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Oribatid mites (*Acariformes*: *Sarcoptiformes*) in Sub-Antarctic Islands and Antarctica: a track analysis

Abstract. Southern non-marine mites are widely distributed in the continents that developed out of the macrocontinent Gondwana, with similar groups found in Australia, New Zealand, Sub-Antarctic Islands, and southern South America. In the present study, we conducted a literature analysis of non-marine oribatid (moss) mite species (*Acariformes*: *Sarcoptiformes*) studies at the Sub-Antarctic Islands and Antarctic continent, an applied a track analysis. The purpose of the study is to identify sites potentially inhabited by ancestor species and understand the biogeographical patterns of their dispersion to new sites where current species have arisen through speciation processes. The results of the track analysis revealed the existence of species that inhabit three main zones: the first track includes South Georgia and the Sub-Antarctic Islands of the South Atlantic, the southern Indian Ocean and southern Australia and New Zealand. The second track includes South Georgia Island and the Antarctic Peninsula; and the third track includes South Georgia Island and the Falkland Islands. All these tracks intersect in South Georgia Island, suggesting that this island would be the zone from which the species reported spread to the other sites mentioned, colonizing Antarctica, the Falkland Islands, and probably southern South America.

Keywords: biogeography, mite, nodes, oribatid, Sub-Antarctica, track analysis

1 Introduction

The biogeographical distribution of Southern fauna includes groups shared between Antarctica, Sub-Antarctic Islands, Australia, New Zealand, and southern South America. These biogeographical patterns are due to the existence of the ancient macrocontinent Gondwana; when it broke up, these landmasses separated and migrated to their present positions under the effects of continental drift (Bayly, 1993; Menu-Marque et al., 2000; Díaz et al., 2019; Cannizzaro & Berg, 2022). We may, therefore, infer that taxa currently present in Sub-Antarctic Islands are descended from ancestors that originated in Gondwana (Cannizzaro & Berg, 2022).

Among the invertebrates reported for southern latitudes, terrestrial mites would comply with this biogeographical pattern (Starý & Block, 1998). This is supported by studies of Sub-Antarctic Islands which report the presence of shared oribatid species between different Sub-Antarctic Islands as well as Antarctica, Australia, New Zealand, and southern South America (Pugh, 1993; Starý & Block, 1995; 1996; Starý et al., 1997; Subías, 2004). Furthermore, studies of inland water mites of southern South America have reported the presence of species shared with adjacent Sub-Antarctic islands (Cook, 1988; Pešić et al., 2010). In the present study, we conducted a literature analysis of non-marine mites from the Sub-Antarctic Islands and Antarctica to apply a track analysis. The object of the study was to identify sites potentially inhabited by ancestor species and understand the biogeographical patterns of their dispersion to new sites where current species have arisen through speciation processes (Morrone, 2009; Cannizzaro & Berg, 2022).

2 Materials and methods

Records and sites of oribatid mites reported for Sub-Antarctic Islands and Antarctica were obtained from literature (Pugh, 1993; Starý & Block, 1995; 1996; Starý et al., 1997; because consulted references were based on review of literature antecedents, the obtained data would be preliminary), and taxonomic ranks were confirmed by ITIS (Integrated Taxonomic Information System, www.itis.gov). Coordinates of localities were obtained from the literature or calculated on maps and rounded off to minutes. Within each site, the localities are ordered in a roughly south-north direction.

The panbiogeographic approach involves plotting distributions of different taxa on maps and joining their separate localities with lines called individual tracks. These tracks represent the geographical coordinates of species or higher taxa (Morrone, 2009). Operationally, they consist of lines drawn on a map of the localities at which the taxa occur. These localities are connected according to their geographical proximity (Morrone & Crisci, 1995; Menu-Marque et al., 2000). When different individual tracks are superimposed, the resulting summary lines are considered "generalized tracks" (Morrone & Crisci, 1995; Morrone, 2009). Generalized tracks are interpreted as indicating the pre-existence of ancestral biotas that subsequently became fragmented by tectonic and/or climatic change (Menu-Marque et al., 2000; Morrone, 2009). If two or more generalized tracks intersect in a given area, this is classified as a "node" (Morrone & Crisci, 1995; Morrone, 2009). The presence of a node indicates that different ancestral biotic and geological fragments intersected in space and time due to terrain collision, docking, or suturing. These fragments thus constitute a composite area. For further details on panbiogeographic methods, see Morrone (2009; 2015). Map was done with R software (R development Core Team, 2023) and package "ggmap" (Kahle & Wickham, 2013).

