de fósseis fraturados (aproximadamente 100% dos fósseis manipulados nesse trabalho possuíam algum grau de fraturamento, nenhum crânio completo foi observado). Esse fato associado a uma “boa” preservação (presença de detalhes anatômicos, como suturas e foramens) na maioria dos espécimes, salvo os casos de fusão do fóssil com a matriz fosfática, torna intrigante a gênese desse depósito. No entanto, o fraturamento observado é marcadamente característico de fratura em material previamente substituído (Reif, 1971 apud Holz, 2002).

A hipótese de retrabalhamento poderia explicar a grande abundância e diversidade, que seriam então, tafonomicamente criadas, já que há evidências que os fósseis foram transportados depois de exumados do depósito original, sendo redepositados no “bone-bed”.

Uma provável idade para a deposição e soterramento primários seria, pelo menos, do Tortoniano médio (também Neomioceno) quando o nivel médio do mar ainda se mantinha alto (fim da seqüência 1; Fig, 4), conservando sua profundidade máxima (MFS – maximal flooding surface), ou o máximo transgressivo. Após esse período, ocorreu uma queda expressiva do nível médio do mar ocasionado por uma taxa de subsidência alta de 0,68 para a Bacia de Caldera (Achurra, 2004), alterando assim o nível de base das ondas e possibilitando o retrabalhamento de depósitos anteriores. Esse período de intenso retrabalhamento, no qual o nível médio do mar (NMM) ficou baixo até os 3,7 M.a., proporcionou uma camada muita rica em material fosfático. Uma nova subida do NMM, a partir daquele momento, criou as condições necessárias para a formação dos abundantes nódulos de fosfato que ocorrem acima do “bone-bed”.

O alto grau de retrabalhamento observado poderia indicar que ocorreu um expressivo “time-averaging” na tafocenose, porém, não foram observados diferenças no modo de fossilização entre os fósseis (exceto deterioração por intemperismo atual).

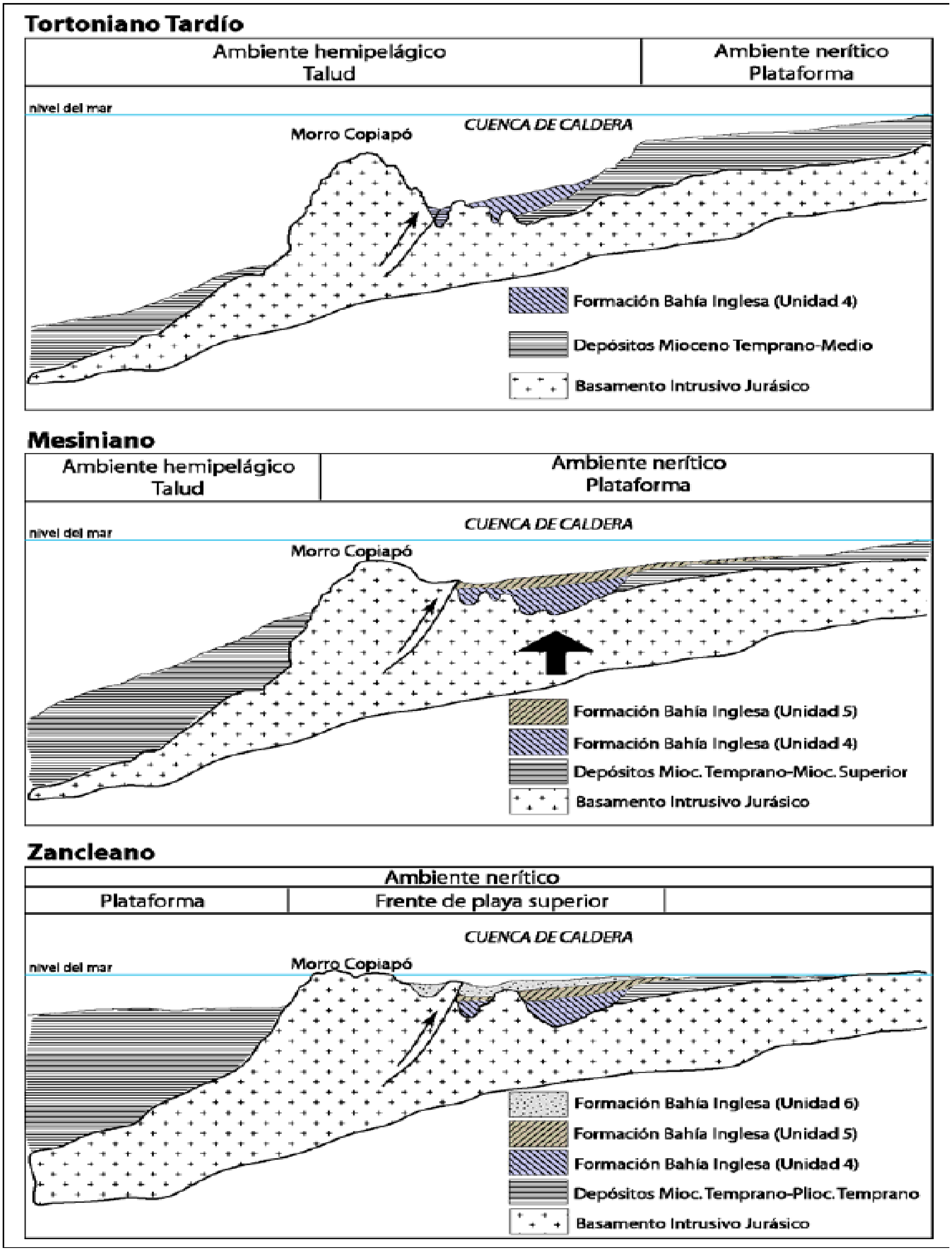

Figura 3. Reconstrução paleogeográfica da zona ocidental da Bacia de Caldera. Estão representadas somente as unidades estratigráficas depositadas sintectonicamente a atividade da falha inversa que levantou o Morro de Copiapó. Extraído de Achurra (2004).

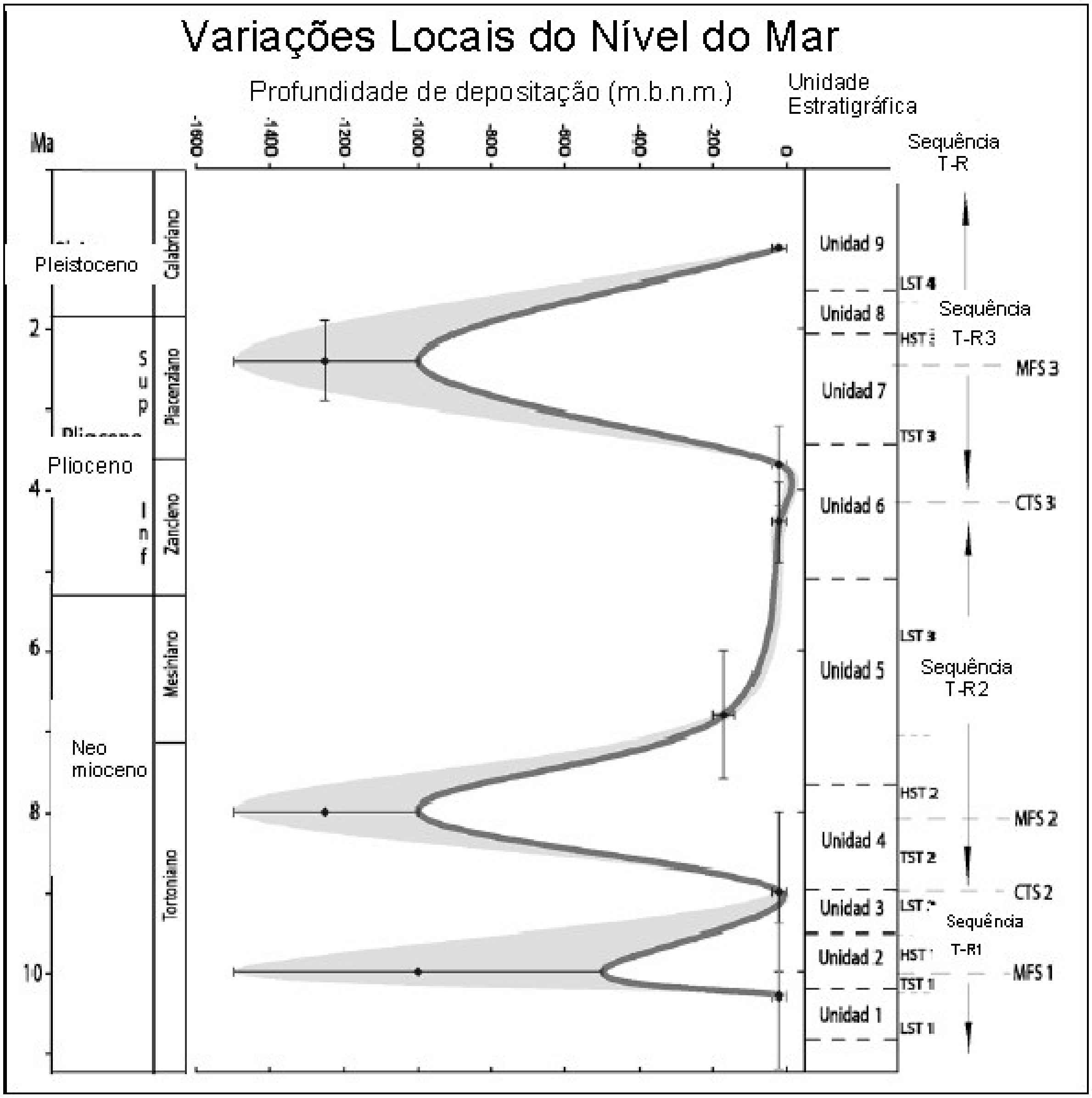

Figura 4. Curva de variações locais do nível do mar na bacia de Caldera. As profundidades obtidas da análise de foraminíferos correspondem ao valor mínimo. Na coluna da direita estão as unidades estratigráficas definidas por Achurra (2004). Os contatos com linha descontínua, entre as unidades, correspondem a aquelas onde não se tem certeza da sua localização temporal. Na última coluna da direita estão representadas as seqüências transgressivo-regressivas definidas por Achurra (2004), com seus contatos respectivos. CTS) Extraído de Achurra (2004).

3.3. Correlações bio e cronoestratigráficas entre as Formações B. Inglesa e Pisco.

Poucos estudos foram realizados com o intuito de correlacionar as duas formações. DeVries e Frassinetti (2003) DeVries e Frassinetti (2003) propuseram a existência de uma barreira climática entre o Chile e o Peru no Neógeno (águas quentes no Peru e frias no Chile) com base na distribuição (Bioestratigráfica e geográfica) da malacofauna de modo que as semelhanças observadas entre as faunas de moluscos chilena e peruana, observadas por Guzmán et al. (2000) representavam eventos episódicos e se deviam a eventos de El Niño que poderiam transportar larvas de moluscos para as águas chilenas. No entanto, essas barreiras não parecem haver atuado para táxons de tubarões, mamíferos aquáticos e aves marinhas, com formas presentes em ambas as formações (Suárez e Marquardt, 2003, Walsh e Naish, 2002; Walsh e Naish, 2001).

Associações faunísticas entre as duas formações foram propostas informalmente (p. ex., Suárez et al. 2005, Tabela 1), com base em alguns gêneros e espécies comuns, como, por exemplo, a espécie *B. mazeasi* (Gutstein et al., este volume:Fig.1). Porém os "níveis de vertebrados" de Muizon e DeVries (1988) não podem ser caracterizados para a Fm. B. Inglesa, já que há discordâncias nas associações de faunas de alguns níveis, como por exemplo, *P. littoralis* como indicador de Plioceno (Tabela 1, Muizon & DeVries, 1985), que aparece no mesmo nível que os demais Pontoporiidae assignados a Mioceno em todas as formações que foram descritos. Algumas semelhanças marcantes puderam ser observadas e utilizadas para correlacionar as duas formações (Tab. 1).

A presença de *Acrophoca* sp. (Monachinae, Phocidae) abaixo do "bonebed" (FBI), no topo do Membro Morro (Walsh e Naish, 2002) equivalente à porção médio-superior da unidade 5 (Achurra, 2004) indica que essa não pode ser mais antiga que Mesomioceno, já que esta seria a idade para o aparecimento de Monachinae (Muizon, 1982). A primeira ocorrência de *Acrophoca* sp. (Muizon e DeVries, 1985) na Fm. Pisco é no Neomioceno concordando com uma idade Messiniana para o topo do Membro Morro (Walsh e Suárez, 2005; meso unidade 5 de Achurra, 2004). Walsh e Suárez (2005) consideraram que mesmo que a assembléia de tubarões seja dominada por *Cosmopolitodus hastalis*, *Carcharodon carcharias* também está presente (com menor abundância) no "bone-bed". A presença de dentes dessas espécies tem sido

Tabela 1 – Lista da fauna (parcial) correlata entre as Formações Pisco e Bahía Inglesa. * registros retirados de Muizon e DeVries (1985), atualizados segundo Muizon (1988); +, presença; (+) presença registrada no presente trabalho.

Taxa	**Fm. Pisco***		**Fm.B.Inglesa**	**Autores registros Fm.B. Inglesa**
	Mioceno	**Plioceno**	**“bonebed”**	
Chondricthyes				
Cosmopolitodus hastalis	+		+	Suárez e Marquardt, 2003
Charcarodon carcharias		+	+	Suárez e Marquardt, 2003
Charcharocles megalodon	+	+	+	Suárez e Marquardt, 2003
Aves				
Procellaridae				
Procellaridae indet.		+		
Pachyptilla sp.			+	Salaberry et al., no prelo
Sphenicidae				
Sphenicidae indet.			+	Walsh e Hume, 2001
Sphenicidae indet. 1		+		
Sphenicidae cf. *Spheniscus*	+	+		
Paleospheniscus			+	Hospitaleche e Canto, 2005
Sulidae	+	+	+	Walsh e Hume, 2001
cf. *Sula* sp.	+	+		
Phalacrocoracidae	+	+	+	Walsh e Hume, 2001
cf. *Phalacrocorax* sp.	+	+		
Pelagornithidae				
Pelagornithidae indet.			+	Walsh e Hume, 2001
cf. Pelagornithidae indet.	+	+		
Reptilia				
Crocodiliformes	+	+	+	Walsh e Suárez, 2005
Mammalia				
Pinnipedia				
Pinnipedia indet.			+	Walsh e Naish, 2002
Phocidae				
Acrophoca			+	Walsh e Naish, 2002
Piscophoca aff. pacifica			+	Walsh e Naish, 2002
Phocidae indet.			+	Walsh e Naish, 2002
Cetacea				
Pontoporiidae				
Pliopontos littoralis		+		
cf. *Pliopontos*			+	Canto et al., 2002
Brachydelphis mazeasi	+		(+)	Gutstein et al. no prelo
cf. *Brachydelphis* n. forma	(+)		(+)	Gutstein et al. no prelo
cf. *Brachydelphis* indet.	(+)		(+)	Gutstein et al. no prelo
cf. *Pontistes*			(+)	Observação pessoal
Phocoenidae				
Phocoenidae indet.			+	Quilodrán, 2002
Piscolithax longirostris		+		
Australithax	+			
Lamacetus	+			

utilizadas para diferenciar sedimentos Miocênicos de Pliocênicos na Fm. Pisco e na FBI (e.g., Muizon e DeVries 1985; Walsh e Hume 2001; Walsh e Naish 2002), mas a presença de *C. carcharias* nessas camadas bem datadas como Mioceno sugerem que se deve ter cautela no seu uso para correlações cronoestratigráficas (Walsh e Suárez, 2005; Suárez e Marquardt, 2003).

