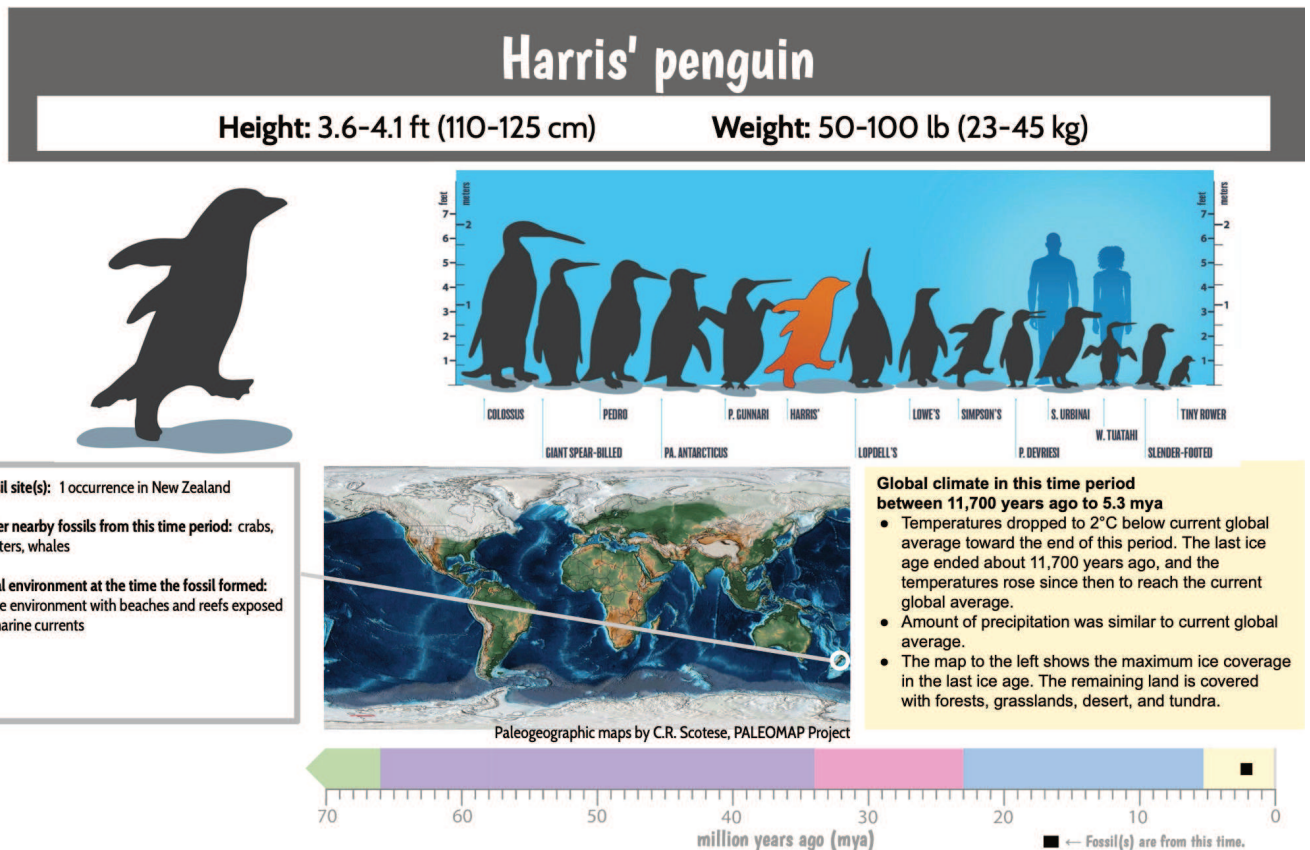


Ancient Penguin Data Cards

The trait variation data used in this lesson were compiled and merged from the following two resources.

- supporting online material published along with Clarke, J. A., Ksepka, D. T., Salas-Gismondi, R., Altamirano, A. J., Shawkey, M. D., D'Alba, L., Vinther, J., DeVries, T. J., & Baby, P. (2010). Fossil evidence for evolution of the shape and color of penguin feathers. *Science*, 330(6006), 954–957. <https://doi.org/10.1126/science.1193604>
- appendix published along with Clarke, J. A., Ksepka, D. T., Stucchi, M., Urbina, M., Giannini, N., Bertelli, S., Narvaez, Y., & Boyd, C. A. (2007). Paleogene equatorial penguins challenge the proposed relationship between biogeography, diversity, and Cenozoic climate change. *Proceedings of the National Academy of Sciences*, 104(28), 11545–11550. <https://doi.org/10.1073/pnas.0611099104>

Harris'	
AA	?
BB	1
CC	2
DD	2
EE	1
FF	1
GG	?
HH	?
II	?
JJ	1
KK	0
LL	0
MM	1
NN	?