3 Results

The available information revealed the existence of isolated species for areas shown in Appendix C, Figure C1, such as the Falkland Islands (*Eobrachychthonius oudemansi, Ceratoppia* sp., *Crotonia* sp., *Alaskozetes antarcticus intermedius*, *Heminothrus skottsbergi, Hermannia falklandica*, *Globoppia intermedia*, *G. maior*, *Anomaloppia dispariseta*, *Oribatella palustris*, *Tuxenia manantialis*, and *Tectocepheus velatus*) and South Georgia Islands (*Heminothrus skottsbergi, Edwardzetes australis, Malaconothrus flagelliformis,* and *Sandenia georgiae*). Other species shared with the Falklands and/or South Georgia were reported for other Sub-Atlantic islands: South Shetland, South Orkney, South Sandwich and Beauchêne (*Eobrachychthonius oudemansi, Edwardzetes dentifer, E. elongatus, Granizetes curvatus, Sphaerozetes quadrilobatus,* and *Globoppia maior*). Some species reported for South

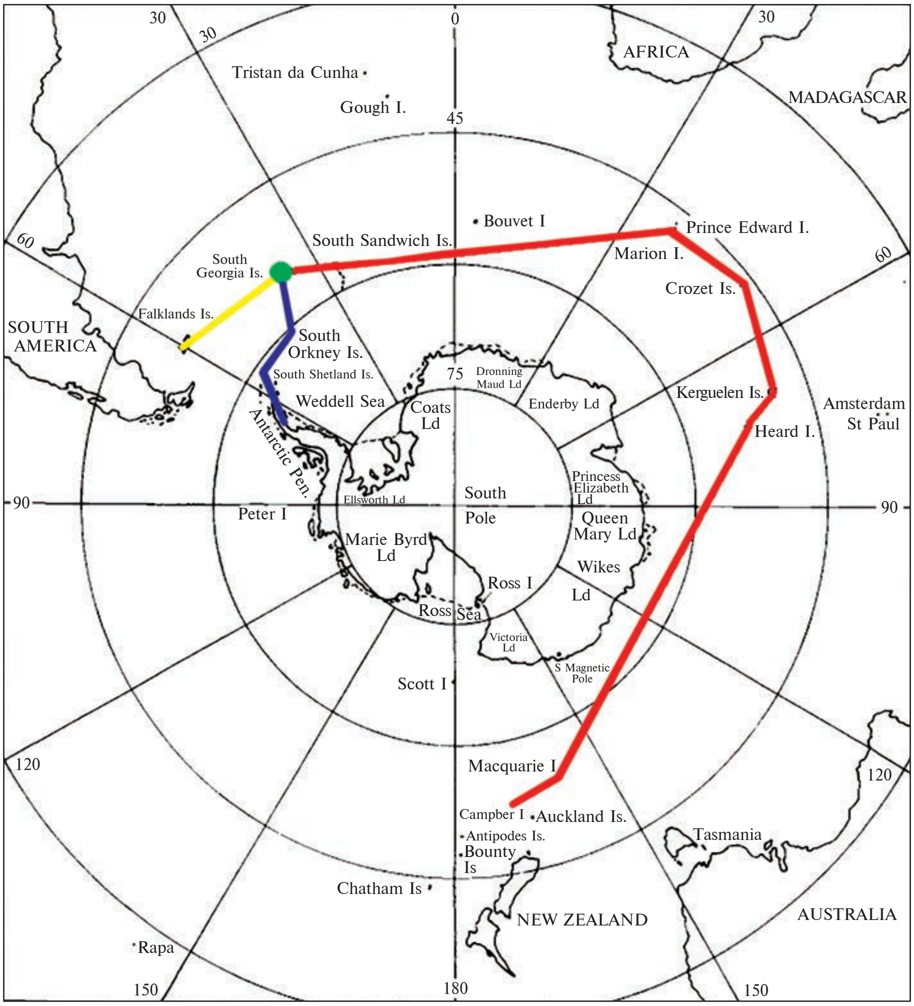

Figure. Generalized tracks for species reported in the present study (yellow = first track South Atlantic Islands; blue = second track, Antarctic and South Atlantic Islands; red = third track Circum-Antarctic)

Atlantic islands were also reported for islands in the southern Indian and Pacific Oceans (Marion Island, Kerguelen Islands, Macquarie Island, Crozet Islands): *Pseudantarcticola georgiae*, *Alaskozetes antarcticus, Halozetes crozetensis, Podacarus auberti, Liochthonius australis,* and *Globoppia intermedia*. *Alaskozetes antarcticus grandjeani* was reported only for islands in the southern Indian and Pacific Oceans. Finally, the species *Alaskozetes antarcticus intermedius, Ceratozetella antarcticus, Halozetes belgicae, Liochthonius mollis, Austroppia crozetensis,* and *Membranoppia loxolineata* were reported as shared with Antarctica. Of these, *Austroppia crozetensis* was reported also for Tierra del Fuego in southern South America (see Fig. C1 and capture to this figure). The list of the systematic arrangement of species reported (verified by ITIS) is presented in Appendix A. The species list is given in Appendix B.