A assembléia de ambas as formações ainda é subestimada levando-se em conta a grande quantidade de materiais referidos a grupos taxonômicos muito abrangentes (Tabela 1) e a abundância de espécimes inéditos já coletados observada nos museus visitados, necessitando-se de estudo exaustivo para esgotar a descrição e classificação dessa diversa e abundante fauna neógena.

4. PALEOBIOGEOGRAFIA DOS ODONTOCETOS NO NEÓGENO

O registro dos cetáceos fósseis é bastante estudado na América do Norte e Europa (Fordyce e Barnes, 1994). Esse registro compreende desde o Eoceno do Egito (Gingerich, 1983) e Eoceno a Plioceno do Atlântico Norte (Hulbert e Petkewich, 1991; Kellogg, 1928) até o Neógeno do Mediterrâneo (Pilleri, 1986; Bianucci, 1996; 1997). No Hemisfério Sul, o Pacífico Ocidental (costa Oeste) apresenta amplo registro, do Eoceno ao Pleistoceno, na Nova Zelândia (Fordyce 1992, 1983, 1994, 2002). Na América do Sul, até 1980, esses estudos eram concentrados no Oceano Atlântico, em especial nos depósitos Neógenos (fluvial e marinho) da Patagônia Argentina (Cozzuol, 1996). Na década de 80, a costa Leste do Pacífico Sul foi mais intensivamente estudada, na Formação Pisco, Peru (de Muizon, 1983; 1988b; 1988c).

Os odontocetos modernos em geral pertencentes ao clado Delphinida (Delphinoidea, Inioidea e Lipotoidea; *sensu* Muizon, 1988b) aparecem no registro no fim do Oligoceno e início do Mioceno, tornando-se diversificados durante o Neógeno. Delphinoidea (*sensu* Muizon 1988b) inclui o grupo mais diverso atualmente, os Delphinidae, que apareceram no Mesomioceno e se fizeram dominantes durante o Neomioceno e Plioceno. Esse aumento de diversidade se deu concomitantemente com o declínio de famílias que eram muito diversificadas durante o Oligoceno superior e Eo-Mesomioceno, como por exemplo, Kentriodontidae (Fordyce e Barnes, 1994; Fordyce e Muizon, 2001 Cozzuol, 1996). Lipotoidea apresenta, atualmente, apenas uma espécie *Lipotes vexliffer* e suas relações com Inioidea são confusas, tornando os registros fósseis atribuídos a esse clado também confusos. Inoidea era também mais diversificado durante o neógeno, contando com apenas dois gêneros atuais (*Pontoporia* e *Inia*).

A família Pontoporiidae apresenta sua maior diversidade no registro fóssil do Meso-Neomioceno. Apresenta 3 gêneros, no intervalo Mesomioceno-Plioceno (Cozzuol, 1996): *Pontistes, Brachydelphis* e *Pliopontos*, sendo os dois primeiros restritos ao Mioceno. *Pontistes rectifrons* Burmeister, 1885 foi primeiramente descrito para a Fm. Ituzaingó, Argentina e possui registro duvidoso (material não comparável ao holótipo) no Neomioceno da Formação Solimões no Acre (Negri et al, 1999); *Pliopontos littoralis* Muizon 1983 foi descrito para a FM. Pisco, no Peru, e *Pliopontos* sp. foi registrado para as Fs. Bahía Inglesa e Coquimbo, no Chile (Canto e Cozzuol, 2002; Canto *et al.,* 2002). Um registro recente e ainda inédito indica a presença de uma espécie de pontoporídeo para a Fm. Puerto Madryn (Neomioceno) da Patagônia Argentina (Cozzuol, com. pessoal, 12/2005). Muizon (1988b) agrupou esses dois últimos gêneros, junto com *Pontoporia* (Pleistoceno - Recente), para formar a subfamília Pontoporiinae, caracterizada por possuir rostro longo e vértex simétrico.

Brachydelphis mazeasi Muizon, 1988 foi descrito com espécimes do Mesomioceno da localidade de Cerro la Bruja, na Formação Pisco, Peru. Esse gênero monoespecífico foi alocado em uma nova subfamíla, Brachydelphinae (Muizon, 1988a) que seria caracterizada por apresentar um rostro muito curto e vertex assimétrico.

Apesar da predominância de registros na América do Sul, registros mais recentes e novas interpretações, ainda que fragmentários, tem sido reportados para o Atlântico Norte (Whitmore ,1994; Lambert, 2005).

A família Pontoporiidae possui apenas um representante atual, *Pontoporia blainvillei,* que ocorre nas costas brasileira, uruguaia e argentina (Siciliano, 1994; Crespo et al. 1998) sendo abundante nas regiões costeiras e estuarinas do estado do Rio Grande do Sul (Sechi et al., 2001). Essa espécie também possui registros pleistocênicos no Rio Grande do Sul (Ribeiro *et al*. 1998), apresentando-se muito similares aos espécimes atuais, porém com assimetria no vertex. Certo grau de assimetria pode ser observado com freqüência em espécimes atuais de *P. blainvillei*, de modo que essa característica isolada não indica uma diferença com significação taxonômica.

Uma vez que o registro fóssil de Pontoporiidae, durante o Neógeno, é completamente divergente do atual, a paleobiogeografia desta família torna-se intrigante. O registro de pontoporídeos é mais abundante e mais antigo na América do Sul. O consenso em reconhecer a Pontoporiidae e Iniidae como grupos irmãos e a distribuição dos Iniidae restrita à A. do Sul, sugerem que o ancestral de ambos clados deveria se encontrar no litoral sul-americano, sem poder se precisar se na costa pacífica ou atlântica.

Brachydelphis mazeasi é a espécie mais antiga (Mesomioceno) referida à família Pontoporiidae, e tem sido interpretado como indicador da origem Pacífica para a família (Banguera-Hinestroza et al., 2002). A partir desse registro, foi calibrado o tempo de divergência entre Pontoporiidae e Iniidae para o Mesomioceno (11,2 a 16,4 MAAP), utilizando um relógio molecular baseado na taxa de mutação genética entre *Inia boliviensis*, *I. geoffrensis* e *P. blainvillei* que outorgou um intervalo de 8,8 a 17,6 milhões de anos para essas famílias.

Recentes achados e reinterpretações de espécies já descritas têm estendido o registro dos pontoporídeos até o Atlántico Norte (Whitmore, 1994; Lambert, 2005) para o Eoplioceno. A idade destes registros sugere mais uma dispersão tardia do que uma eventual origem naquela área.

5. A IMPORTÂNCIA DOS MATERAIS DE *B. MAZEASI* NO ESTUDO DA VARIAÇÃO MORFOLÓGICA EM ODONTOCETOS

Estudos de variação morfológica em cetáceos estão sendo aplicados com maior frequência para detectar diferenças populacionais, sexuais ou entre espécies viventes de cetáceos (Higa *et al.*, 2002; Monteiro-Filho *et al.*, 2002; Pinedo, 1991). Fósseis de cetáceos em bom estado de conservação são raros e o número de exemplares é reduzido. Assim, assumem extrema importância para o conhecimento das espécies e para a consolidação de caracteres morfológicos que, em uma série de material completo, podem ser comparados e verificados, aumentando a confiabilidade de cada caractere. Isto é particularmente importante para clados nos quais a maioria dos táxons está extinta, como no caso dos Pontoporiidae.

Além disso, a análise da variação morfológica pode informar sobre a amplitude da variação morfológica e permitir a identificação de caracteres taxonômicos que sirvam para diferenciar as espécies estudadas fornecendo subsídios importantes para a sistemática e filogenia do grupo (Perrin, 1975; Purves e Pilleri, 1986). O material disponível para este estudo constitui-se num raro exemplo de uma série de espécimes fósseis praticamente completos e bem preservados, indispensável para este tipo de análise. O estudo da variação morfológica ganha importância sobretudo, tendo em vista que o material até hoje conhecido para Inioidea da América do Sul é extremamente fragmentário (Cozzuol, 1996).

Esse estudo contribuirá para um melhor conhecimento morfológico e evolutivo dos Pontoporiidae, na medida em que permitirá uma comparação entre uma série de espécimes do Mioceno da Formação Bahía Inglesa e da Formação Pisco, com indivíduos da única espécie vivente deste grupo, que ocorre na costa Oeste do Atlântico Sul, *Pontoporia blainvillei*.

Paralelamente, a ocorrência de indivíduos da mesma espécie (*B. mazeasi*), em camadas geneticamente similares, dentro das Formações Pisco, no Peru, e Bahia Inglesa, no Chile, contribui para o refinamento bio e cronoestratigráfico entre estas unidades, bem como para um melhor conhecimento do Neógeno do Pacífico Sul Oriental como um todo.

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SKULL VARIATION OF *BRACHYDELPHIS* (CETACEA, ODONTOCETI, PONTOPORIIDAE) FROM SOUTH-EASTERN PACIFIC NEOGENE.

VARIAÇÃO DO CRÂNIO DE BRACHYDELPHIS (CETACEA, ODONTOCETI, PONTOPORIIDAE) DO NEÓGENO DO PACÍFICO SUL ORIENTAL.

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Skull variation of *Brachydelphis*

SKULL VARIATION OF *BRACHYDELPHIS* (CETACEA, ODONTOCETI, PONTOPORIIDAE) FROM SOUTH-EASTERN PACIFIC NEOGENE.

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ABSTRACT

Brachydelphis maseazi Muizon 1988, from Pisco Formation (Middle Miocene, Peru), is an odontocete originally known by two incomplete skulls and a few associated postcranial elements, assigned to the family pontoporiidae and to a new subfamily, Bachydelphinae. The holotype is a juvenile because it has no alveolar septa and open cranial sutures. This is important since some of the diagnostic features are actually juvenile features and not taxonomic significant traits. Here we offer a more comprehensive view of the morphology and variation of these taxon with new specimens from both Pisco and Bahía Inglesa Formation (Chile). A revision of the description of Muizon (1988), comparatively with other taxa of Inioidea clade and a morphometric (geometric and traditional) analysis, compared to *Pontoporia blainvillei* (living Pontoporiidae), are also provided. The shape variation of fetuses, young and adult specimens of *P. blainvillei* were compared to juvenile and adult specimens of *B. mazeasi* to evaluate ontogenetic, individual, intra and interespecifical variation.

Key words: *Brachydelphis mazeasi*; skull variation; Bahía Inglesa Formation; Pisco Formation; Neogene; Pontoporiidae; Inioidea

Brachydelphis maseazi is a fossil odontocete with a short rostrum found in the Middle Miocene levels of the Pisco Formation of Peru. This species was described based in two partial skulls, associated bulla, periotic and a few post cranial remains. This taxon was referred to a new subfamily by Muizon (1988a) mainly due to its short rostrum. Muizon (1988b) considered this taxa as a basal Pontoporiidae within the subfamily Brachydelphinae, differing of the other by the absence of the reversal conditions of two characters in the remaining Pontoporiidae (subfamily Pontoporiinae, *sensu* Muizon, 1988b): reappearance of lateral lamina of pterygoid and acquisition of symmetrical vertex.

The record of Pontoporiidae ranges from Middle Miocene to Recent and is mostly restricted to South America. However, North Atlantic fragmentary records have been assigned to the family more recently, sucha as: cf. *Pontoporia* from the Pliocene of Yorktown Formation (USA) and *Protophocaena minima* from Europe (Whitmore, 1994; Lambert, 2005). The oldest record is *B. mazeasi*, from Pisco Formation (Muizon, 1988a), followed by *Pontistes rectifrons* from early Late Miocene, Paraná F. (Argentina; Burmeister, 1885; Cione et al., 2000), and *Pliopontos littoralis* Muizon, 1983, from the Pliocene levels of Pisco F., Peru, recently reported also for Coquimbo F., Chile (Canto et al. 2002). New records of *Pontistes*, *Pliopontos* and *Brachydelphis* have been mentioned for the Late Miocene Bahía Inglesa Formation, Chile (P. Quilodrán and J. Yañez, in litt; J. Canto and M. A. Cozzuol, in litt; C. S. Gutstein, in litt.). The Recent genus, *Pontoporia*, is recorded with doubts for the Late Miocene in Argentina (Cozzuol, 1985) and the living species for Pleistocene units from Argentina and Southern Brazil (Cozzuol, 1996; Ribeiro et al. 1998). Presently, the family is restricted to Southern Atlantic Ocean from Espírito Santo (Brazil) to Península de Valdés, (Argentina) coasts, with a single species, *Pontoporia blainvillei* (Siciliano, 1994; Crespo et al. 1998).

The phylogenetic relationships of Pontoporiidae are controversial. Initially this clade was put together with the so called “river dolphins”, (Iniidae, Platanistidae and Lipotidae) considered as Platanistoidea or Platanistidae (for a revision see Barnes, 1985). But several further analysis have found different afinities between those taxa. Different additional analysis conclude that this clade is not a monophyletic group, and its external similarities were considered convergences (but see Geisler & Sanders, 2003). There are consensus about the monophyly of Inioidea (Pontoporiidae + Iniidae; Muizon 1988a, 1991; Arnason & Guldberg, 1996; Yang and Zhou 1999). Sometimes Lipotidae (*Parapontoporia* + *Lipotes*) appears within this clade or as sister group of the latter (Barnes, 1985, Heyning 1989; Yang and Zhou 1999); or also as sister group of the Inioidea + Delphinoidea clade, called Delphinida by Muizon (1988b; Messenger and McGuire, 1998). Molecular studies (Cassens et al. 2000, Hamilton et al. 2001) confirm the poliphyly of “river dolphins” but also suggest the sister-group relationship of *Lipotes vexliffer* (Lipotidae) with Inioidea and Delphinoidea.

The variation within *P. blainvillei* has been the subject of several works based on skull morphometrics and molecular analysis (Pinedo, 1991; Sechi et al., 1998; Ramos et al. 2002) and was commonly justified by Northern-Southern geographic distribution disjunction, thus sub-populations organization. Geometric Morphometric studies also were carry on and two different sub-populations from the South and North Brazil were recognized (Higa et al., 2002). However, distribution hiatus often mentioned for Santa Catarina state (Brazil), between Northern and Southern sub-populations, was not confirmed since regular records and a resident population within the Babitonga bay was recently reported (Cremer and Simões-Lopes, 2005).

Fossil specimens from the bonebed, Late Miocene of “Mina Fosforita” locality (Bahía Inglesa F., Nothern Chile), are here described together with the holotype and paratype from Pisco F. (Peru), plus additional material from the same formation, but from different sites. Due to a carefully morphologic and morphometric analysis, it was possible to observe the variation of characters within this fossil species, comparatively to the living species, P. blainvillei. A new form of cf. *Brachydelphis* also could be recognized. It has the characters that usually designate *B. mazeasi* together with a distinctive large rostrum. A discussion of characters polarity and definition is also provided, since individual variation was also recognized.