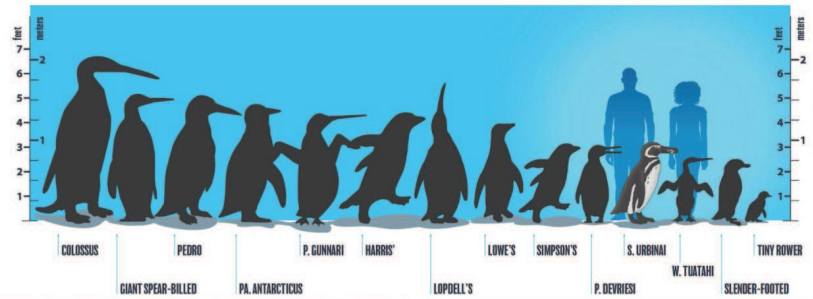


<i>S. urbinai</i>	
AA	2
BB	1
CC	2
DD	?
EE	1
FF	1
GG	?
HH	2
II	1
JJ	1
KK	0
LL	0
MM	1
NN	2

S. urbinai

Height: 2.3-3 ft (70-91 cm)

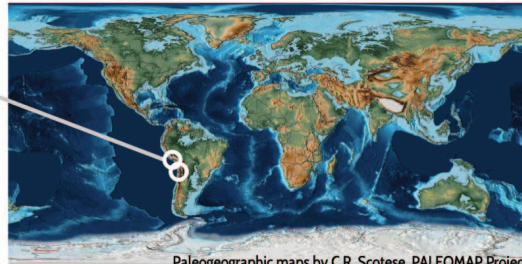
Weight: 10.5-17 lb (4.8-7.7 kg)



Fossil site(s): 3 occurrences in Peru, 1 occurrence in Chile

Other nearby fossils from this time period: clams, rock snails, rays, sharks including Megalodon, ray-finned fish, crocodiles, seals, aquatic sloths, whales, dolphins, seals, other birds

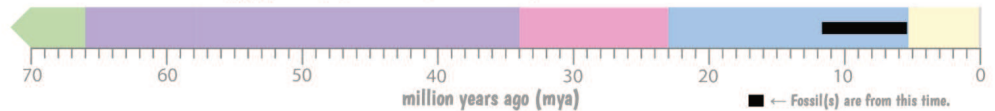
Local environment at the time the fossil formed: shore environment with beaches and reefs exposed to marine currents



Paleogeographic maps by C.R. Scotese, PALEOMAP Project

Global climate in this time period between 5.3 mya to 23 mya

- Temperature was 3°C above current global average.
- Amount of precipitation was similar to current global average.
- Inland seas from previous period dried out and polar ice caps formed.
- The amount of grasslands and deserts and tundra increased and the amount of forest decreased compared to the previous time period.

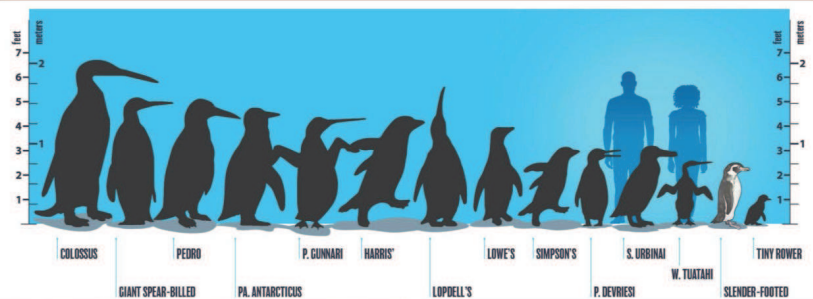


<i>Slender-footed</i>	
AA	?
BB	?
CC	?
DD	2
EE	1
FF	1
GG	1
HH	2
II	2
JJ	1
KK	0
LL	0
MM	1
NN	1

Slender-footed penguin

Height: 2.3-2.5 ft (70-76 cm)

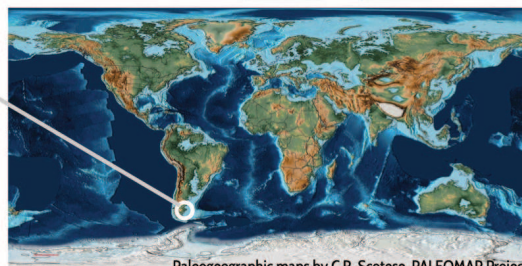
Weight: 8-13 lb (3.6-5.9 kg)



Fossil site(s): 1 occurrence in Argentina

Other nearby fossils from this time period: sharks, oysters and other shellfish, hooved mammals