Track analysis revealed three main tracks (Figure). The first (Figure, yellow line) is the South Atlantic track, which includes the Falklands, South Georgia and Beauchêne islands (*Eobrachychthonius oudemansi, Heminothrus skottsbergi, Edward-*

zetes australis, Granizetes curvatus, Sphaerozetes quadrilobatus, Crotonia sp., *Hermannia falklandica, Ceratoppia* sp., *Nanhermannia elegantissima, Globoppia maior, Lanceoppia elegantula, Anomaloppia dispariseta, Oribatella palustris, Sandenia georgiae, Totobates breviporosus, Tuxenia manantialis,* and *Tectocepheus velatus.* The second track (Figure, blue line) is the Antarctic and South Atlantic islands track, which included the species *Alaskozetes antarcticus, A. antarcticus intermedius*, *Ceratozetella antarcticus,* and *Edwardzetes dentifer.*

The third track (Figure, red line) is Circum-Antarctic, which includes the South Atlantic Islands close to the Indian Ocean and the islands of the south Indian and Pacific Oceans, with the species *Alaskozetes antarcticus grandjeani, Pseudantarcticola georgiae, Halozetes crozetensis, H. marionensis, Podacarus auberti*, *Liochthonius australis, Edwardzetes elongatus, Austroppia crozetensis, Globoppia intermedia,* and *Macquarioppia striata*. The species associated with the Circum-Antarctic islands include two reported for Graham Land in Antarctica (*Halozetes belgicae* and *Liochthonius mollis*). The tracks all intersect in South Georgia Island (Figure, green circle), and this convergence node shares species reported also for Antarctica (*Alaskozetes antarcticus, A. antarcticus intermedius, Eobrachychthonius oudemansi, Liochthonius mollis*), Falkland Islands (*Austroppia crozetensis, Globoppia intermedia, Eobrachychthonius oudemansi, Sphaerozetes quadrilobatus*).

Also, this convergence node shares species reported for Sub-Antarctic Islands (*Alaskozetes antarcticus, A. antarcticus intermedius, Austroppia crozetensis, Ceratozetella antarcticus, Podacarus auberti, Eobrachychthonius oudemansi, Globoppia intermedia, Liochthonius australis, L. mollis, Edwardzetes elongatus, Pseudantarcticola georgiae, Sphaerozetes quadrilobatus*).