ABBREVIATIONS AND TERMINOLOGY.

SGO-PV, Sección Paleontología, Museo Nacional de Historia Natural, Santiago, Chile; MNHN PPI, Museum National d'Histoire Naturell, Paris, France; MPC, Museo Paleontológico de Caldera, Municipalidad de Caldera, III Región, Chile; MUSM, Museo Nacional de la Universidad Mayor de San Marcos; UFSC, Laboratório de Mamíferos Aquáticos, Departemento de Ecologia e Zoologia, Universidade federal de Santa Catarina, Santa Catarina, Brasil. Measurements are in milimeters (mm), * means digital measures (tpsDIG; Rohlf , 2004). Terminology for description follows Barnes (1985) and Fordyce (1994, 2002).

LOCALITIES, GEOLOGY, AGE AND CORRELATION OF PISCO AND B. INGLESA F.

The materials come from neogene marine sediments belonging to the Pisco Formation in Peru and Bahía Inglesa F. in Chile. Both formations were formed by marine transgressive-regressive systems (Muizon and DeVries, 1985; Achurra, 2004) and present large neogene marine vertebrate assemblage, including fish, birds, pinnipeds and cetaceans (Muizon, 1981, 1983, 1984, 1988a; Stuchi, 2004; Walsh and Hume, 2001; Walsh and Naish, 2002; Suárez et al. 2003; Suárez and Marquardt, 2003; Sallaberry et al., in press).

The Pisco F., located Southern from Lima, ranges 350 km from Pisco to Yauca (Fig. 1; Muizon & DeVries, 1985). It has already been assigned to different temporal ranges but following DeVries and Shrader (1997) it is ranged from Middle Miocene to Early Pliocene. It presents hundreds of meters of sandstone and diatomite intercalated with volcanic ash, as a result of upwelling and increasing of diatom sedimentation rates, presenting cross-bedding hummocky structures (Brand et al. 2004). Also has been reported a phosphatic pebble-laden hardground (DeVries and Shrader, 1997).

Muizon and De Vries (1985) recognized vertebrate based levels for the Pisco F. (Sacaco, Sudsacaco, Montemar, Aguada de Lomas, El Jahuay and Cerro la Bruja) tha could correlate isolate strata from different localities by presence/absence and association of vertebrate taxa, including sharks, bony fishes, turtles, crocodiles, birds and mammals (cetaceans, seals and edentates).

From Cerro la Bruja (CLB) locality was described *B. mazeasi*, and following DeVries and Shrader (1997) and DeVries (1998) it would represent Middle Miocene or even 10mya old sediments since presents the phosphatic bed that was interpreted to correspond to the great global lowering of eustatic level occurred at this age. This observation differs from the study of Garrison (1992) that postulates that the phosphate preferential deposition occurs at high stands intervals. However, following this affirmative not compromises the Middle Miocene assignation of DeVries and Shrader (1997), once this sequence (CLB) was probably older than 10mya. There are many other localities in Pisco Formation that has no confirmed correlation with the vertebrate levels ordination, but trough observation of distinguishable layers it is possible that at least the Corre-Viento locality is correlated to the base of Cerro la Bruja, (L. Brand pers. comm.), however more study is needed.

The Bahía Inglesa F. was primarily described by Rojo (1985) who has designated the “Mina fosforita” locality (in front of Bahía Inglesa beach) as the type locality. Later it was emended by Marquardt et al. (2000a), corresponding to coquina intercalated with sandstones and roofed by phosphatic beds, that vary from phosphatic sandstone (bellow) to hardgrounds of cemented phosphate with nodules (above) passing by non cemented phosphatic conglomerates (Fig.1). Achurra (2004) has proposed three transgressive-regressive sequences, from Late Miocene to Pleistocene divided in nine lithologic units, eight of them belonging to B. Inglesa F.

The second transgressive-regressive sequence is observed in “Mina Fosforita” locality with well marked facies succession cited above, the phosphatic beds corresponds to P- and D-phosphates (Achurra, 2004), that were formed in deepness, between 45 to 180m (Blatt *et al*. 1972 after Achurra, 2004), they are followed by siltstone and diatomites in this site (Fig. 1).

The D-phosphate has an important taphonomic implication; it is mostly reworked and occurs preferentially at unconformities, as a consequence of extended periods of non-sedimentation in the marine environment (Garrison, 1992). This contributes to the interpretation of the genesis of the bonebed and is consistent to explain the great abundance, not only of taxa but also of fossil specimens. Additionally, the high degree of post fossilization fractures on fossils, once practically all specimens are broken in some degree, reasonable explained by the rework-redeposition hypothesis.

The sea-level local variation reconstruction of Achurra (2004) to Caldera basin crossed with the transgressive-regressive model proposed and Sr series dating, gave a 6.8mya antiquity to unit 5 (containing the bonebed) in its medial-upper portion, which corresponds to a Messinian age (Late Miocene). This Sr series dating differs from the K-Ar dating done by Marquardt (1999), of 7,6 ± 1,3 which was interpreted to correspond to reworked ash layer, thus would not correspond to the deposition time (Achurra, 2004). Considering that unit 5 lies on the lower stand of sequence 2, a reasonable hypothesis to the bonebed genesis would be that the first deposition of these fossils should correspond at least to the maximum flooding surface (MFS) of sequence two, occurred at Tortanian stage (8mya, Miocene). This hypothesis is corroborate by biostratigraphic mollusk data (Guzmán et al. 2000) and vertebrate association studies (Walsh and Hume, 2001; Walsh and Naish, 2002; Suárez and Marquardt, 2003; Walsh and Suárez, 2005). Other transgressive-regressive models already have been suggested (Marchant et al. 2000, Walsh and Suárez, 2005) but these models are not described in detail.

Another interesting fact is that the Cerro la Bruja locality from Pisco F. also presents a phosphatic hardground at the top of the sequence, mentioned above (DeVries and Shrader,1997; DeVries, 1998). Considering that the model for phosphogeneis was proposed by Garrisson (1992) based in samples from perforation offshore in Peru and Alta California, and that the transgressive-regressive cycles result from global eustatic levels, with some local variation (Achurra, 2004). The phosphatic rocks of B. Inglesa F. seems to be synchronize with D-phosphate of MonteRey F. (Messinian-Tortonian; Garrisson, 1992). Thus, is reasonable a provisional correlation to Cerro la Bruja and the bonebed by phosphatic occurrence and faunal assemblage. This is relevant since DeVries and Frassinetti (2003) studying Chilean and Peruvian mollusks faunas have conclude that there was a climate barrier separating them, thus making difficult the correlation by mollusks and potentially to other invertebrate susceptible fauna as well.

Different of the postulate by Muizon and DeVries (1985), Walsh and Suárez (2005) have considered that even the shark assemblage *Cosmopolitodus hastalis* is more abundant, *Carcharodon carcharias* is present in the bonebed (B. Inglesa F.). This species had been used to guide about Miocene-Pliocene boundary but would be used carefully (Walsh e Suárez, 2005; Suárez & Marquardt, 2003). In Pontoporiidae records of Pisco F., *P. littoralis* and *B. Mazeasi*, were proposed to indicate Pliocene and Miocene strata, it could not be extended to B. Inglesa F. since they are found in the same layer (bonebed) that even if it is reworked, it is not with Pliocene sediments.

Despite it was not possible to use the approach of Muizon and DeVries (1985) for correlation the Pisco and the B. Inglesa F. by the vertebrate levels, it was possible to find several similarities in faunal assemblage. Also were found geological and chronological evidences, such as the phosphogenesis cycle that could be used in this purpose.

MATERIAL AND METHODS

The fossil materials were examined, and in some cases prepared mechanically with a vibro-tool, in collections from Chile, at the Museo Nacional de Historia Natural, Santiago and Museo Paleontológico de Caldera, Caldera (SGO-PV 746-750, 757, 758b, 759, 966, 968, 972, 1109 and MPC 202, 377s, 391s,); and from Peru at the Museo Nacional de la Universidad Mayor de San Marcos, Lima (MUSM 565, 590, 591, 593, 884, 885, 886, 887). Additionally the holotype (MNHN PPI 121) and paratype (MNHN PPI 124) through photos, were also included in the analysis (morphometric and morphological). Field trips were carried on to B. Inglesa Formation, Caldera town during the first semester of 2005 and to Pisco F. at Ica, in May of 2005.

Geometric morphometric analysis was carried on with the landmarks (Fig. 2) ploted on the dorsally complete skulls of *Pontoporia blainvillei* (UFSC 1004, 1022, 1023, 1037-1039, 1058, 1059, 1066, 1070, 1091, 1092, 1121, 1214, 1217, 1221, 1262, 1284, 1288, 1290, 1310, 1314), *Brachydelphis mazeasi* holotype and the most complete specimens (SGO-PV 746, 750, 1109;

MPC 391s and 377s; MUSM 565, 887; MNHN PPI 121). Two analysis were run, one with only confirmed adults (excluding MNHN PPI 121, SGOPV 746 and 748) of both species and the other including all set of ontogenetic level available for *P. blainvillei* and all complete specimens of *B. mazeasi*, since we think that one of the main causes of variation within the specimens the difference of their respective ontogenetic levels. As ontogenetic ordination criteria we compared the curve growth of Ramos (2000a) with rostral groove presence and or number of ossified alveoli, because it was observed to non mature (approximate 3 years old, estimate by curve of total body length; Ramos, 2000a) and also to some fossil specimens.

The landmarks were digitized on tpsDig 2.04, 2005 (Rohlf , 2004) on dorsal skull photos (Fig. 2a). The data matrix with geometrical coordinates was transferred to PAST 1.4, 2006 (Hammer et al., 2001) and then transformed to Procrustes coordinates to remove size tendencies and rotate to major axis. PCA shape (2D; principal components analysis for landmarks data) was run to visualize the specimens distribution, and for significance test was used NPMANOVA (non parametric multivariate analysis of variance), since the samples were not of equal size neither multivariate normally distributed. An exploratory cluster analysis was also run, it was used as similarity measure the non parametric correlation (Rho), for the same reason explained above, comparing the results of both single and paired linkage index to identify more robust groups.

For identification of rostrum type (short or long) was done a traditional morphometric study, with centimeter to centimeter width measures from the base (given by a line between the antorbital notches) to the anterior extremity. This measures were plotted in a log scale chart to maximize curve tendencies of width decreasing across the rostrum. These measurements were taken through tpsDig 2.04, 2005 (Rohlf , 2004) to minimize error, because some specimens only could be measure by photo (e.g. holotype) and only relative values were used to rostrum morphometry. The deformed specimens were not measured. Other descriptive traditional measurements (Fig. 2b) made with caliper (precision 0.05mm) followed Muizon (1988b) with smaller modifications, the mean and SD (standard deviation) values are shown.

RESULTS

Infra-Order Delphinida Muizon, 1984

Super-family Inioidea Gray, 1846

Family Pontoporiidae Burmeister, 1885

Genus *Brachydelphis* Muizon, 1988a

Brachydelphis mazeasi Muizon, 1988a

Figures 3-6

Referred materials. - Dorsal portions of skulls (SGO-PV 746, 748, 750 and MPC 377s) and ventral portions (SGOPV 749, 966 and MPC 202) from Bahía Inglesa Formation, Chile. From Peru, at Pisco F., besides the holotype and paratype, three partial skull: MUSM 593, MUSM 885, with both periotics and humerus associated; MUSM 886, with mandibles. There are, also, two virtually complete skulls: MUSM 565, skull with almost complete mandibles, a partial tympanic and cervical vertebra; and MUSM 887, complete skull with articulated mandibles and skeleton, still in the matrix.

Locality and age. – (Fig. 1) The peruvian specimens are from different localities of Pisco F. (MUSM 885-887 from Correviento locality, Ica; MUSM 565 from Cerro Colorado, Ica; MUSM 593 and are here referred to Middle to Late Miocene (Muizon, 1988b, Muizon and DeVries, 1985, DeVries and Shrader, 1997) and the Chilean specimens (SGO-PV 746, 748, 750, 749 and 966; MPC 202, 377s) are all from Mina Fosforita, Caldera to Messinian-Tortanian (Late Miocene; Achurra, 2004, Marquardt, 1999, Walsh and Suárez, 2005).

Measurements. – TL, 220.5 (46.21, n=5); LB, 108.57 (21.2, n=5); LR, 116.17 (27.01, n=6); WR, 57.52 (9.57, n=12); WPo, 99.06 (10.66, n=11); WPx, 55.44 (9.63, n=8); WN, 26.19 (2.99, n=9); LN, 30.28 (5.94, n=6); WNh, 7.77 (1.71, n=6); WM, 109.09 (21.46, n=10); LO, 48.63 (5.6, n=10); LZ, 51.03 (6.54, n=2); SH, 86.33 (14.6, n=2)WB, 56.77 (6.75, n=2); WF, 26.8 (4.94, n=2). See figure 2 for measurements descriptions.

General description. - The preservation vary from well preserved partial (SGO-PV 748, 749, 750 and MPC 202, 377s) or complete skulls (MUSM565, MUSM 887) to deteriorated partial skulls. Some specimens from both formations (MUSM 593, 885, 886; SGO-PV 966) seems to be deformed, but when compared with the others the main characters can be observed. The rostrum is curved upwards, and it is here confirmed that this is not a post-mortem deformation, since it appears in all specimens being less accentuated in the ones deformed by dorso-ventral compression. The same is true for the cranial asymmetry, but with a significant variation.

Additionally the MUSM 887 (which presents a curved upwards rostrum) is particularly well preserved with the skeleton articulated still in the matrix presenting a contour that seems to correspond to the living animal soft tissue or simply a decomposition capsule, and also presents the curved upwards rostrum. MUSM 565 and 887 have well preserved mandibles that follow, at same degree, the curve of the rostrum.

Cranium. - The cranium (*sensu* Fordyce, 1994) has width and length sub equals and is telescoped, having anteroposterior compression (*sensu* Barnes, 1985a). The premaxilla reaches a posterior position over the supraorbital process of the maxilla, contacting the nasals in most of the cases. The vertex is slightly asymmetric, curved to the right which differs from *Pliopontos*, *Pontistes* and *Pontoporia*. It is also elevated, in a slender plate formed by the narrow curved frontals and a maxillary crest on maxilla medial edge, similarly to other Pontoporiidae, Iniidae and *P. sternbergi* (Lipotidae, Muizon, 1988b), though not as accentuated as in the latter species. The vertex decays posteriorly to this plate, in the supraoccipital crest contacting the frontal.

The holotype, SGO-PV 746 and 748 have wide opened sutures (e.g. maxilla-frontal-lacrimal suture on lateral view); these materials plus MUSM 593, have big lacrimals, not covered by maxilla and smooth maxillary crests. The other specimens (SGOPV 750, MPC 202, 377s, MUSM 565, 885-887) have at least some individualized alveoli, cranial sutures visible but not open, maxillary crests well developed, lacrimal mostly covered by maxilla in dorsal view. In all, the vertex is slightly elevated and asymmetric, with an inclined supraorbital process of maxilla, being convex at vertex and concave laterally.