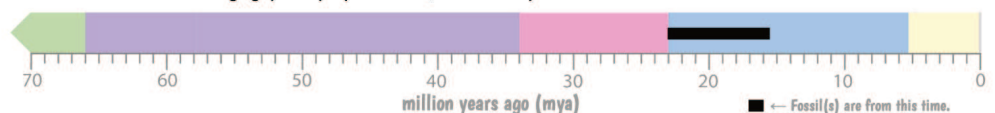
Local environment at the time the fossil formed: shore environment with beaches and reefs exposed to marine currents



Paleogeographic maps by C.R. Scotese, PALEOMAP Project

Global climate in this time period between 5.3 mya to 23 mya

- Temperature was 3°C above current global average.
- Amount of precipitation was similar to current global average.
- Inland seas from previous period dried out and polar ice caps formed.
- The amount of grasslands and deserts and tundra increased and the amount of forest decreased compared to the previous time period.

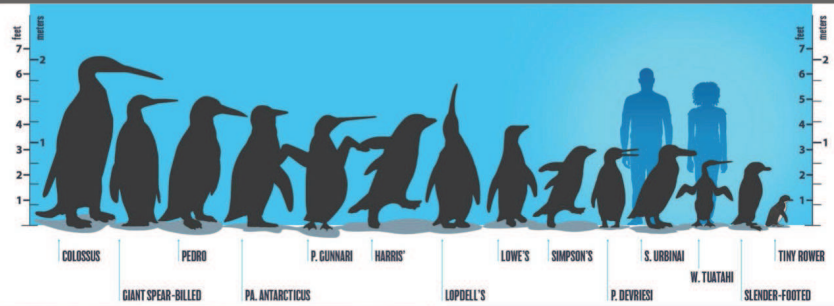


Tiny rower	
AA	?
BB	?
CC	?
DD	?
EE	?
FF	?
GG	?
HH	2
II	2
JJ	1
KK	0
LL	0
MM	1
NN	1

Tiny rower penguin

Height: 1.1-1.2 ft (33.5-36.6 cm)

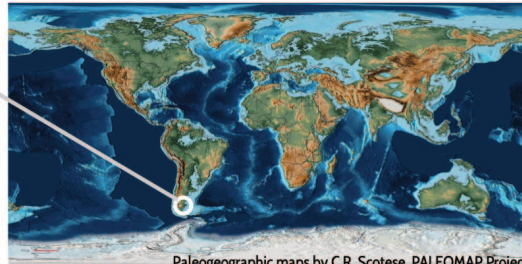
Weight: 2.1-2.3 lb (0.9-1.0 kg)



Fossil site(s): 3 occurrences in Argentina

Other nearby fossils from this time period: toothed and baleen whales, sharks, seals, turtles, hooved mammals, shellfish, other penguins

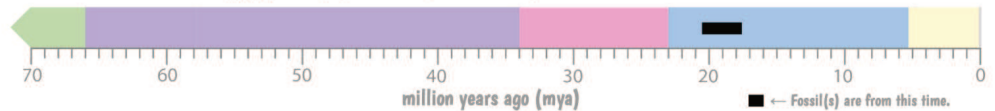
Local environment at the time the fossil formed: shore environment with beaches and reefs exposed to marine currents



Paleogeographic maps by C.R. Scotese, PALEOMAP Project

Global climate in this time period between 5.3 mya to 23 mya

- Temperature was 3°C above current global average.
- Amount of precipitation was similar to current global average.
- Inland seas from previous period dried out and polar ice caps formed.
- The amount of grasslands and deserts and tundra increased and the amount of forest decreased compared to the previous time period.



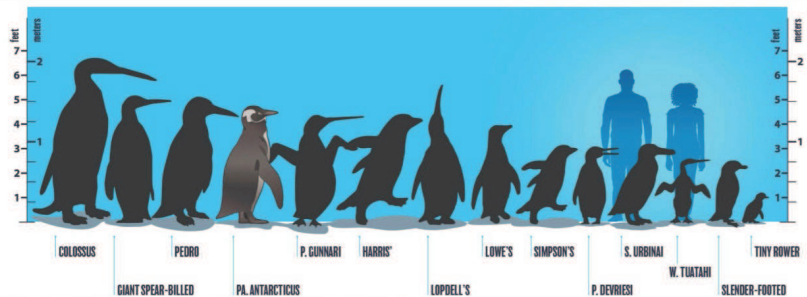
← Fossil(s) are from this time.