4 Discussion

The literature revealed a similar pattern to that recorded for inland water crustaceans, for which spatial distribution patterns exist showing species distributed in Sub-Antarctic Islands and the Antarctic Peninsula, and a few species shared with southern South America (Pugh & Convey, 2000; Menu-Marque et al., 2000; Pugh et al., 2002; Mortimer, 2008; Mortimer et al., 2011; Díaz et al., 2019).

These results are similar to descriptions of freshwater mites in Chile, where many species local to southern South America have not been reported as shared with Sub-Antarctic Islands (Tuzovskij & Stolbov, 2016; 2017; Tuzovsky & Stolbov, 2016; 2017; Pešić & Smit, 2020; Smit, 2021); nevertheless, at least two species reported in the southernmost part of Chile (Magallanes region, 50°S) are also reported for the Falkland Islands (Cook, 1988; Pešić et al., 2010). These observations agree with descriptions of South American freshwater mites, in which some species exist with wide distribution, while others are restricted to narrow regions, such as southern South America (Rosso de Ferrádas & Fernández, 2005; 2009). In this context, it would be very probable that a few species are shared between southern South America and the Sub-Antarctic islands.

Pešić and Smith (2020) reported a few species shared between New Zealand and Sub-Antarctic islands and furthermore described a genus shared between New Zealand, Sub-Antarctic islands, and southern South America; this supports descriptions in the literature suggesting that species present in southern Australia, New Zealand, southern South American and Sub-Antarctic islands originated in Gondwana (Starý & Block, 1998). Our results, obtained by track analysis, agree with the descriptions of Starý and Block (1998), who used a different methodology based on a similarity index between different regions and principal coordinates analysis. Also, Pugh and Convey (2000) found similar results, including also Gamasida (= Mesostigmata), Actinedida (= Prostigmata), and Oribatida. Complementary use of both kinds of analysis would improve our understanding of biogeographical patterns. Ideally, the results obtained from Sub-Antarctic regions should be complemented with results from South America to obtain potential biogeographical patterns on a large spatial scale, such as have been reported for inland water copepods (Menu-Marque et al., 2000), amphipods (Cannizzaro & Berg, 2022) and inland water fishes (Cussac et al., 2004). These patterns suggest a convergence zone of fauna now distributed in the Neotropical, Antarctic, and Australian regions; the geographical distribution patterns of species included in the present study would thus be attributable to continental drift on the basis that all these regions belonged to the former macro-continent Gondwana, such as was reported for inland water crustaceans such as calanoids copepods, amphipods, or inland water fishes.

Author contributions. PD.E.: redaction, conceptualization, data analysis; PJ.S.: data interpretation, conceptualization; E.A.: redaction and conceptualization.

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Conflict of Interest. The authors declare they do not have a conflict of interest.

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Орібатидні кліщі (*Acariformes*: *Sarcoptiformes*) на субантарктичних островах і в Антарктиді: аналіз треків

Реферат. Південні неморські кліщі поширені на континентах, які виникли з макроконтиненту Гондвана, подібні групи зустрічаються в Австралії, Новій Зеландії, субантарктичних островах і на півдні Південної Америки. У цьому дослідженні ми провели аналіз літератури щодо видів неморських орібатидних (мохових) кліщів (*Acariformes*: *Sarcoptiformes*) на субантарктичних островах і Антарктичному континенті, застосувавши аналіз треків. Мета дослідження полягає у тому, щоб визначити місця, потенційно населені видами-предками, і зрозуміти біогеографічні закономірності їх розселення на нові місця, де нинішні види виникли через процеси видоутворення. Результати аналізу треків виявили існування видів, які населяють три основні зони: перший трек включає Південну Джорджію та субантарктичні острови Південної Атлантики, південь Індійського океану та південь Австралії і Нової Зеландії; другий – включає острів Південна Джорджія і Антарктичний півострів; третій – включає острів Південна Джорджія та Фолклендські острови. Усі ці треки перетинаються в Південній Джорджії, що свідчить про те, що цей острів був зоною, з якої види поширилися до інших згаданих місць, колонізуючи Антарктиду, Фолклендські острови та, ймовірно, південь Південної Америки.