Rostrum - All specimens like the holotype (MNHN PPI 121) and paratype (MNHN PPI 124) have a short triangular rostrum (1.24 to 1.29 times the braincase length, for MUSM 565 and 887). Muizon (1988a) originally described the species as having a rostrum shorter than the brain-case length. This was observed to SGO-PV 746 and 748 (0.8 to 0.99 times the braincase length). However, these specimens, as well as MUSM 593, have no individual alveoli but an alveolar or dental groove. In other specimens, the rostrum is slightly longer that the cranium. The base of the rostrum is flattened, but most of the specimens do not present a medial basin as observed in *Parapontoporia sternbergi* (Barnes, 1985) and in SGO-PV 746, 748 and the holotype (MNHN PPI 121). The mesorostral groove at dorsal view is wide opened along its extension, after rostrum base (posteriorly) appears the vomer within it in almost all specimens, the later has a variable extension.

The maxilla-premaxilla suture is not visible, having a deep longitudinal groove across the rostrum as in other Pontoporiidae and *Parapontoporia*. In ventral view, the palate is flat to concave and becomes narrower anteriorly, at the beginning of the longitudinal groove where the premaxilla appears. The vomer and palatine form a deep narrow keel posteriorly to the antorbital notches, between the internal nares, but not as deep as in *Parapontoporia*. The tooth rows are ventrally oriented at the extremity and become more lateralized at its posterior end, where it curves upward, before the antorbital notches. The alveoli, when defined, are circular and more lateral near the base of the rostrum (SGO-PV 966, MUSM 565, 886 and 887).

Premaxilla. - The premaxilla is constricted (more concave) at lateral border at the level of antorbital notches (Muizon, 1988a), actually this feature corresponds to the medial position of anterior dorsal infraorbital foramina (for trigeminal nerve) and the convexity of maxilla at this portion, that lies more laterally and present a deep groove in all other genera observed. Anteriorly to the premaxillary foramina lies, in each premaxilla, a rough triangular surface, commonly interpreted as the *nasal plug muscle* attachment that is also laterally limited by the associated sulci of these foramina (anteromedial groove for premaxillary vein). This structure is inconspicuous in this specie, as in *P. blainvillei*. The posterolateral groove of this foramen is curved in an open angle, it does not reaches the posterior part of premaxilla, like in *P. blainvillei* and *P. littoralis*, instead, opens laterally at the maximum width portion of premaxilla, similarly to *P. rectifrons, Parapontoporia* and *Lipotes*. The posteromedial groove of this foramen is not well marked in *B. mazeasi* but is not roofed by bone as it is in *Parapontoporia.*

The dorso-lateral edge of premaxilla is flattened and not markedly elevated as in *Pontoporia*. At orbit level, the premaxilla ranges the maximum width, corresponding to half of skull maximum width, like the holotype. The prominent premaxilla plate (=*spiracular plate, sensu* Barnes, 1985), the region that had supported the premaxillary sacs (diverticula of the nasal passages, Mead, 1975), is a prominent portion of premaxilla between the nasal passage and the premaxillary foramen, delimited anterolaterally by the posterolateral groove for premaxillary vein mentioned above. The premaxilla posterior portion contacts medially the nasals in the vertex, through a posteromedial process. This configuration is unique among the Pontoporiidae and Lipotidae, althought a posteromedial process is present in *P. rectifrons* and *Parapontoporia* together with a posterolateral one, and in *Lipotes* it appears alone but do not contacts the nasals, once they are highly elevated.

Maxilla. - The maxilla is inclined posterolaterally, reach the highest portion on the elevated vertex where partially overlies the frontal in its suture. The lowest portion is at postorbital process of frontal, also at lateral border of the cranium. *B. mazeasi* does not present a temporal crest at temporal fossa roof, instead, the maxilla and frontal are fused in a smooth surface, differing from *P. blainvillei* adults and similar to the fetus (UFSC 1059).

The posterior dorsal infraorbital foramen that has supplied the maxillary branch of trigeminal nerve (or blood vessels and nerves to the facial muscles, *sensu* Fordyce, 1994), lies more posteriorly than in *P. blainvillei* and *P. littoralis,* at the postorbital process level. In Pontoporia, between maxillary crest and premaxilla border, lies a deep channel that extends backward well posterior to the nares. In *B. mazeasi* this channel does not exists and the region between posterior and anterior dorsal infraorbital foramina is elevated. Different from the concavity of *P. blainvillei* and *P. littoralis* or from the flatened surface of *P. rectifrons* . The anterior dorsal infraorbital foramen is medially placed only in *B. mazeasi*. The anterior maxillary foramina dorsal opening of the infraorbital channel is medially placed. The maxillary crests above the orbit reach the maximum development at the preorbital process of frontal and are asymmetric, similar to *P. blainvillei* and differing from other genera. In ventral view, the maxilla posterior extremity is not so well defined, but the palatine suture is visible in MUSM 565 and the holotype (*sensu* Muizon, 1988a) similarly to *Pliopontos*, *Lipotes* and *Parapontoporia* and differing from *P. blainvillei* and *Inia.* It also seems to articulate with lacrimal, jugal and palatine, without participation on orbit. Medially it contacts the palatines and vomer anteriorly to the ventral keel formed by palatine, vomer and pterygoid (hamular process), differing from *P. blainvillei*, where it have a process within this keel, between the pterygoid hamular process and palatines.

Lacrimal and Jugal. - The lacrimals are robust and the antorbital notches are deep, delimiting the maxillary branch of trigeminal nerves (V2) trajectory. Only in SGO-PV 746, 748 the lacrimals are almost its extension exposed dorsally along almost its extension. A small portion of the jugal is preserved ventrally at rostrum base (SGO-PV 966), and it is articulated with lacrimal at the antorbital notch and at rostrum base, lying within antorbital notch, but in a more posterior position, similar to *Parapontoporia*.

Frontals. - The frontals in the vertex are very thin and short (more than 3 times shorter than the nasals), curved to the right (SGO-PV 746, MUSM 565, 887, MPC 203), being asymmetric and so differing from all other Pontoporiidae. Anteriorly they are inserted between the nasals, in a V-shaped (posteriorly openned) suture, like in Pontoporiidae, but more similar to *Pontistes*. The supraoccipital crest is only slightly projected anteriorly differing substantially from *Pliopontos*. The frontals are covered by maxilla in almost all its dorsal extension. Only appear above the orbits, laterally to the maxillary crest, less apparent than Pontoporiidae, similar to *Inia, Lipotes* and *Parapontoporia.* In lateral view, there is a visible suture with lacrimal and maxilla at anterorbital process. The postorbital process is triangular in shape and touches the zygomatic process of squamosal (MUSM 565) on its extremity, since it is strongly inclined upwars. In ventral view, lies the optic infundibulum limited at postorbital level by the postorbital ridge, well marked in MUSM 565. Anteriorly should appear the optic foramina and the preorbital ridge between this foramen and the infraorbital foramina but these features are only poorly marked, since on MUSM 565 the details can be confused due to the presence of incrusted sediments. But in SGO-PV 966 it can be seen an anterolaterally foramen (at the left side) in front of the preorbital ridge, here interpreted as the anterior infrorbital foramen, differing from *Parapontoporia* and *Pontoporia.* The orbit and the postorbital sinus are markedly bigger than in adults of *Pontoporia*, being similar to the fetus condition in the latter. The fronto-parietal suture was not observed.

Nasals. - The nasals are long, narrow, mostly curved to the right and triangular to rectangular shaped. In MUSM 565 and MUSM 887 the distal portion of the nasals that contacts the frontals are less than 1/3 thick from its own proximal portion. In MPC 377s the nasals are markedly rectangular shaped. The alignment of the naso-frontal suture gives a triangular or rectangular aspect of nasal, being this feature also variable in *P. blainvillei.* In most of the cases, the nasals are cut on anterolateral corner, by the posterior processes of the premaxillas that contact the nasals as in *P. rectifrons.* In *P. blainvillei* it was only observed in juvenile specimens that were still developing the nasals. The elevation and deflection of the nasals are more similar to *Lipotes and Parapontoporia*, but still in a smaller degree. This slightly elevation on face at nasal level indicates a moderate development of maxillo-naso-labialis muscle.

Mesethmoid. - Within the nasal passage, the mesethmoid appears inclined but not as inclined as the nasals, like in *Parapontoporia*. It definitively does not support and elevates the nasals as in Delphinidae, Ziphidae and other modern dolphins. The fossa for olfactory nerve was not observed. The mesethmoid septum has an irregular dorsal end that could indicate a cartilage continuation (*sensu* Fordyce, 1994). Its septum has a little deviated to the right, given an asymmetric profile to the nasal passage, differing of *P. blainvillei* and *P. littoralis*, but similar to *P. sternbergi*.

The nasal passage has a variable form, from broad, with rounded premaxilla suture (MPC 391s, SGO-PV 748, 1109) to slender, with V-shaped premaxilla suture (MPC 377s, SGO-PV 746, 750). This variation seems to be related to whether the premaxilla is highly elevated (inflated) on spiracular plate or not, respectively. MUSM 887 presents an intermediate pattern regarding both structures.

Palatine, vomer, pterygoid and pterygoid sinus. - In the basicranium, the lateral lamina of the palatine bone is preserved, but only in its proximal portion, thus its real extension and shape are unknown. The same is observed for pterygoid lateral lamina, differing from the original interpretation of *B. mazeasi* (Muizon, 1998a, figure 53). In the holotype and paratype a thin posterior portion of palatine and pterygoid lateral lamina is preserved, that reaches the end of nasals passage; see Muizon (1988a, figure 59).

MUSM 565 has the best preserved basicranium, with the hamuli process of pterygoid almost complete. It articulates in the base with vomer and basioccipital, as in the holotype. Anteriorly, the palatine articulates with maxilla in a rounded shape, as an antero-lateral process. Medially the palatine appears as a thin lamina between pterygoid hamuli of each side in contact with the latter and the vomer between them posteriorly. Anteriorly, a maxillary process is inserted between palatines and petrygoids, all this complex sutures form a keel that is thiner than in *P. blainvillei*, and the hamuli pterygoid process almost contact each other, even being broken in its posterior portion.

The pterygoid sinuses are well developed on this species. The fossa for anterior lobe are very well marked over the palatine, having an elongate shape and extends from just after the palatine-maxilla suture to just after the antorbital notch (MUSM 565, 887 and SGOPV 966). The fossa for pre and postorbital lobe lies anteriorly and posteriorly of postorbital ridge of frontal (Fordyce, 1994), they are rounded and vary from deeply marked on MUSM 565, to slightly marked on SGOPV 966, that is broken after postorbital ridge. The fossa for middle lobe of pterygoid sinus is observed above the falciform process and glenoid fossa (MUSM 565, 887 and holotype). There are also excavations on paraoccipital bone, for posterior lobe, and on the lateral border of basioccipital crest, a fossa for the sinus pterygoid in alisphenoid-basisphenoid bones (=peribullary lobe of sinus pterygoid). It was not observed a subcircular fossa (*sensu* Muizon, 1987) or periotic fossa (*sensu* Fordyce, 1994). The jugular notch is wide separated from basiocipital and the foramen hypoglossal is large and lies within this notch (MUSM 565).

The vomer forms the nasal passage septum medially, contacts posteriorly the basiocciptal and laterally the pterygoids medial laminas that are robust and also articulate with basiocciptal, posteriorly.

Squamosal.- In dorsal view, the zygomatic process of squamosal is barely seem on MUSM

565, only specimen with squamosal complete. It is strongly upward oriented as *Parapontoporia* and *Pontoporia*, but in higher degree, and not laterally projected as in *Lipotes,* very apparent in dorsal view. Its suture with parietal is visible, but its dorsal extension is lower than in *Pliopontos* and *Pontoporia*, being more similar to that of *Parapontoporia*. On its anteroventral edge seems to have a facet for jugal articulation. The postglenoid process is robust and pointed ventrally projected similar to *Parapontoporia* and not rounded as in *Pontoporia*. The lambdoid crest comes from the posterior portion of this fossa, it gets more posterior than occiptal condyle giving an elongate aspect for temporal fossa. This fossa is very high and roofed by the maxilla and frontal expansions, this also is excavated by the postorbital lobe of pterygoid sinus (MUSM 565 and 887) differing from *Lipotes*.

In ventral view, above the external auditory meatus and post-tympanic process, the zygomatic process has a fossa, where should have attached the *sternomastoideus*, *scalenus ventralis*, *longus capitis* and *mastuhumeralis* muscles (Schulte & Smith, 1918).

Present a falciform process barely projected medially with a posterior spiny process (*sensu* Muizon, 1987) not accented, but it can be broken. Even though, there is a shallow fossa for medial sinus below the falciform process. The glenoid fossa is wide and delimited by a lateral and a posterior ridge, the last one marks the beginning of post-glenoid process. The external auditive meatus is deep between the latter and a roughly surface that must correspond to post-tympanic process (Fordyce, 1994), where the tympanic articulates with squamosal.

Alisphenoid, basisphenoid, orbitosphenoid and parietal. - In lateral view, trough the fossa temporal appears the parietal, with a visible suture squamosal-parietal. The other sutures are barely delimited since the only specimen that has the basicranium well preserved (MUSM 565) seems to be an old specimen that has had all the bones fused. In ventrolateral view, the bones suture and foramina seems to be fused or conbined, it is only present the *cranial hiatus* (Fraser & Purves, 1960) asin many other derivate odontocets, with all foramina unified. The oval foramen is not well defined as well, so that the possible location of the further is in front of the *cranial hiatus* and above the bony bridge that should correspond to alisphenoid-basisphenoid bones that are fused and broken. Therefore, the oval foramen is not separated from the cranial hiatus but it is possible that it correspond to non preservation of this thin bony lamina. Laterally the parietal articulates with alisphenoid-basisphenoid. The orbitoesphenoid was not recognized. The path for mandibular nerve (branch of trigeminal nerve) is not evident, but seems to be present in a bony bridge that may correspond to the alisphenoid and the path for anterior branch of trigeminal nerve (V3), it is visible and runs parallel to medial lamina of pterygoid to just below the postorbital ridge.

Dorsally, at cranium posterior edge the parietal appears between the maxilla and the supraoccipital only in MUSM 887.

Basioccipital. - The basioccipital has a high and relatively thin crest (=falcate process), anteriorly continued by pterygoid medial lamina. The suture of this bones with basispehenoid-alisphenoid can not be securely recognized, therefore continuous to this crest together with basisphenoid-alisphenoid bones are very excavated for the fossa for peribullary sinus (*sensu* Fraser &Purves, 1960) or alisphenoid-basisphenoid sinus (*sensu* Fordyce, 1994). The basioccipital-vomer and basioccipital-pterygoid lateral lamina sutures are evident medially, laterally the carotid foramen seems to appear in the level of oval foramen, but it is not well preserved.