Pa. antarcticus	
AA	?
BB	1
CC	2
DD	?
EE	?
FF	?
GG	2
HH	2
II	1
JJ	1
KK	0
LL	0
MM	1
NN	1

Pa. antarcticus

Height: 3.6-4.6 ft (110-140 cm)

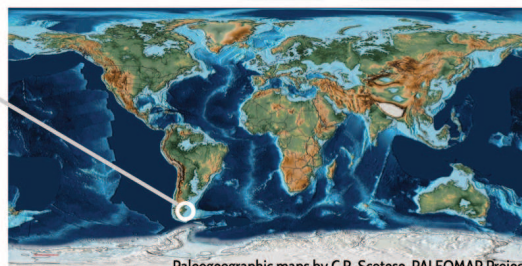
Weight: 75-125 lb (34-57 kg)



Fossil site(s): 3 occurrences in Argentina

Other nearby fossils from this time period: toothed and baleen whales, sharks, seals, turtles, hooved mammals, shellfish, other penguins

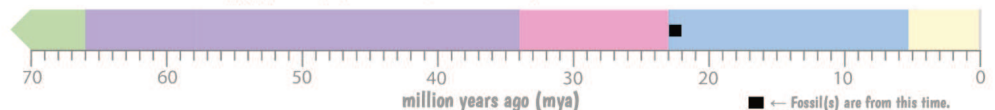
Local environment at the time the fossil formed: shore environment with beaches and reefs exposed to marine currents



Paleogeographic maps by C.R. Scotese, PALEOMAP Project

Global climate in this time period between 5.3 mya to 23 mya

- Temperature was 3°C above current global average.
- Amount of precipitation was similar to current global average.
- Inland seas from previous period dried out and polar ice caps formed.
- The amount of grasslands and deserts and tundra increased and the amount of forest decreased compared to the previous time period.



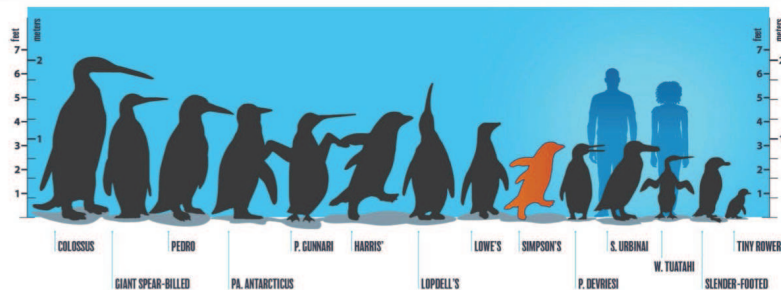
← Fossil(s) are from this time.

Simpson's	
AA	?
BB	?
CC	?
DD	1
EE	1
FF	0
GG	?
HH	?
II	?
JJ	1
KK	0
LL	0
MM	0
NN	?

Simpson's penguin

Height: 2.3-3.1 ft (70-95 cm)

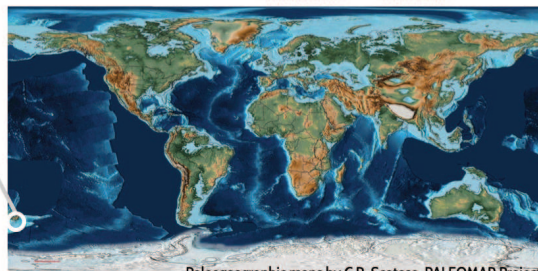
Weight: 20-40 lb (9-18 kg)



Fossil site(s): 1 occurrence in New Zealand

Other nearby fossils from this time period: whales, sharks, fish, other penguins, various shellfish, starfish, corals

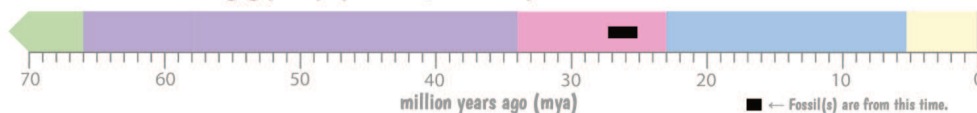
Local environment at the time the fossil formed: shore environment with beaches and reefs exposed to marine currents



Paleogeographic maps by C.R. Scotese, PALEOMAP Project

Global climate in this time period between 23 mya to 34 mya

- Temperatures dropped from 12°C above current global average to 3°C above current global average by the end of this period.
- Much higher precipitation occurred than the current global average at the start of this period. It dropped to an amount similar to today by the end of this period.
- Smaller areas of the continents were covered by warm, shallow seas than the previous period.
- Most of the remaining land was covered with forests, with small amounts of grasslands or deserts.