Ключові слова: аналіз треків, біогеографія, вузли, кліщ, орібатиди, суб-Антарктида

APPENDIX A

Systematic arrangement of species

Systematic arrangement of species reported (verified by ITIS).
Species reported (taxonomy verified by ITIS)
Superorder: Acariformes
Order: Sarcoptiformes
Suborder: Oribatida Dugès, 1834
Infraorder: Enarthronota Grandjean, 1947
Family: Brachychthoniidae Thor, 1934
Genus: *Eobrachychthonius* Jacot, 1936
Eobrachychthonius oudemansi Hammen, 1952
Genus: *Liochthonius* Hammen, 1959
Liochthonius australis Covarrubias, 1968
Liochthonius mollis (Hammer, 1958)
Infraorder: Holosomata Grandjean 1969
Family Malaconothridae Berlese, 1916
Genus: *Tyrphonothrus* Knülle, 1957
Tyrphonothrus wallworki (Starý & Block, 1995)
Tyrphonothrus translamellatus (Hammer, 1958)
Genus: *Malaconothrus* Berlese, 1904
Malaconothrus flagelliformis (Wallwork, 1970)
Family Ceratoppiidae Grandjean, 1954
Genus: *Ceratoppia* Berlese, 1908
Ceratoppia sp.
Family Crotoniidae Thorell, 1876
Genus: *Heminothrus* Berlese, 1913
Heminothrus skottsbergi (Trägårdh, 1931)
(= *Platynothrus skottsbergi expansus* Wallwork, 1966)
Genus: *Crotonia* Thorell, 1876
Crotonia sp.
Infraorder: Brachypylina Hull, 1918
Family: Ameronothridae Vitzthum, 1943
Genus: *Alaskozetes* Hammer, 1955
Alaskozetes antarcticus (Michael, 1903)
(according to Starý & Block, 1995)
Alaskozetes antarcticus grandjeani (Dalenius, 1958)
Alaskozetes antarcticus intermedius Wallwork, 1967
Genus: *Pseudantarcticola* Balogh, 1970
Pseudantarcticola georgiae (Wallwork, 1970)
Genus: *Halozetes* Berlese, 1916
Halozetes belgicae (Michael, 1903)
Halozetes crozetensis (Richters, 1908)

Halozetes marionensis Engelbrecht, 1974
Genus: *Podacarus* Grandjean, 1954
Podacarus auberti Grandjean, 1954
Family Ceratozetidae Jacot, 1925
Genus: *Edwardzetes* Berlese, 1913
Edwardzetes dentifer Hammer, 1962
Edwardzetes elongatus Wallwork, 1966
Edwardzetes australis Starý & Block, 1995
Genus: *Granizetes* Hammer, 1961
Granizetes curvatus Hammer, 1961
Genus: *Ceratozetella* Shaldybina, 1966
Ceratozetella antarcticus (Michael, 1895)
Ceratozetella processus (Hammer, 1962)
Genus: *Sphaerozetes* Berlese, 1885
Sphaerozetes quadrilobatus (Wallwork, 1966)
Family Ceratoppidae Grandjean, 1954
Genus: *Macquarioppia* Wallwork, 1964
Macquarioppia striata (Wallwork, 1963)
Family Hermanniidae Sellnick, 1928
Genus: *Hermannia* Nicolet, 1855
Hermannia falklandica (P. Balogh, 1988)
Family Nanhermanniidae Sellnick, 1928
Genus: *Nanhermannia* Berlese, 1913
Nanhermannia elegantissima Hammer, 1958
Family Oppiidae Sellnick, 1937
Genus: *Austroppia* Balogh, 1983
Austroppia crozetensis (Richters, 1908)
Genus: *Globoppia* Hammer, 1962
Globoppia intermedia Hammer, 1962
(= *Globoppia intermedia longiseta* Wallwork, 1970)
Globoppia maior Hammer, 1962
Genus: *Membranoppia* Hammer, 1968
Membranoppia loxolineata (Wallwork, 1965)
Membranoppia scotiae (Wallwork, 1970)
Genus: *Lanceoppia* Hammer, 1962
Lanceoppia elegantula Starý & Block, 1995
Genus: *Anomaloppia* Subías, 1978
Anomaloppia dispariseta (Hammer, 1958)
Family Oribatellidae Jacot, 1925
Genus: *Oribatella* Banks, 1895
Oribatella palustris Hammer, 1962
Family Liebstadiidae Balogh & P. Balogh, 1984
Genus: *Totobates* Hammer, 1961
Totobates breviporosus (Mahunka, 1980)
Family Protoribatidae Balogh & P. Balogh, 1984
Genus: *Tuxenia* Hammer, 1958
Tuxenia manantialis Hammer, 1962
Family: Parakalummidae Grandjean, 1936
Genus: *Sandenia* Oudemans, 1917
Sandenia georgiae (Oudemans, 1914)
Family Tectocepheidae Grandjean, 1954
Genus: *Tectocepheus* Berlese, 1896
Tectocepheus velatus (Michael, 1880)