Supraoccipital, exoccipital. - The occipital plate is almost vertical and present longitudinal and oblique sulci, separating the two marked cerebral bulbous and the occipital condyle, respectively, differing substancially from the globoid aspect of *Pontoporia* and *Pliopontos*. It has a longitudinal sulcus separating the cerebral bulbous and a mediolateral sulcus, that splits the paraoccipital from supraoccipital. The exoccipital is larger and more robust than in *Pontoporia and Pliopontos* and similar to *Parapontoporia,* the paraoccipital process of this bone is ventrally projected and is longer than basioccipital. The jugular notch is broad and profound; it splits the paraoccipital from exoccipital ventrally.

Teeth - The teeth are present in variable number in the different specimens. Its shape is similar to other Pontoporiidae only with smaller size (9,91mm length), but the root was not observed since the teeth are all articulated (MUSM 886 and 887). In MUSM 886 was observed some variation of shape with some narrower and some more conical, with a broad base (width: 3,30mm conical and 2,25mm narrower). On this specimen the teeth seems to be all laterally oriented in some degree, from the anterior extremity to rostrum base.

Mandible. - The mandibles are short, lateromedially compressed and curved upwards, as the rostrum. There is no symphisis only a contact region in the anterior extremity from where the bony axis deviates in posterolateral direction, in contrast to the long symphisis present in all other Pontoporiidae, Iniidae and Lipotidae. The mandibular foramen or fossa is wide and occupies most of posterior end of each bone, between the condyle and the anterior end of coronoid (dorsally) and angular (ventrally) process. The condyle is only preserved in MUSM 887 and it is articulated, so it is only possible to know that is very rounded. The teeth row ends in the base of coronoid process that is very high. In the anterior extremity there is only a shallow sulcus, not accepted as in all other Pontoporiidae. Approximately 18 alveoli are present in MUSM565. These mandibles are completely different from all Pontoporiidae mandibles known.

cf. Brachydelphis new form

Figure 7

Referred materials. – Incomplete ventral and dorsal views of skull (SGO-PV 972 and MUSM 884), a dorsal portion of skull (SGO-PV 1109) and a rostrum fragment (SGO-PV 759).

Locality and age. – A provisory age is referred to MUSM 884 from Pisco F. near Ocucaje , Ica (Peru) from Middle to Late Miocene (Muizon and DeVries, 1985; DeVries and Shrader, 1997) and the others, from Mina Fosforita, Caldera (Chile) to Messinian-Tortonian (Late Miocene; Achurra, 2004, Marquardt, 1999, Walsh and Suárez, 2005).

Measurements. – TL, 290a; LB, 101,78; LR, 176,9a; WR, 60,3; WPo, 106,8; WPx, 60,75b; WN, 30,05; LN, 25,65b; WNh, 6,5b; WM, 117,6b; LO, 53,95. (a, only SGOPV 972; b, only SGOPV 1109). See Fig. 2b for measurements descriptions.

General description. – These specimens have basically the same features observed above for *B. mazeasi*, therefore only the differing features will be summarized here.

Rostrum. - They differ basically in the rostrum that is: longer (more then1.63 times bigger than the cranium length, in SGO-PV 972 that is not complete), slender, not curved upward, has a thiner base and higher premaxilla in lateral view. In ventral view, the palate is also thinner and has a continuous width decreasing instead of the abrupt decreasing that gives the triangular shape of the rostrum in *B. mazeasi.* A more detailed morphometric analysis of rostrum types can be seen bellow. The vomer and palatine forms the keel between internal nares, but less accentuated than in *B. mazeasi* described above, since the palatine fossae is also poorly marked.

Cranium. - There are some other characteristics that can be confused when comparing to all ontogenetic and individual variation showed above to *B. mazeasi*. They are: preorbital process more robust; more marked concavity in supraorbital process (cranial portion) of maxilla that is rather dorsolaterally oriented than laterally, as in *B. mazeasi;* vertex almost symmetric and more elevated, triangular nasals in SGO-PV1109 and MUSM 884, but never so narrow as described for some specimens of *B. mazeasi* (MUSM 565 and MUSM 887). SGO-PV 972 presents more than 26 circular to squared alveoli that marks a polydonty comparing to *B. mazeasi*, but not with *Lipotes*, and less with *Pontoporia* and *Parapontoporia*. The real extension of the rostrum is not known, but one can estimates a rostrum 1.63 times longer than the cranium length, based in SGO-PV 972, that has almost all the rostrum preserved.

In ventral view, the anterior, pre and postorbital lobes of pterygoid sinus are less marked than observed in *B. mazeasi.* The infraorbital foramina on ventral portion of frontal, has a different conformation, the fossa bellow the palatine lateral lamina is elongated in SGO-PV 972 while it is more circular in *B. mazeasi* (SGO-PV 966). The optic infundibulum, on frontal, is barely marked compared to *B. mazeasi* and, at postorbital level, the postorbital ridge of frontal (Fordyce, 1994) is more anterior having a small and narrow orbit and fossa for pre and postorbital sinus than *B. mazeasi.*

The specimen SGO-PV 747, despite of having some of these characters more similar to cf. *Brachydelphis* new form, was classified as long-rostrum type through the morphometric analysis of the rostrum (see bellow), see bellow. Since the rostrum shape and basicranial sinus disposition are the main characters of this form.

The squamosal, occipitals, parietals, and other bones and structures of basicranium are not known, once all the specimens referred to this new form are broken on this portion or have only dorsal preservation.

Mandibles. - The specimen MUSM 884, presents a fragment of mandible that is very deteriorated and do not present the strong upwards curve, but presents a long symphisis. Differing from *B. mazeasi* and similar to the other pontoporids, *Lipotes* and *Parapontoporia.*

cf. Brachydelphis indet.

Referred materials. – Dorsal portions (SGO-PV 747, 968, MPC 203 and 391s) and ventral portion of skulls (MUSM 590) and a partial rostrum (MUSM 590).

Locality and age. – The Peruvian specimens come from Pisco F. from Cerro los Huesos (MUSM 590) and Cerro Tres Piramides, Ica (MUSM 591) we referred to a provisory age of Middle to Late Miocene (following Muizon and DeVries, 1985; DeVries and Shrader, 1997). The Chilean specimens are from Mina Fosforita, Caldera and are referred to a Messinian-Tortonian age (Late Miocene; Achurra, 2004, Marquardt, 1999, Walsh and Suárez, 2005).

Measurements. – TL, 145.65i; LB, 91.5; LR, 52.45i; WR, 57.15; WPo, 106.3; WPx, 57.3; WN, 27.3; WNh, 9.0; WM, 116.1; LO, 48.55 (only based on SGO-PV 747; i, incomplete)

Description. – These are other specimens that we could not determine whether they have long or short rostrum, but definitively are near to *Brachydelphis*, by presenting deep antorbital notches, with big lacrimals and a thick antorbital process, elevated and asymmetric to near symmetric vertex, large and narrow nasals and slender frontals, flat palate and triangular postorbital process.

Ontogenetic comparisons

Comparing the relative size structures between fetus and adults of *P. blainvillei* and the juveniles and adults of some specimens of *B. mazeasi* we could note that there are some features observed to this fossil species that resemble much more the feti and juveniles than the adults of the living species (Fig. 8). Such as: relatively broader cranium; slightly bigger size of orbit, that is even bigger in holotype, SGO-PV 746 and 748; a more posterior position of the nasals; higher vertex; markedly shorter and curved upwards rostrum; longer paraoccipital process (MUSM565); thicker zygomatic process in MUSM 565 and slender in MUSM 887, but both shorter, remembering the fetus condition in *P. blainvillei*; anterior position of squamosal in its base and well marked fossae for musculature (*m. sternomastoideus* and *brachiocephalicus*). These characteristics could suggest heterocronic trends in the family.

Morphometry

Geometric Morphometrics. **-** A Geometric morphometry analysis was carry on with the dorsally complete skulls of *Pontoporia blainvillei, Brachydelphis mazeasi* (the holotype and the specimens referred here). Since the holotype described by Muizon 1988a (PPI 121) and other two specimens (SGOPV 746 and 748) have some characteristics here observed for *P. blainvillei* juveniles as explained above.

The shape PCA (principal component analysis) of the landmarks recognize two groups in the dataset, differentiating *P. blainvillei* and *B. mazeasi*, with some variation within both groups (Fig. 9). The NPMANOVA gives a significant value to this PCA shape (p=0). The first component that explains 60,1% splits the two species in negative (*B. mazeasi*) and positive values (*P. blainvillei*). The first component should not reflect size, since the data matrix was transformed to Procrustes coordinates 2D before the analysis to eliminate size-effect (Monteiro and Reis, 1999), instead have important (approximately -0,5) participation of landmarks 6 and 32, corresponding to maximum premaxilla width on cranial portion, with higher values in *B. mazeasi*, that confirms the character for the species: premaxilla maximum width on postorbital process level constituting half of cranium maximum width, this landmark also corresponds to the lateral ending of posterolateral groove for premaxillary foramina, that is posterior in *P. blainvillei* where this species has the premaxilla maximum width but never so accentuated as in *B. mazeasi*, as shows this analysis.

The landmarks 4 and 34 also contribute to this axis (aproximate 0.20), reflecting major diference between the species as well, the posterolateral process of premaxilla in *P. blainvillei,* instead of posteromedial as in *B. mazeasi*. Landmarks 8 and 30 (0.17<x<0.20), corresponding to medial position of anterior maxillary foramen in *B. mazeasi* and more laterally position in *P.*

blainvillei, respectively. This confirms the diagnostic character to the species: concave premaxilla at antorbital notch level caused by a medial position of anterior maxillary foramen. The other higher landmarks (0,19) are 3 and 38 that correspond to the naso-frontal medial suture and 10 and 11 (0,15-0,16) that corresponds to width of maxilla and premaxilla at most anterior point of rostrum.

An important variation in the components 2 and 3 for the fossil specimens could reflect the existence of the two forms described above. Due to this variation it was not possible to differentiate both species through components 2 and 3, but this components explain only 18% of total variation (9,6% and 7,3% respectively). Since the cf. *Brachydelphis* new form and *B. mazeasi* specimens were put all together independently of its locality and whether they have long or short rostrum for all multivariate analysis, constantly this group shows more variation than *P. blainvillei*. Both fossil groups has not split from each other on this analysis, this could be explained by the fact that main difference lies on rostrum morphology after 7-9mm of its base, landmarks that were not added, because of sample size. The differences between *P. blainvillei* and the fossil species is due to an interaction of almost all points in component 2: 6, 10, 11, 14, 16, 17, 21, 22, 24, 27, 28, 39 (0,19-0,29). In this component, the points 4, 33 and 34 (0,23 – 0,40) present the highest negative values, and 4, 6, 10, 11, 17, 28, 32 with the highest positive values, although they are smaller than the negative ones (0,15 – 0,19). They represent: posterior process of premaxilla (4 and 34, lateral position; 4 and 34, regular growth), maximum width of premaxilla (6 and 32), width and shape of rostrum (10, 11, 28), orbit anterior process (17) and position of infraorbital foramen (33). *P. blainvillei* shows almost no variation within this component.

The juvenile specimens SGO-PV 746 and UFSC1059 (fetus) are distant from the rest of the specimens (in both species) mainly by landmarks 4 and 34 that corresponds to posterior process of premaxilla on both sides of skull. This process get more posterior with regular animal growing in *P. blainvillei* specimens with relative ontogenetic sequence known. This observation lead us to mantain the specimen SGO-PV 746 in the analysis even we are not shure it is not broken on this portion as interpreted for the holotype (MNHN PPI 121) by Muizon (1988a). Additionally the PCA shape run without it showed no difference on others specimens position. The specimens holotype (MNHN PPI 121) and SGO-PV 746 are not separated by components 1 and 2, but lie on opposite extremes of variation on component 3 by the same landmarks influence cite above (4 and 34), since the holotype has (following Muizon, 1988a reconstruction) the posterior process of premaxilla reaching the nasals as observed in other adult specimens. The specimen MUSM 887 considered and adult with all alveoli formed also lies together with these juvenile specimens.

An only adult specimens analysis was also carry on, given the same results with more confidence (first component explains 66,8% of variation and splits the two specimens with 95% probability ellipses).

In the relative warps scores the two species also were split in a 95% confidence ellipse and *P. blainvillei* was bounded to negative values in warp one (or score one) and *B. mazeasi* were all highly positives (values >1).

A cluster analysis was also done and showed two groups, one composed only by *P. blainvillei* specimens and the other with *B. mazeasi* and cf. *Brachydelphis* specimens (indet. and new form). When keeping all ontogenetic series available the fetus and juveniles appeared on the base of both groups. The new form cf. *Brachydelphis* lies also in a basal position of the cluster in both algorithm utilized (single and paired linkage) between the juveniles of *B. mazeasi* (SGO-PV 746 and MNHN PPI 121, holotype).

Traditional morphometrics. - The two forms, short an long rostrum (*B. mazeasi* and cf. *Brachydelphis* new form) were not well differentiate by simply morphology observation or by the geometric morphometrics because there are few specimens with complete rostrum and virtually complete cranium at the same time. To elucidate the rostrum morphology an its variability we measure the rostrum width across it. It was observed that the main differences of the rostrum in size and shape is markedly present after the region of 7 to 9 cm after the base of rostrum (that is mostly broken in dorsally complete skulls used to geometric analysis; Fig. 10).

Were recognized two main tendency lines of width loss in each rostrum type (short and long known a priori; Fig. 10a-b). This analysis allowed us to define better what is a short and long rostrum specimen considering its shape variation. The MPC391, 377, MUSM 887 and SGO-PV 749 were classified posteriorly to this analysis as short rostrum type. And the SGO-PV 747 lies as a possible longrostrum type, it was not possible define better because it is broken near its base. Some ontogenetic variation was also analyzed here since the fetus of *P. blainvillei* is very similar to short rostrum tendency, actually it has a sort of transitional form (Fig. 10c).

DISCUSSION

The comparison of different specimens of *B. mazeasi* with specimens of known ontogenetic level of *P. blanvillei* allowed us to asses the ontogenetic variation for that species. Some similarities, for example the late (delayed) ossification of the teeth alveoli in rostrum was observed in fetus and juveniles (from postnatal stage to before the sexual maturity, Ramos, 2000a) of *P. blanvilleii*, led us to conclude that the holotype (MNHN PPI 121) of *B. mazeasi* is a juvenile. Other characters such as the wide open suture of maxilla, frontal and lacrimal in lateral view are also observed in juvenile individuals of *P. blanvillei*. Additionally the low maxillary crests and proportionally large orbits compared with temporal fossa are observed in fetuses of *P. blanvillei*, indication of it young age. The rostrum length shorter than the braincase length (Muizon, 1988a) and only slightly curved upwards were than also interpreted here like juvenile characters for *B. mazeasi*, once there is a major growth of the rostrum from the fetuses to juvenile and adult specimens of *P. blanvillei* too. Therefore, these morphological characters described for the holotype of *B. mazeasi* by Muizon (1988a), are not usefull as diagnostic for the species.

Other characters such as the discontinue lamina lateral of pterygoid ranging well posterior to level of the postorbital process and the small paraoccipital process of exoccipital were not confirmed here, since they were not observed in any of the new specimens. Actually they cannot either be confirmed in the holotype and the paratype (Muizon, 1988a: Figs. 52 and 59). The constriction of the premaxilla at the antorbital level was found to be variable in our larger sample. Consequently the diagnosis provided by Muizon (1988a) for *B. mazeasi* must be modified.