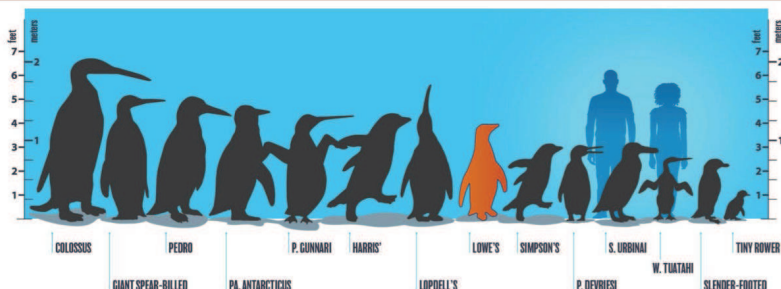


Lowe's	
AA	?
BB	?
CC	?
DD	?
EE	0
FF	0
GG	2
HH	?
II	?
JJ	1
KK	1
LL	0
MM	0
NN	1

Lowe's penguin

Height: 2.7-3.7 ft (82-113 cm)

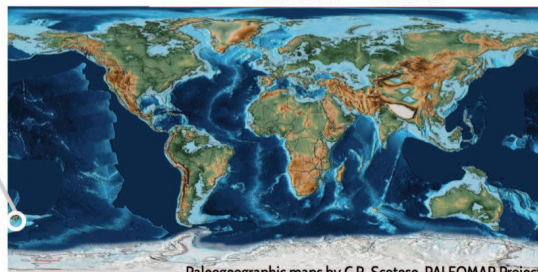
Weight: 40-70 lb (18-32 kg)



Fossil site(s): 1 occurrence in New Zealand

Other nearby fossils from this time period: whales, sharks, fish, other penguins, various shellfish, starfish, corals

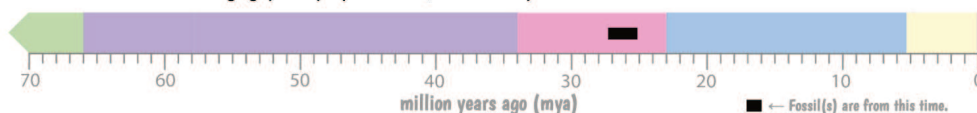
Local environment at the time the fossil formed: shore environment with beaches and reefs exposed to marine currents



Paleogeographic maps by C.R. Scotese, PALEOMAP Project

Global climate in this time period between 23 mya to 34 mya

- Temperatures dropped from 12°C above current global average to 3°C above current global average by the end of this period.
- Much higher precipitation occurred than the current global average at the start of this period. It dropped to an amount similar to today by the end of this period.
- Smaller areas of the continents were covered by warm, shallow seas than the previous period.
- Most of the remaining land was covered with forests, with small amounts of grasslands or deserts.

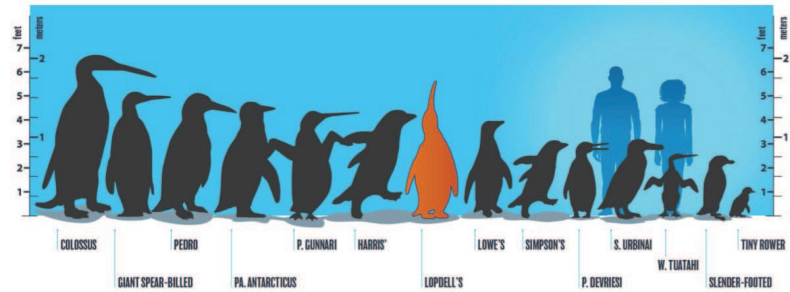


Lopdell's	
AA	?
BB	?
CC	?
DD	?
EE	0
FF	0
GG	?
HH	2
II	1
JJ	?
KK	?
LL	0
MM	?
NN	?

Lopdell's penguin

Height: 2.9-3.9 ft (88-119 cm)

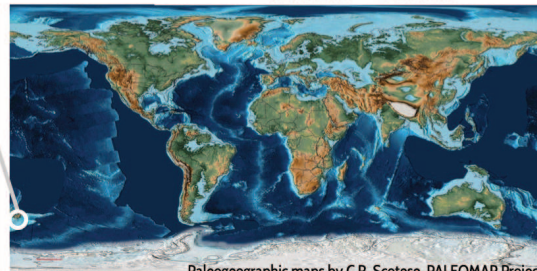
Weight: 30-90 lb (14-41 kg)



Fossil site(s): 1 occurrence in New Zealand

Other nearby fossils from this time period: whales, sharks, fish, other penguins, various shellfish, starfish, corals

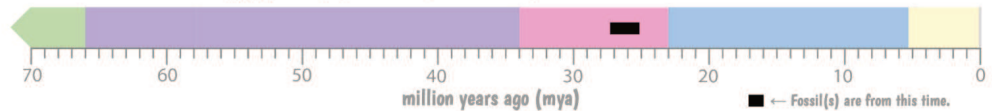
Local environment at the time the fossil formed: shore environment with beaches and reefs exposed to marine currents



Paleogeographic maps by C.R. Scotese, PALEOMAP Project

Global climate in this time period between 23 mya to 34 mya

- Temperatures dropped from 12°C above current global average to 3°C above current global average by the end of this period.
- Much higher precipitation occurred than the current global average at the start of this period. It dropped to an amount similar to today by the end of this period.
- Smaller areas of the continents were covered by warm, shallow seas than the previous period.
- Most of the remaining land was covered with forests, with small amounts of grasslands or deserts.