APPENDIX B

Species list

Family: Brachychthoniidae

Eobrachychthonius oudemansi Hammen, 1952. South Georgia Is. (54°26′S; 36°33′W), South Sandwich Is. (54°16′S; 36°30′W) (Starý & Block, 1995), Falkland Is. (51°48′S; 59°31′W) (Starý & Block, 1996)

Liochthonius australis Covarrubias, 1968. South Shetland Is. (62°00′S; 58°00′W), Crozet Is. (46°23′S; 51°44′E), Kerguelen Is. (49°15′S; 69°10′E), South Georgia Is. (54°26′S; 36°33′W) (Starý & Block, 1995)

Liochthonius mollis (Hammer, 1958). Graham Land (Antarctica) (66°00′S; 63°30′W), South Shetland Is. (62°00′S; 58°00′W), South Orkney Is. (60°35′S; 45°30′W), South Georgia Is. (54°26′S; 36°33′W), Crozet Is. (46°23′S; 51°44′E), Kerguelen Is. (49°15′S; 69°10′E) (Starý & Block, 1995)

Family Malaconothridae

Tyrphonothrus wallworki (Starý & Block 1995). South Georgia Is. (54°26′S; 36°33′W) (Starý & Block, 1995)

Tyrphonothrus translamellatus (Hammer, 1958). South Georgia Is. (54°26′S; 36°33′W) (Starý & Block, 1995), Falkland Is. (51°48′S; 59°31′W) (Starý & Block, 1996)

Malaconothrus flagelliformis (Wallwork, 1970). South Georgia Is. (54°26′S; 36°33′W) (Starý & Block, 1995)

Family Ceratoppiidae

Ceratoppia sp. Falkland Is. (51°48′S; 59°31′W) (Starý & Block, 1996).

Family Crotoniidae

Crotonia sp. Falkland Is. (51°48′S; 59°31′W) (Starý & Block, 1996)

Heminothrus skottsbergi (Trägårdh, 1931) (= *Platynothrus skottsbergi expansus*) Wallwork, 1966. South Georgia Is. (54°26′S; 36°33′W) (Starý & Block, 1995)

Family Ameronothridae

Alaskozetes antarcticus (Michael, 1903). Graham Land (66°00′S; 63°30′W), Palmer Land (71°30′S; 65°00′W) (Antarctica), South Shetland Is. (62°00′S; 58°00′W), South Orkney Is. (60°35′S; 45°30′W), South Georgia Is. (54°26′S; 36°33′W), Marion Is. (46°54'S; 37°43'E), Kerguelen Is. (49°15′S; 69°10′E), Macquarie Is. (54°37′S; 158°51′E) (Starý & Block, 1995)

Alaskozetes antarcticus grandjeani (Dalenius, 1958). Heard Is. (53°04′S; 73°29′E), Macquarie Is. (54°37′S; 158°51′E) (Starý et al., 1997)

Alaskozetes antarcticus intermedius Wallwork, 1967. Palmer Land (71°30′S; 65°00′W) and Graham Land (66°00′S; 63°30′W) (Antarctica), South Orkney Is. (60°35′S; 45°30′W), South Sandwich Is. (54°16′S; 36°30′W), South Georgia Is. (54°26′S; 36°33′W), Kerguelen Is. (49°15′S; 69°10′E) (Starý & Block, 1995). Beauchêne Is. (52°54′S; 59°11′W), Falkland Is. (51°48′S; 59°31′W) (Starý & Block, 1996).