The following characters are maintained from the original diagnosis: posterior process of premaxilla contacting nasals on vertex, vertex slightly asymmetric, deep antorbital notch with big lacrimal, thick antorbital process with high maxillary crests and paraoccipital process excavated by fossa for posterior pterygoid sinus. In addition to those original features, the following ones are considered important to define the species: rostrum short (compared to other Inioidea), triangular in dorsal view and curved upwards; cranium length and width subequals; premaxilla with maximun width corresponding to half of cranium width at orbit level; prominent premaxilla between the premaxillary foramen in the nasal passage. In ventral view the sinus fossa is well developed, with the anterior, pre and postorbital lobe of pterygoid sinus present, as the middle and peribullary sinus fossa; the pterygoid hamular process complete; high occiptal plate and temporal fossa; postorbital process triangular in shape; visible palatine lateral lamina-maxilla suture, laterally in the base of rostrum; plane to concave palate near the base the rostrum, with a medial groove that shows the premaxilla, more anteriorly; circular alveoli; cranium width and length sub equals, at rostrum base, palatine-maxilla suture visible observed in old specimens, conical teeth, mandibles with small (less than half of the mandible length) not fused symphisis deflected upwards; nasals and frontals elevated on vertex and laterally covered by maxilla; convex maxilla at antorbital notch level.

After redefining *B. mazeasi*, it was possible to distinguish a second form, called here cf. *Brachydelphis (new form)*, from specimens from both, Pisco and B. Inglesa Formations. (SGO-PV 759, 972,1109, MUSM 884). This form was characterized by having a longer rostrum (more than 1.63 times the cranium length) with a long mandibular symphisis (probably more than a half of the mandible total length). Other characters observed are: more concave supraorbital process of maxilla, more rectangular nasals, less marked fossa for anterior sinus of pterygoid and narrower cranium. They could be in part due to individual variation, but the amount of differences support a taxonomical distinction. There is not much evidence for this feature to be a sexual dimorphism as well. In *P. blainvillei* it has been observed that the female has a bigger size (reflecting in skull and teeth size, Ramos et al. 2000b, Higa et al. 2002) but was not registered any case of rostral size difference as sexual dimorphism in odontocetes.

Additionally, long and short rostrum could be interpret to have different food habits, but still this inferences are difficult to delimit to living species and may be less crucial in the animal life than it has been generally thought, Goodall and Galeazzi (1985) has pointed that the diets thought to be specifical of some species and higher groups (e.g. family) of cetaceans have been found variable according to food supplies and geographic displacement. More simply the different rostrum types could be regarded to the greater diversity of the hole clade Inioidea during Middle to Late Miocene showed in the fossil record, so far regarded to South American coast records (Cozzuol, 1985, 1996; Muizon, 1983; Muizon; 1988a; Fordyce and Muizon, 2001; Hamilton et al., 2001; Banguera-Hineztroza, 2002).

We decide not to describe a new taxon untill better specimens and a phylogenetic background be available.

In the proper variation study, interestingly some characters described as diagnostic to different groups within Delphinida (Muizon, 1988b: 23) are found to be variable in *B. mazeasi* and in *P. blainvillei*, such as: nasal passage shape, from broad with premaxilla suture semi-circular (*sensu* Muizon, 1988b; in MPC391s, SGOPV 748, 1109) to slender with premaxilla suture V-shaped or cordiform (*sensu* Muizon,1988b; in MPC377s, SGOPV 746, 750) utilized to differentiate Lipotidae (Parapontoporia + Lipotes) that should have a rounded curve between premaxilla, and Pontoporiidae that should have a 90 degrees corner, the cordiform condition (Muizon, 1988b).

The morphometric study has reveled a higher variation of *B. mazeasi* that can be interpreted as ontogenetic variation in shape (the juveniles are generally far from the medial region of distribution of specimens on PCA shape). But also, was due to the appearance of the new form of cf. *Brachydelphis*, visible on cluster analysis when the new form specimen (SGO-PV 1109) lies near the base of fossil specimens cluster, together with the juveniles. This analysis also has shown a higher similarity of fetus and juveniles from *P. blainvillei* and *B. mazeasi*, respectively, with each other, being both in the base of its correspondent cluster. The geometric morphometrics has been used to elucidate confuse cases of existence of living species or subspecies of Delphinidae (Monteiro-Filho et al. 2002) and of the existence of sub-populations to *P. blainvillei* (Higa et al. 2002), in any of this cases the morphological background must be corroborated to define better this less inclusive clades or groups. Nevertheless, if there are problems to determine and validate living species we are far from solve the problems with fossil taxa, but crossing data (living+fossil records) is a fundamental path to begin.

Evolutionary implications.-The presence of a short rostrum was cited as an autapomorphic character that has defined the subfamily Brachydelphinae (Muizon,1988b). The occurrence of cf. *Brachydelphis new form,* with long rostrum, implies that the validity of this subfamily might be re-evaluated and a new phylogenetic approach should be provided. The short rostrum is probably a consequence of a pedomorphic trend which is shown also by the brachycephalic skull. In other Inioidea and Lipotidae, the trend lead to a peramorphic condition, like in *Inia*, *Lipotes*, in lesser degree, *Pontoporia.*

In the phylogenetic analysis of Muizon (1988b: Fig. 1, pag. 164-166) the characters that define Pontoporiinae are the reappearance of lateral lamina of pterygoid (character 33) and acquisition of symmetrical vertex (character 34). However, the first character is not well known to *Pontistes*, *Pliopontos* and *Brachydelphis*, to support this hipothesys. On the other hand, the asymmetry found in the vertex of *Brachydelphis* is variable and specimens of Pleistocene and living *P. blainvillei* (Ribeiro et al. 1998 and personal observation) have slightly asymmetrical vertex, making of this feature a confuse character that should be used carefully. Heyning (1989) studying soft tissue anatomy of living odontocetes, has said that all odontocetes, including *Pontoporia*, have the left side more developed and so asymmetric at least in soft tissue, this is used to consider the symmetry of Pontoporiidae as a derivative character.

The Inioidea clade was defined by Muizon (1988b:164-166, figure 1) by presenting the following cranial characters: lateral lamina of palatine fused to maxilla (character 21); prominent premaxillary plate (=inflated spiracular plate; 22); premaxilla nearly in contact medially with medial borders equidistant along all their length (23), dorsal erection of lateral border of maxilla above temporal fossa and orbit and reduction of the roof of temporal fossa (24), narial fossa semi-circular and not cordiform (25). From these characters the only one that is visible and undoubtfull present in *B. mazeasi* is the character 22. The character 21 is absent, because it was observed a visible suture of maxilla and palatine even in an old specimen; the characters 23 and 25 were found to be variable, actually the character 23 is essentially not well known because is often broken; and the character 24 is also absent, by presenting a wide roof for fossa temporal and not the erection of maxilla border. Therefore, strictily using the same features of Muizon (1988b) the position of *Brachydelphis* seems to be more likely a basal position within Inioidea than the position within Pontoporiidae. This agrees with recent phylogenetic propositions placing Brachydelphis as the sister group of Inioidea + Lipotoidea + Platanistoidea.

Banguera-Hineztroza et al. (2002) calculate the time of divergence of Pontoporiidae and Iniidae to middle Miocene (17my). They calibrated it using *B. mazeasi*. If *B. mazesi* be more basal the molecular clock would now point to a divergence time of Delphinida for this period, considering the Muizon's (1988b) phylogenetic hypothesis. This lead us to the conclusion that more molecular, morphological and as consequence, phylogenetic studies are needed.

CONCLUSIONS

The holotype of *B. mazeasi* was referred to a juvenile specimen. In this context a redefinition of the species was provided, adding more specimens and anatomical characters, which extends the diagnosis of this taxon. A new form of long rostrum was recognized, probably the same genus, suggesting a greater diversity for the group.

The variability of some characters was evaluated and thus, some characters in the clades related to *B. mazeasi* and *P. blainvillei* were found to be confuse. Consequently, all this new information lead us to question the phylogenetic position of this taxon and its use for the calibration of molecular clocks.

Both taxa are present in the bonebed of Mina Fosforita locality from Late Miocene of the Bahía Inglesa Formation (Chile) and from different localities assigned to Middle and Late Miocene of Pisco Formation (Peru).

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FIGURE LEGENDS

FIG. 1. - Location map of Pisco and Bahía Inglesa Formations and geological section of the later. A) South American map with both Pisco and Bahía Inglesa F. indicated. B) Location of Mina Fosforita locality, from where *B. mazeasi* new specimens were recovered in Chile. C) Geological section of "Mina Fosforita" locality.

FIG. 2. - Schematic drawing of *B. mazeasi* skull with the measurements and landmarks used. A) Landmarks are marked with black circles. B) Measurements according to Muizon, 1988 are given by letters as follows: TL) total lenght of skull, LC) lenght of cranium from antorbital notch to supraoccipital crest*, LR) lenght of rostrum, WR) width of rostrum at the base, Wpo) width between preorbital processes, Wpx) maximum width of premaxillaries, WN) maximum width of nasal fossa, LN) lenght of right nasal, WNh) width of right nasal in half lenght, WM) width of maxillaries in postorbital process level, LO) lenght of orbit: from postorbital process apex to lacrimal-frontal suture at lateral border of skull*, LZ) lenght of zygomatic process of squamosal, SH)supraoccipital high, WB) Bicondyle width, WFm) foramen magnum width. *modified from Muizon, 1988.

FIG. 3. - MUSM 565, most complete specimen (old individuous) of *Brachydelphis mazeasi*. In a) dorsal, b) ventral, c) occipital and d) lateral view. (Black bar=50mm)

FIG. *4.* - A) Dorsal reconstruction of a mean shape for *B. mazeasi*. B) Ventral view drawing from the most complete specimen (MUSM 565). Oblique lines are broken portions (Black bar=50mm).

FIG. 5. - Ventro-lateral view of right side of skull (MUSM 565). A) Photo with pterygoid sinus indicated. B) Drawing with structures indicated, dashed lines are for reconstruction based on left side. Oblique lines are broken portions (Black bar=50mm).

FIG. 6. - Mandibles of MUSM 565 referred to *Brachydelphis mazeasi.* A) Lateral view. B) Medial view. The black arrow indicates the end of teeth row and beginning of deflection of coronoid

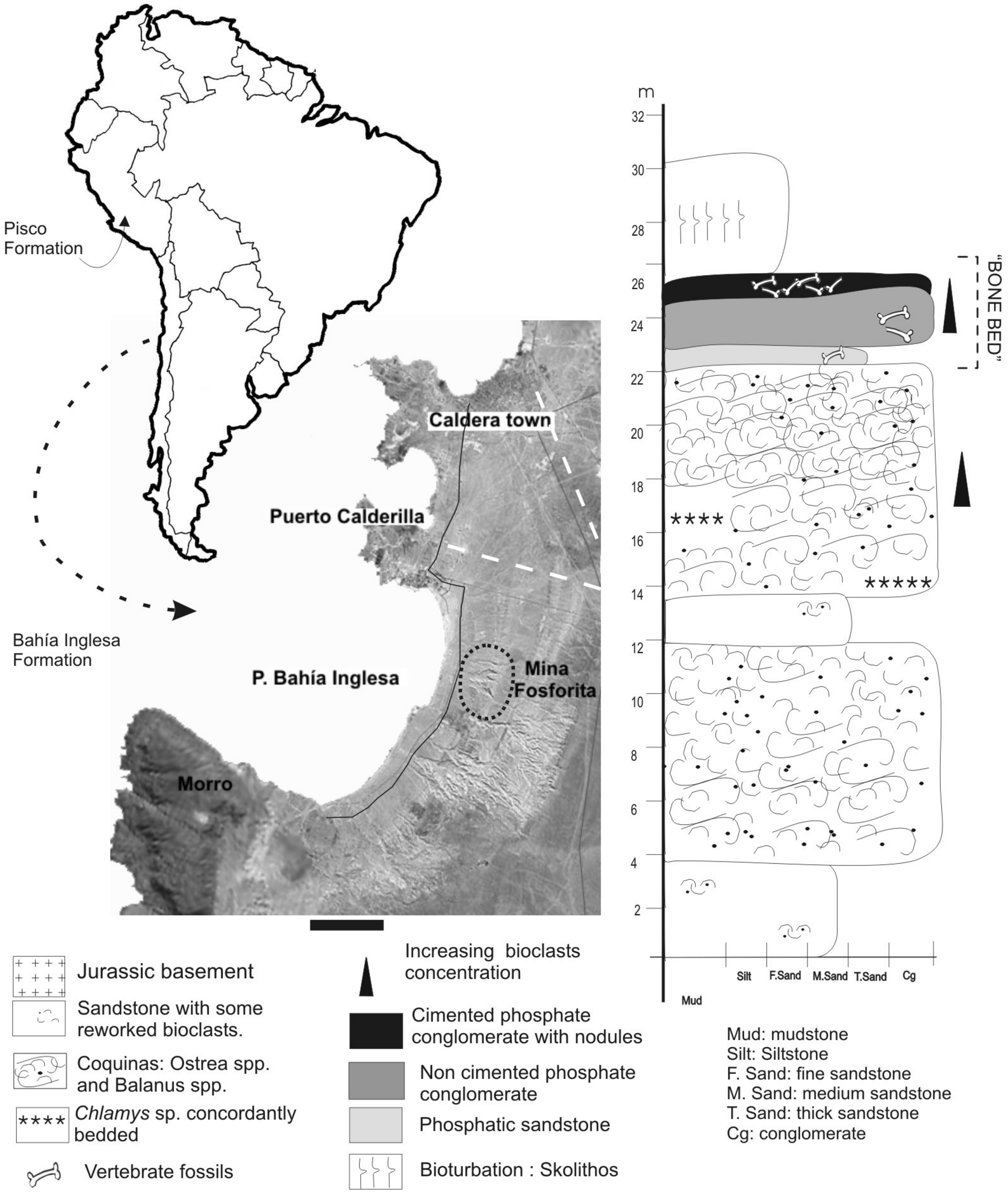
process (Black bar=50mm).

FIG. *7.* - Specimens referred to cf. *Brachydelphis* new form. A) Dorsal view of SGO-PV 1109). B) Ventral view of SGO-PV 972. C) Dorsal view of rostrum (SGO-PV 759). D) Mandibles of MUSM 884 in dorsal view. (Black bar=50mm) .

FIG. 8. - Comparison between skulls of *Pontoporia blainvillei* and *Brachydelohis mazeasi.* A) adult form of *P. blainvillei* (UFSC 1037). B) Juvenile form of *P. blainvillei* (UFSC 1059). C) Juvenile form of *B. mazeasi* (SGO-PV 746), D) adult form of *B. mazeasi* (MUSM 887). Note the similarity between the juvenile skulls of both species rather than the adult ones. (Black bar=50mm)

FIG. 9. - PCA shape analysis scatter diagram from landmarks 2D of fossil specimens (+) and specimens of *Pontoporia blainvillei* (closed circles). Note the greater variation within the fossil group and significant differentiation from *P. blainvillei* (p=0). A) PCA shape scatter with components 1 and 2. B) 3D plot landmarks from three main components rotated in component 1 and 2 axis (X and Y).