Gunnari	
AA	
BB	?
CC	?
DD	?
EE	?
FF	?
GG	
HH	0
II	2
JJ	1
KK	0
LL	?
MM	0
NN	0

P. gunnari

Height: 3.6-4.1 ft (110-125 cm)

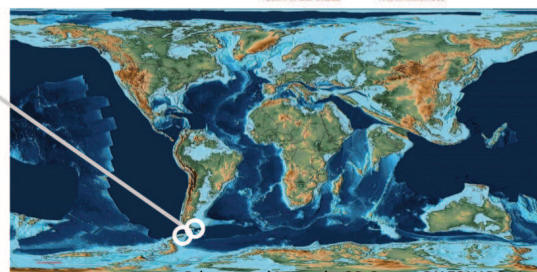
Weight: 75-125 lb (34-57 kg)



Fossil site(s): 10 occurrences in Antarctica, 1 occurrence in Argentina

Nearby fossils from this time period: Terrestrial: trees, ferns, opossum-like marsupials, hoofed mammals, sloths, raptors. Marine: crabs, shellfish, sharks

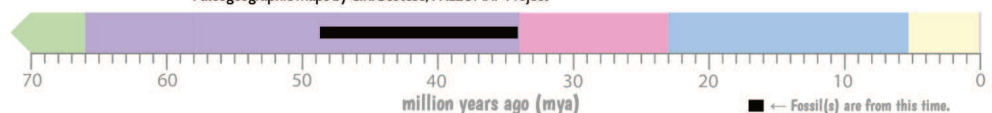
Local environment at the time the fossil formed: shore environment with beaches and reefs exposed to marine currents



Paleogeographic maps by C.R. Scotese, PALEOMAP Project

Global climate in this time period between 34 mya to 66 mya

- Temperature was 10-12°C above current global average.
- Much higher amounts of precipitation occurred than current global average.
- Large areas of the continents were covered by warm, shallow seas, providing habitat for many marine organisms.
- Most of the remaining land was covered by a combination of forests, swamps, and wetlands.



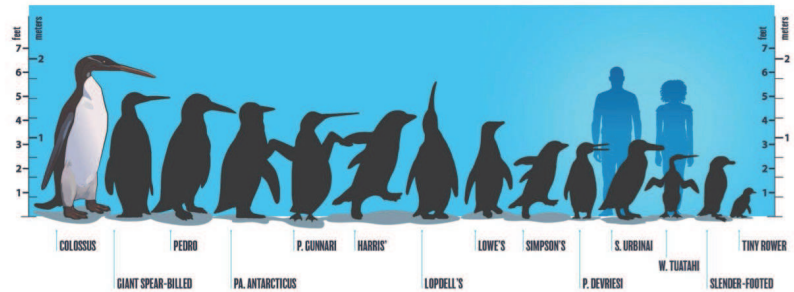
Penguin image credit: Acosta Hospitaleche, C., et al. Late Cretaceous/Paleogene West Antarctica terrestrial biota and its intercontinental affinities. Springer: 2013. DOI:10.1007/978-94-007-5491-1_1, Rights Reserved.

Colossus	
AA	?
BB	?
CC	?
DD	?
EE	?
FF	?
GG	?
HH	0
II	2
JJ	1
KK	0
LL	2
MM	0
NN	?

Colossus penguin

Height: 6.6 ft (201 cm)

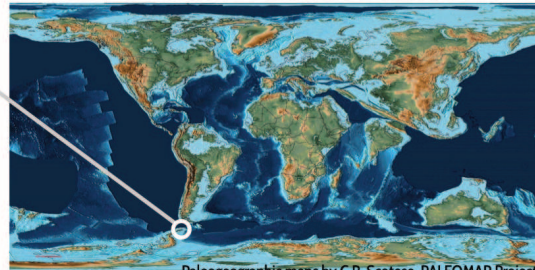
Weight: 250 lb (113 kg)



Fossil site(s): 7 occurrences in Antarctica

Other nearby fossils from this time period: whales, sharks

Local environment at the time the fossil formed: shore environment with beaches and reefs exposed to marine currents



Paleogeographic maps by C.R. Scotese, PALEOMAP Project

Global climate in this time period between 34 mya to 66 mya

- Temperature was 10-12°C above current global average.
- Much higher amounts of precipitation occurred than current global average.
- Large areas of the continents were covered by warm, shallow seas, providing habitat for many marine organisms.
- Most of the remaining land was covered by a combination of forests, swamps, and wetlands.