Pseudantarcticola georgiae (Wallwork, 1970). South Georgia Is. (54°26′S; 36°33′W), Kerguelen Is. (49°15′S; 69°10′E) (Starý & Block, 1995)

Halozetes belgicae (Michael, 1903). Palmer Land (71°30′S; 65°00′W) and Graham Land (66°00′ S; 63°30′W), South Shetland Is. (62°00′S; 58°00′W), South Orkney Is. (60°35′S; 45°30′W), South Georgia Is. (54°26′S; 36°33′W), Marion Is. (46°54'S; 37°43'E), Crozet Is. (46°23′S; 51°44′E), Kerguelen Is. (49°15′S; 69°10′E), Heard Is. (53°04'S; 73°29'E), Macquarie Is. (54°37′S; 158°51′E) (Starý et al., 1997).

Halozetes crozetensis (Richters, 1908). Beauchêne Is. (52°54′S; 59°11′W), Marion Is. (46°54′S; 37°43′E), Crozet Is. (46°23′S; 51°44′E), Kerguelen Is. (49°15′S; 69°10′E), Amsterdam Is. (37°50′S; 77°32′E), St. Paul Is. (38°43′S; 77°31′E), Heard Is. (53°04′S; 73°29′E), Macquarie Is. (54°37′S; 158°51′E), Campbell Is. (52°32′S; 169°08′E) (Starý et al., 1997).

Halozetes marionensis Engelbrecht, 1974. Gough Is. (40°19′S; 09°56′W), Marion Is. (46°54′S; 37°43′E), Heard Is. (53°04′S; 73°29′E) (Starý et al., 1997).

Podacarus auberti Grandjean, 1954. South Georgia Is. (54°26′S; 36°33′W), Crozet Is. (46°23′S; 51°44′E), Kerguelen Is. (49°15′S; 69°10′E), Heard Is. (53°04′S; 73°29′E), Macquarie Is. (54°37′S; 158°51′E) (Starý et al., 1997).

Family Ceratozetidae

Edwardzetes dentifer Hammer, 1962. South Sandwich Is. (54°16′S; 36°30′W), South Shetland Is. (62°00′S; 58°00′W), Livingston Is. (62°36′S; 60°30′W), Falkland Is., (51°48′S; 59°31′W) (Starý & Block, 1996).

Edwardzetes elongatus Wallwork, 1966. South Georgia Is. (54°26′S; 36°33′W), South Sandwich Is. (54°16′S; 36°30′W) (Starý & Block, 1995)

Edwardzetes australis Starý & Block, 1995. South Georgia Is. (54°26′S; 36°33′W) (Starý & Block, 1995)

Granizetes curvatus Hammer, 1961. Beauchêne Is. (52°54′S; 59°11′W), Falkland Is. (51°48′S; 59°31′W) (Starý & Block, 1996).

Ceratozetella antarcticus (Michael, 1895) = *Magellozetes antarcticus* (Michael, 1895). Graham Land (66°00′S; 63°30′W), South Shetland Is. (62°00′S; 58°00′W), South Georgia Is. (54°26′S; 36°33′W), Kerguelen Is. (49°15′S; 69°10′E) (Starý & Block, 1995)

Ceratozetella processus (Hammer, 1962). Kerguelen Is. (49°15′S; 69°10′E), South Georgia Is. (54°26′S; 36°33′W) (Starý & Block, 1995). James Ross Is. (64°10′S; 57°45′W), Vega Is. (63°50′S; 57°25′W), Seymour Is. (64°14′S; 56°37′W), Cockburn Is. (64°12′S; 56°51′W), Falkland Is. (51°48′S; 59°31′W) (Starý & Block, 1996).