FIG. 10. - Log scaled charts of rostrum with in each centimeter from the base of a) known short-rostrum specimens, b) known long-rostrum specimens and c) dubious fossil specimens and fetus of *P. blainvillei*. Note that MUSM 887and MPC377s have short-rostrum tendencies.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"BONE BED"
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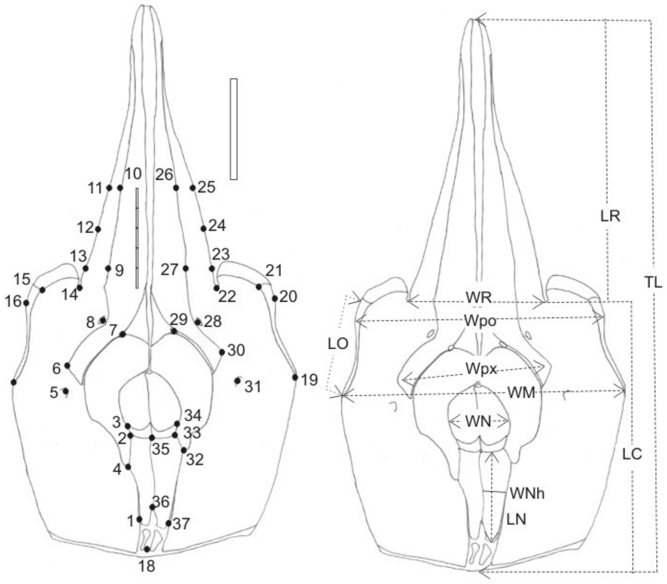
Mud
Silt
F.Sand
M.Sand
T.Sand
Cg
Jurassic basement
Sandstone with some reworked bioclasts.
Coquinas: Ostrea spp. and Balanus spp.
**** *Chlamys* sp. concordantly bedded
Vertebrate fossils
Increasing bioclasts concentration
Cimented phosphate conglomerate with nodules
Non cimented phosphate conglomerate
Phosphatic sandstone
Bioturbation : Skolithos
Mud: mudstone
Silt: Siltstone
F. Sand: fine sandstone
M. Sand: medium sandstone
T. Sand: thick sandstone
Cg: conglomerate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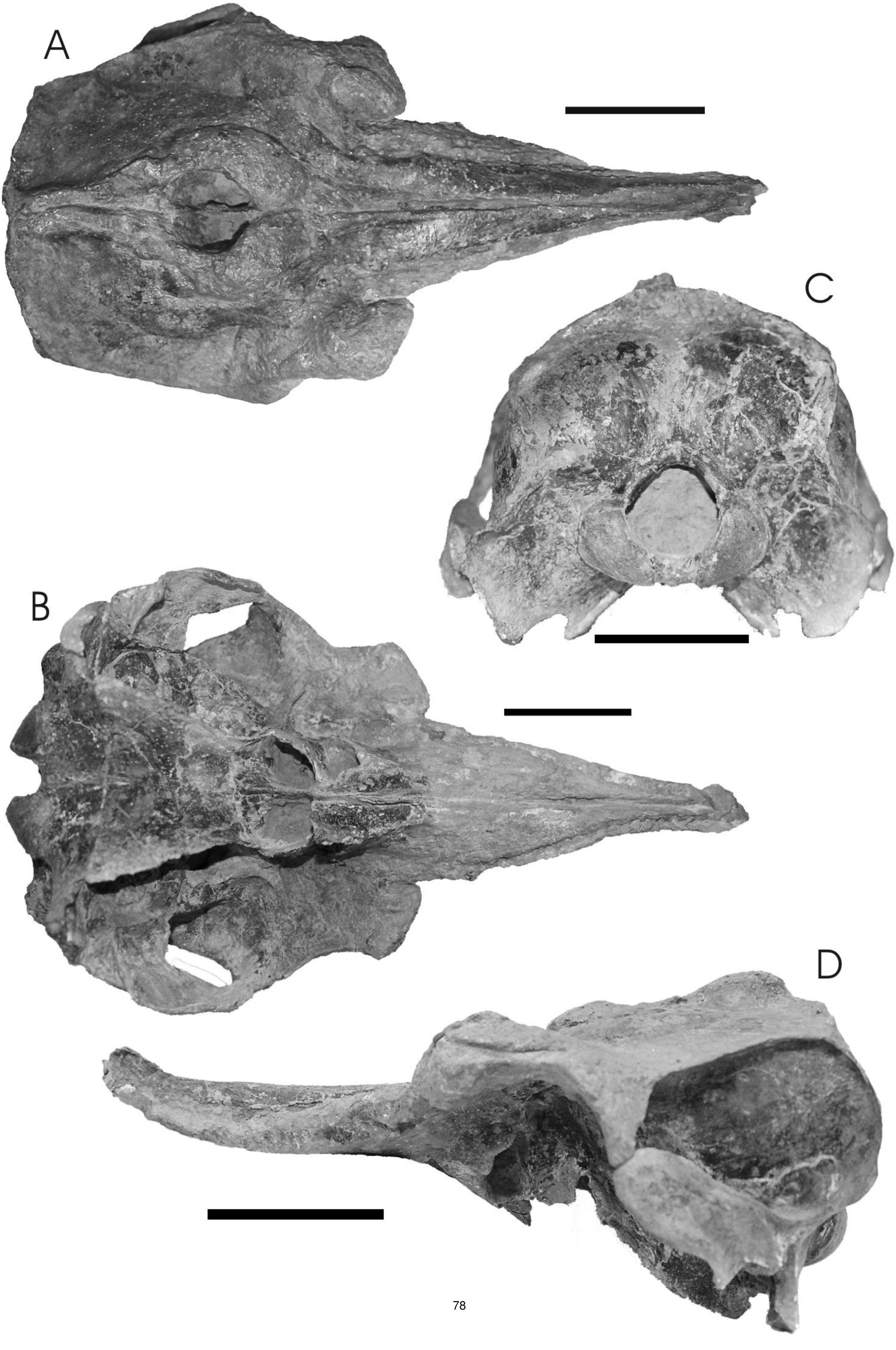
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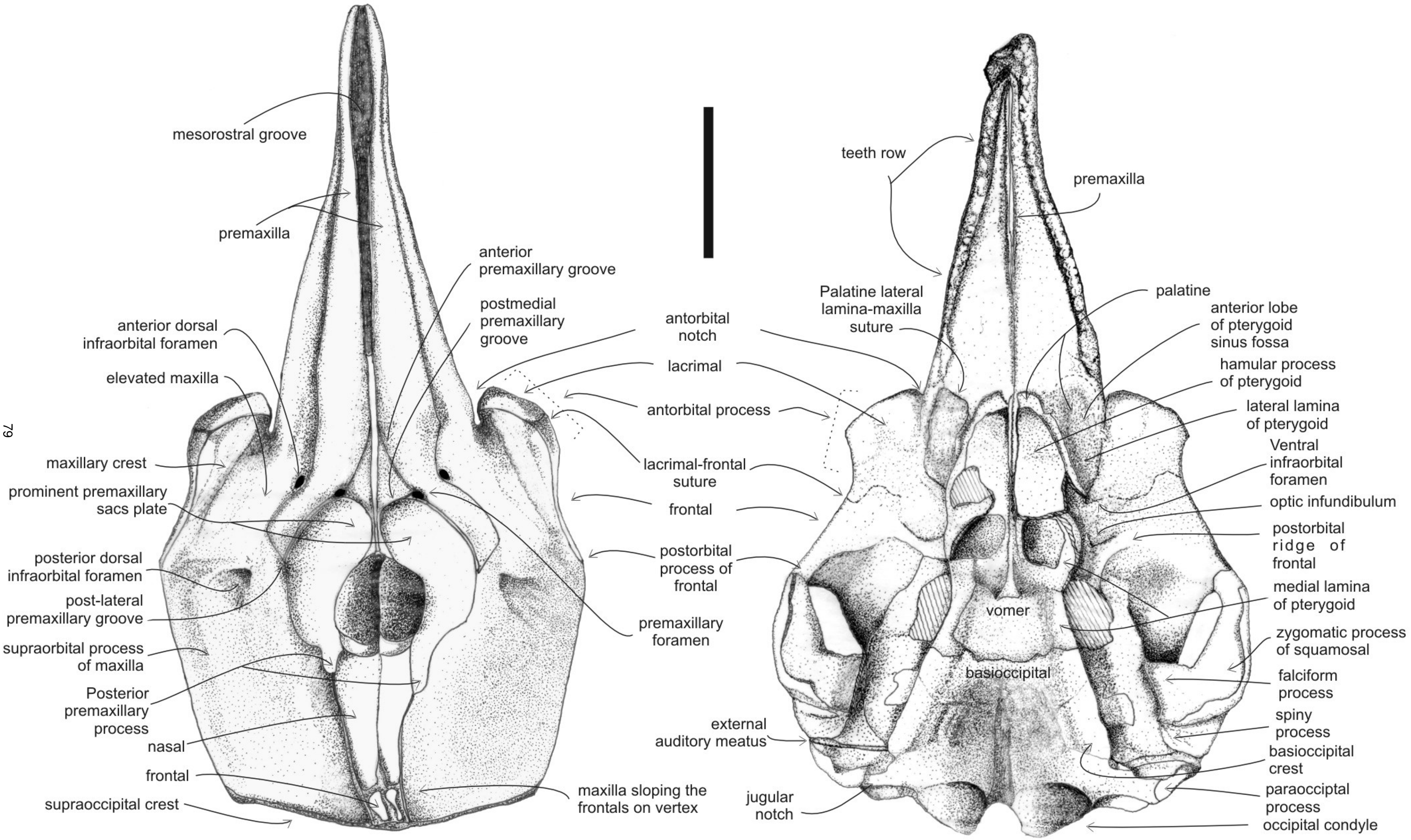
mesorostral groove
premaxilla
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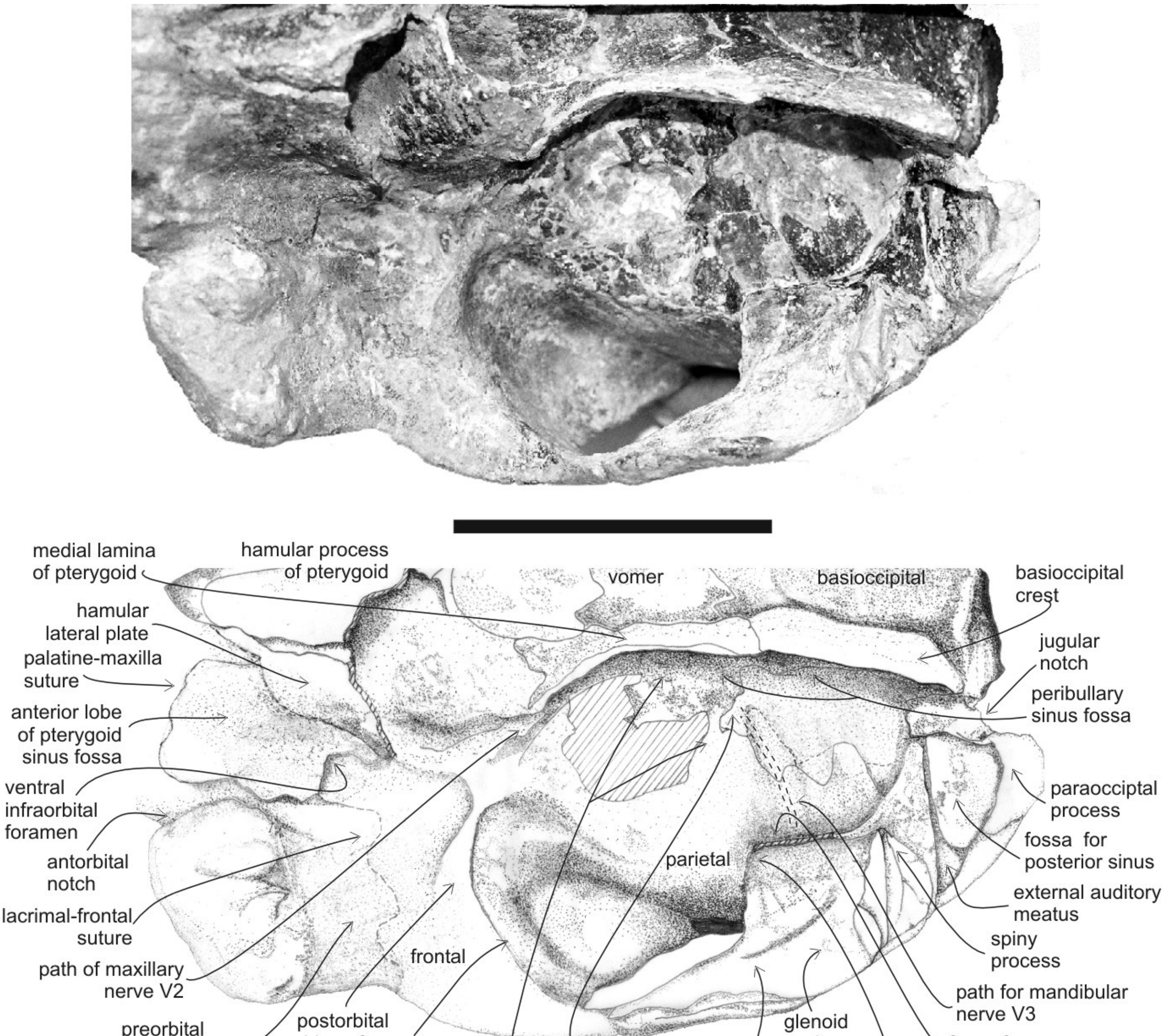
postmedial premaxillary groove
anterior dorsal infraorbital foramen
elevated maxilla
maxillary crest
prominent premaxillary sacs plate
posterior dorsal infraorbital foramen
post-lateral premaxillary groove
supraorbital process of maxilla
Posterior premaxillary process
nasal
frontal
supraoccipital crest
maxilla sloping the frontals on vertex
antorbital notch
lacrimal
antorbital process
lacrimal-frontal suture
frontal
postorbital process of frontal
premaxillary foramen
teeth row
premaxilla
Palatine lateral lamina-maxilla suture
palatine
anterior lobe of pterygoid sinus fossa
hamular process of pterygoid
lateral lamina of pterygoid
Ventral infraorbital foramen
optic infundibulum
postorbital ridge of frontal
medial lamina of pterygoid
vomer
zygomatic process of squamosal
basioccipital
falciform process
external auditory meatus
spiny process
basioccipital crest
jugular notch
paraoccipital process
occipital condyle