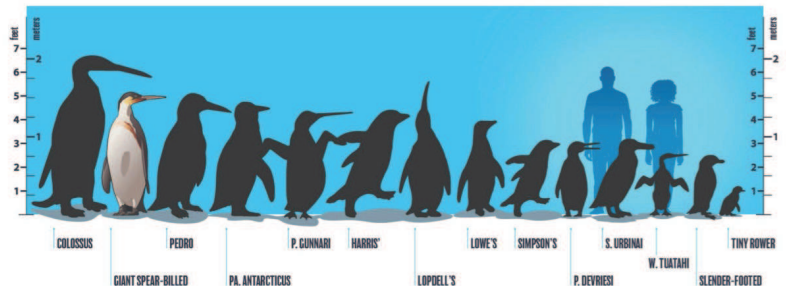


Giant spear-billed	
AA	0
BB	1
CC	2
DD	?
EE	?
FF	?
GG	?
HH	?
II	?
JJ	0
KK	0
LL	0
MM	0
NN	0

Giant spear-billed penguin

Height: 4.9-5.0 ft (149-152 cm)

Weight: 110-176 lb (50-80 kg)



Fossil site(s): 1 occurrence in Peru

Other nearby fossils from this time period: whales, sharks

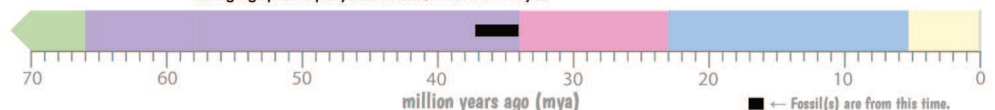
Local environment at the time the fossil formed: shore environment with beaches and reefs exposed to marine currents



Paleogeographic maps by C.R. Scotese, PALEOMAP Project

Global climate in this time period between 34 mya to 66 mya

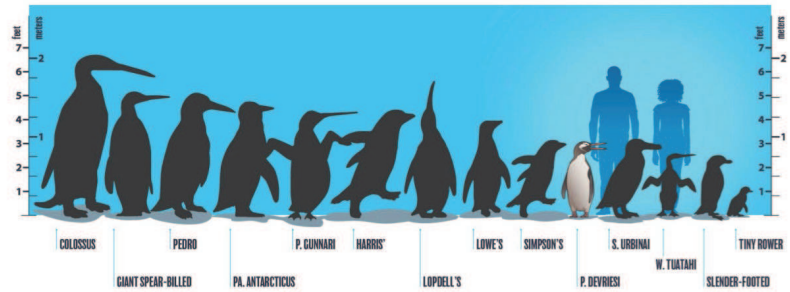
- Temperature was 10-12°C above current global average.
- Much higher amounts of precipitation occurred than current global average.
- Large areas of the continents were covered by warm, shallow seas, providing habitat for many marine organisms.
- Most of the remaining land was covered by a combination of forests, swamps, and wetlands.



<i>P. devriesi</i>	
AA	?
BB	1
CC	2
DD	?
EE	?
FF	?
GG	?
HH	1 or 2
II	?
JJ	?
KK	1
LL	1
MM	0
NN	0

P. devriesi

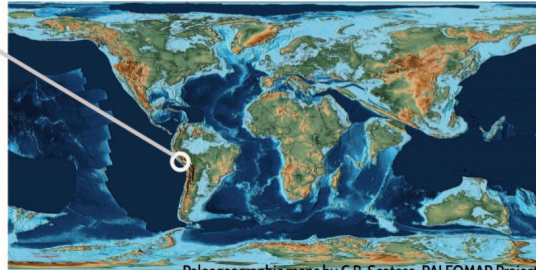
Height: 2.5-3 ft (76-91 cm) Weight: 50-100 lb (23-45 kg)



Fossil site(s): 1 occurrence in Peru

Nearby fossils from this time period: --

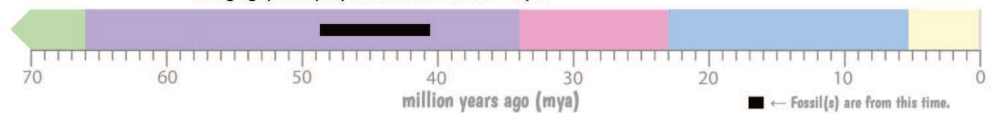
Local environment at the time the fossil formed:
shore environment with beaches and reefs exposed
to marine currents