medial lamina of pterygoid
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anterior lobe of pterygoid sinus fossa
paraoccipital process
ventral infraorbital foramen
fossa for posterior sinus
antorbital notch
parietal
external auditory meatus
lacrimal-frontal suture
spiny process
frontal
path of maxillary nerve V2
path for mandibular nerve V3
glenoid cavity
preorbital lobe of pterygoid sinus fossa
postorbital ridge of frontal
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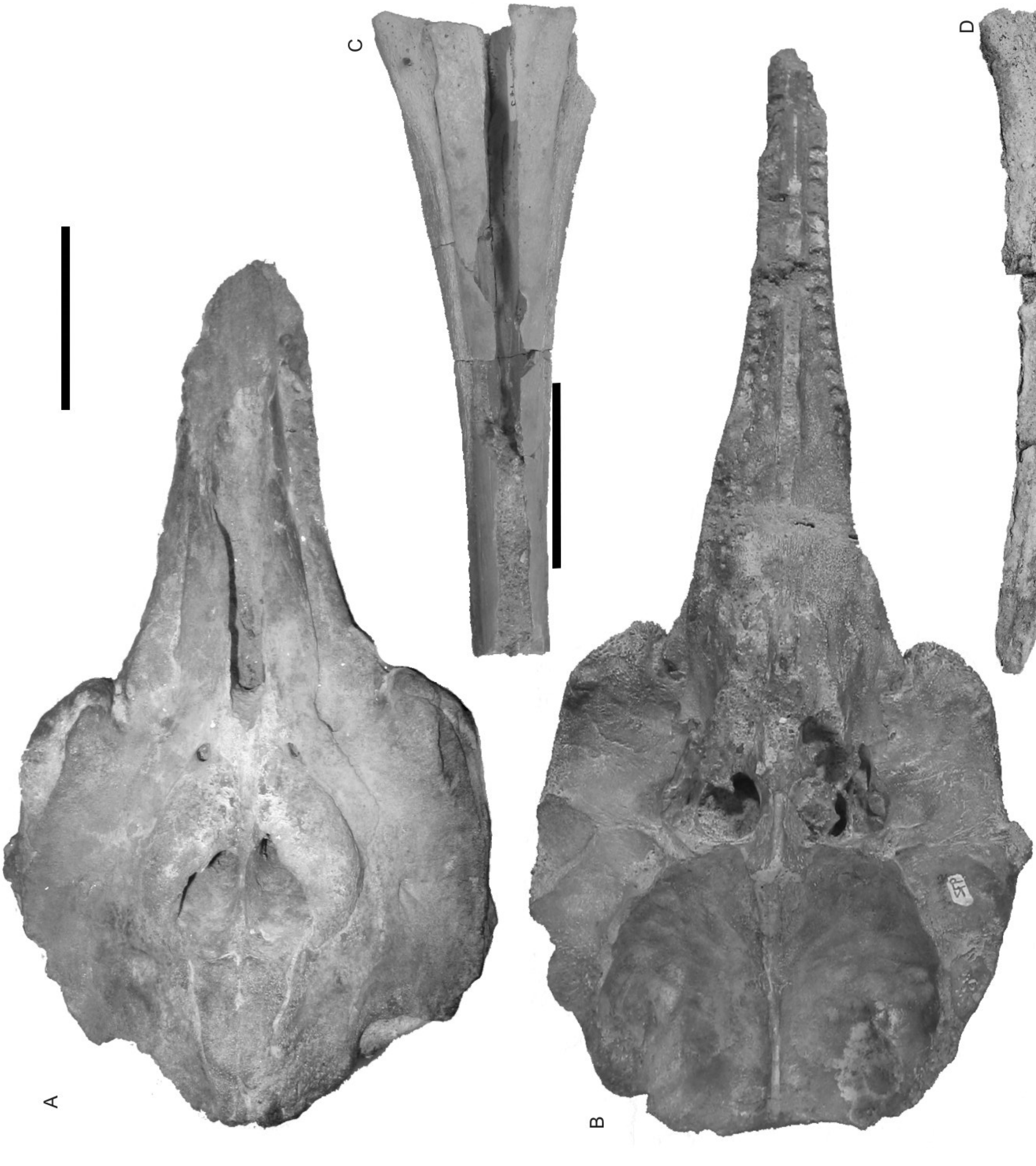
foramen ovale
zygomatic process of squamosal
falciform process
fossa for medial sinus


A
B
Symphisis region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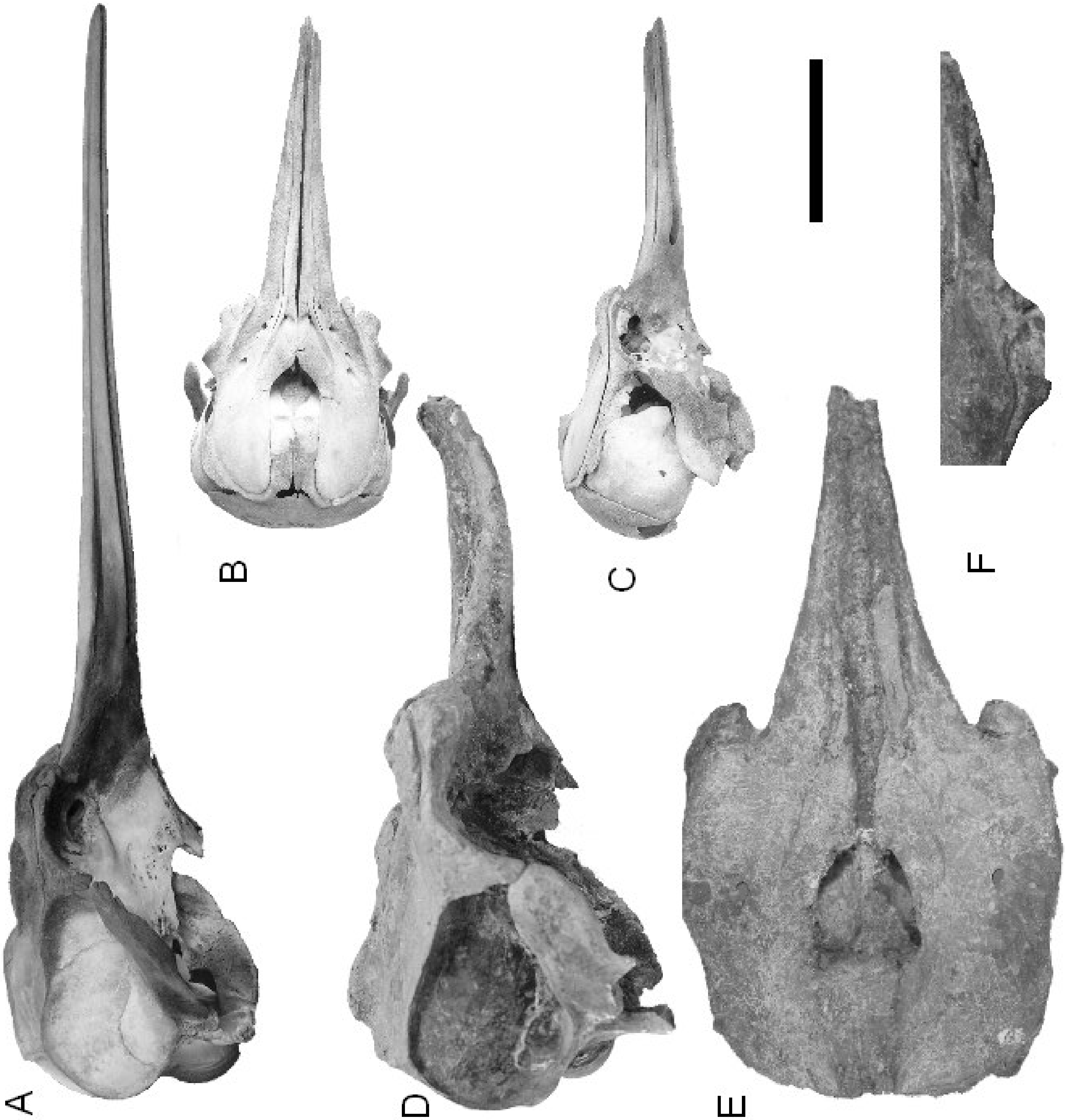
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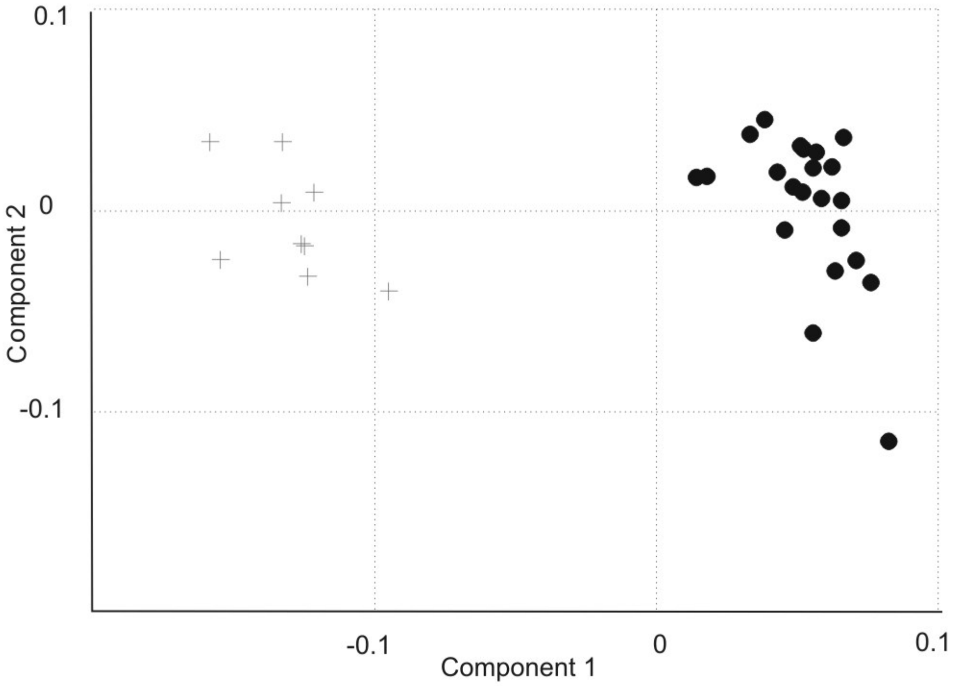
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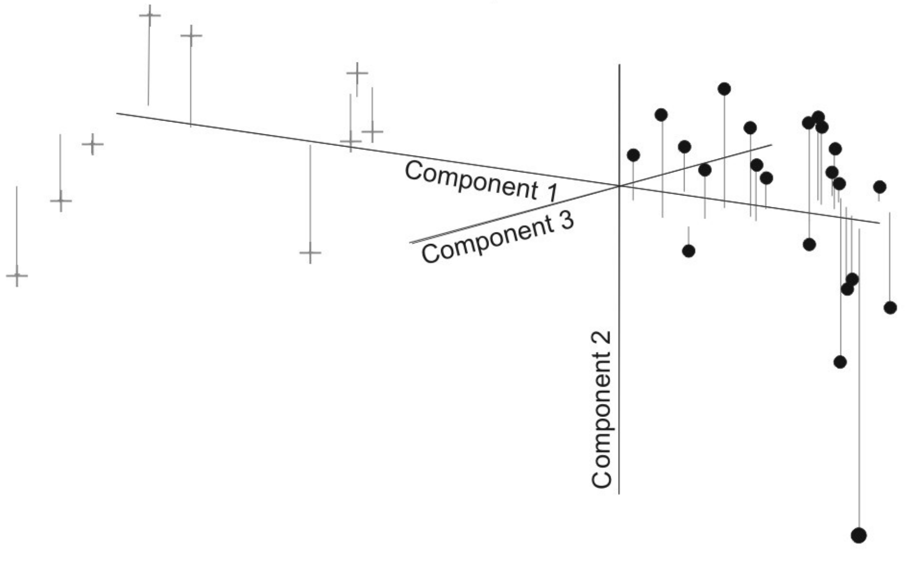
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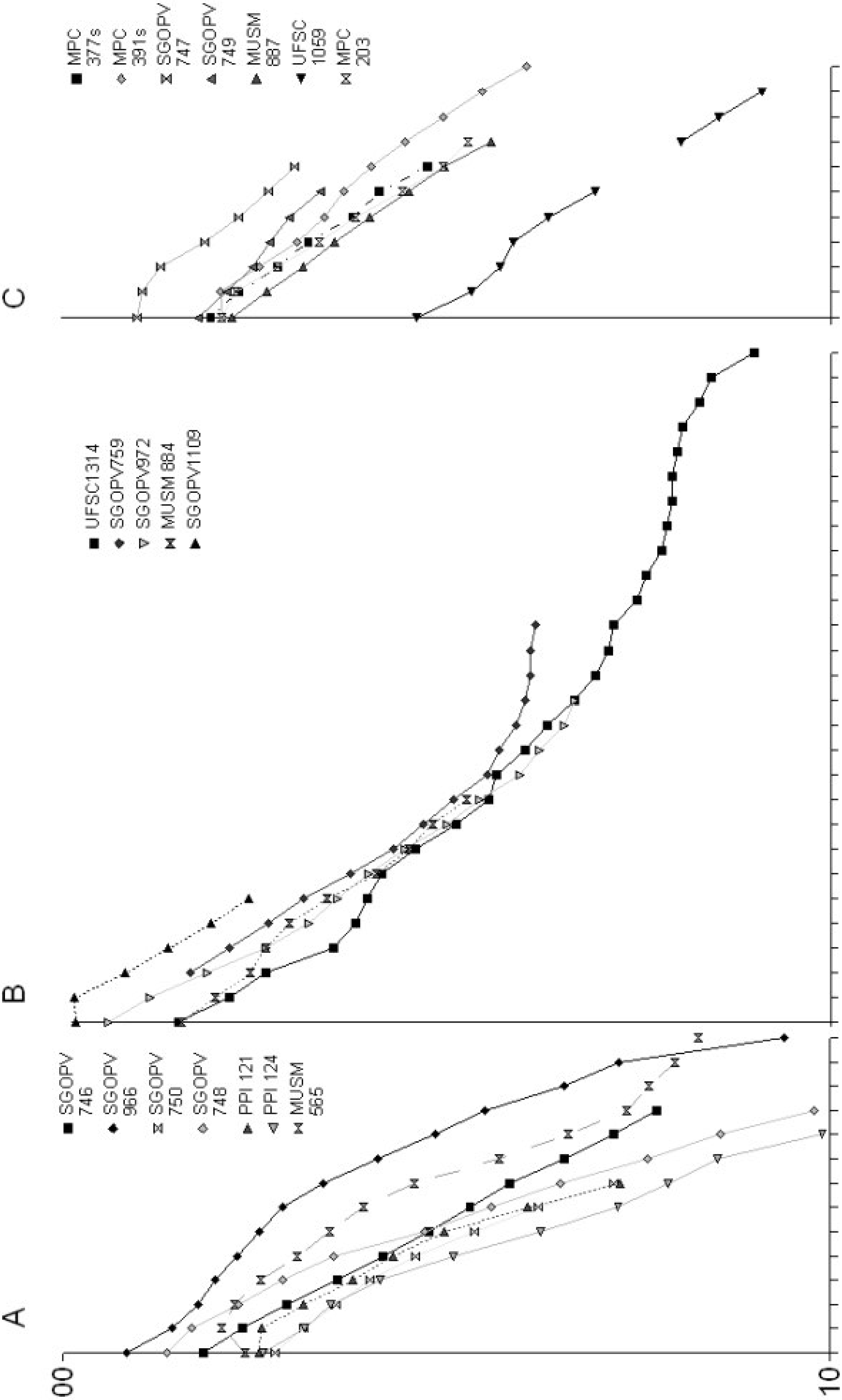
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