Paleogeographic maps by C.R. Scotese, PALEOMAP Project

Global climate in this time period between 34 mya to 66 mya

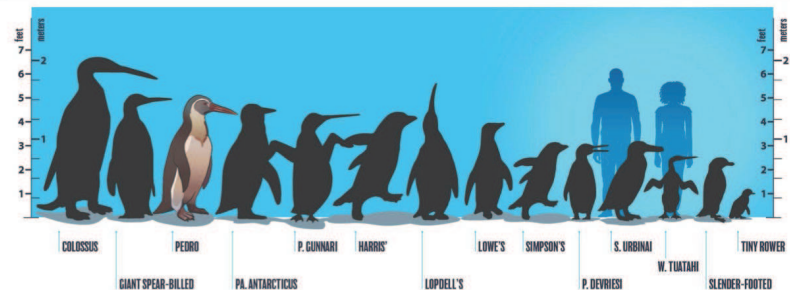
- Temperature was 10-12°C above current global average.
- Much higher amounts of precipitation occurred than current global average.
- Large areas of the continents were covered by warm, shallow seas, providing habitat for many marine organisms.
- Most of the remaining land was covered by a combination of forests, swamps, and wetlands.



Water king/ Pedro (Internal)	
AA	0
BB	1
CC	2
DD	1
EE	0
FF	0
GG	2
HH	2
II	2
JJ	0
KK	0
LL	0
MM	0
NN	0

"Pedro"/ Water King penguin

Height: 5 ft (152 cm) Weight: 100-200 lb (45-91 kg)



Fossil site(s): 1 occurrence in Peru

Nearby fossils from this time period: clams, sea
snails, sharks, ray-finned fish, whales

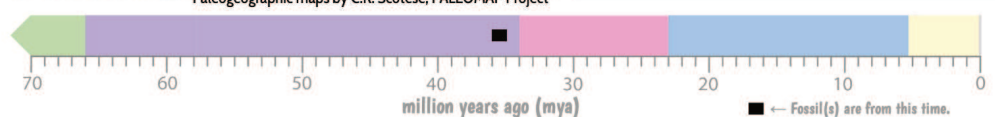
Local environment at the time the fossil formed:
shore environment with beaches and reefs exposed
to marine currents



Paleogeographic maps by C.R. Scotese, PALEOMAP Project

Global climate in this time period between 34 mya to 66 mya

- Temperature was 10-12°C above current global average.
- Much higher amounts of precipitation occurred than current global average.
- Large areas of the continents were covered by warm, shallow seas, providing habitat for many marine organisms.
- Most of the remaining land was covered by a combination of forests, swamps, and wetlands.

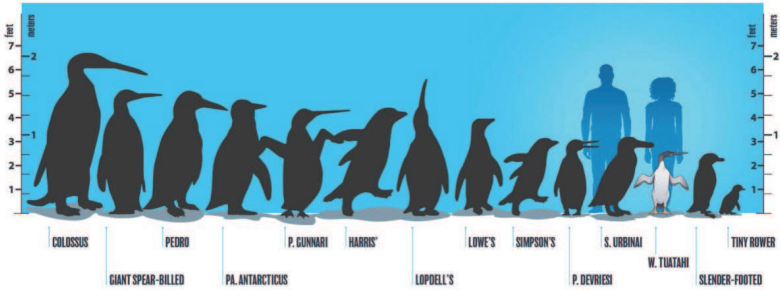


W. tuatahi	
AA	?
BB	?
CC	2
DD	?
EE	0
FF	?
GG	?
HH	0
II	0
JJ	1
KK	1
LL	1
MM	1
NN	1

W. tuatahi

Height: 2.5 ft (76 cm)

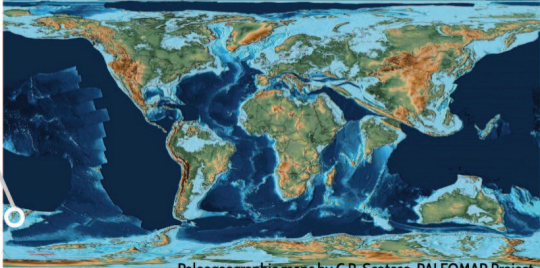
Weight: 22-66 lb (10-30 kg)



Fossil site(s): 4 occurrences in New Zealand

Nearby fossils from this time period: sharks, coral-like organisms, other birds

Local environment at the time the fossil formed: shore environment with beaches and reefs exposed to marine currents



Global climate in this time period between 34 mya to 66 mya

- Temperature was 10-12°C above current global average.
- Much higher amounts of precipitation occurred than current global average.
- Large areas of the continents were covered by warm, shallow seas, providing habitat for many marine organisms.
- Most of the remaining land was covered by a combination of forests, swamps, and wetlands.