Sphaerozetes quadrilobatus (Wallwork, 1966) = *Magellozetes polygonalis quadrilobatus* Wallwork, 1966. South Georgia Is. (54°26′S; 36°33′W). Beauchêne Is. (52°54′S; 59°11′W), Falkland Is. (51°48′S; 59°31′W) (Starý & Block, 1996)

Family Ceratoppiidae

Macquarioppia striata (Wallwork, 1963): Marion Is. (46°54′S; 37°43′E), Crozet Is. (46°23′S; 51°44′E), Kerguelen Is. (49°15′S; 69°10′E), Heard Is. (53°04′S; 73°29′E), Macquarie Is. (54°37′S; 158°51′E) (Starý et al., 1997)

Family Hermanniidae

Hermannia falklandica (P. Balogh, 1988). Falkland Is. (51°48′S; 59°31′W) (Starý & Block, 1996)

Family Nanhermanniidae

Nanhermannia elegantissima Hammer, 1958. Falkland Is. (51°48′S; 59°31′W) (Starý & Block, 1996).

Family Oppiidae

Austroppia crozetensis (Richters, 1908). South Georgia Is. (54°26′S; 36°33′W), South Orkney Is. (60°35′S; 45°30′W), Marion Is. (46°54′S; 37°43′E), Crozet Is. (46°23′S; 51°44′E), Kerguelen Is. (49°15′S; 69°10′E), Macquarie Is. (54°37′S; 158°51′E) (Starý & Block, 1995), Falkland Is. (51°48′S; 59°31′W) (Starý & Block, 1996), Heard Is. (53°04′S; 73°29′E), Tierra del Fuego Is. (54°00′S; 68°00′W) (Starý et al., 1997)

Globoppia intermedia Hammer, 1962. South Orkney Is. (60°35′S; 45°30′W), South Sandwich Is. (54°16′S; 36°30′W), South Georgia Is. (54°26′S; 36°33′W), Crozet Is. (46°23′S; 51°44′E), Kerguelen Is. (49°15′S; 69°10′E) (Starý & Block, 1995). Falkland Is. (51°48′S; 59°31′W) (Starý & Block, 1996), Heard Is. (53°04′S; 73°29′E), Kerguelen Is (49°15′S; 69°10′E), Beauchêne Is. (52°54′S; 59°11′W) (Starý & Block, 1995).

Globoppia maior Hammer, 1962. Beauchêne Is. (52°54′S; 59°11′W), Falkland Is. (51°48′S; 59°31′W) (Starý & Block, 1996)

Membranoppia loxolineata (Wallwork, 1965). Graham Land (66°00′S; 63°30′W), South Shetland Is. (62°00′S; 58°00′W), Heard Is. (53°04′S; 73°29′E) (Starý et al., 1997).

Membranoppia scotiae (Wallwork, 1970). South Georgia Is. (54°26′S; 36°33′W) (Starý & Block, 1995)

Lanceoppia elegantula Starý & Block, 1995. South Georgia Is. (54°26′S; 36°33′W) (Starý & Block, 1995)

Anomaloppia dispariseta (Hammer, 1958). Falkland Is. (51°48′S; 59°31′W) (Starý & Block, 1996).

Family Oribatellidae

Oribatella palustris Hammer, 1962. Falkland Is. (51°48′S; 59°31′W) (Starý & Block, 1996)

Family Liebstadiidae

Totobates breviporosus (Mahunka, 1980). Falkland Is. (51°48′S; 59°31′W) (Starý & Block, 1996)

Family: Protoribatidae

Tuxenia manantialis Hammer, 1962. Falkland Is. (51°48′S; 59°31′W) (Starý & Block, 1996)

Family: Parakalumnidae

Sandenia georgiae (Oudemans, 1914). South Georgia Is. (54°26′S; 36°33′W) (Starý & Block, 1995)

Family Tectocepheidae

Tectocepheus velatus (Michael, 1880). Falkland Is. (51°48′S; 59°31′W) (Starý & Block, 1996).

APPENDIX C

Individual tracks for mite species

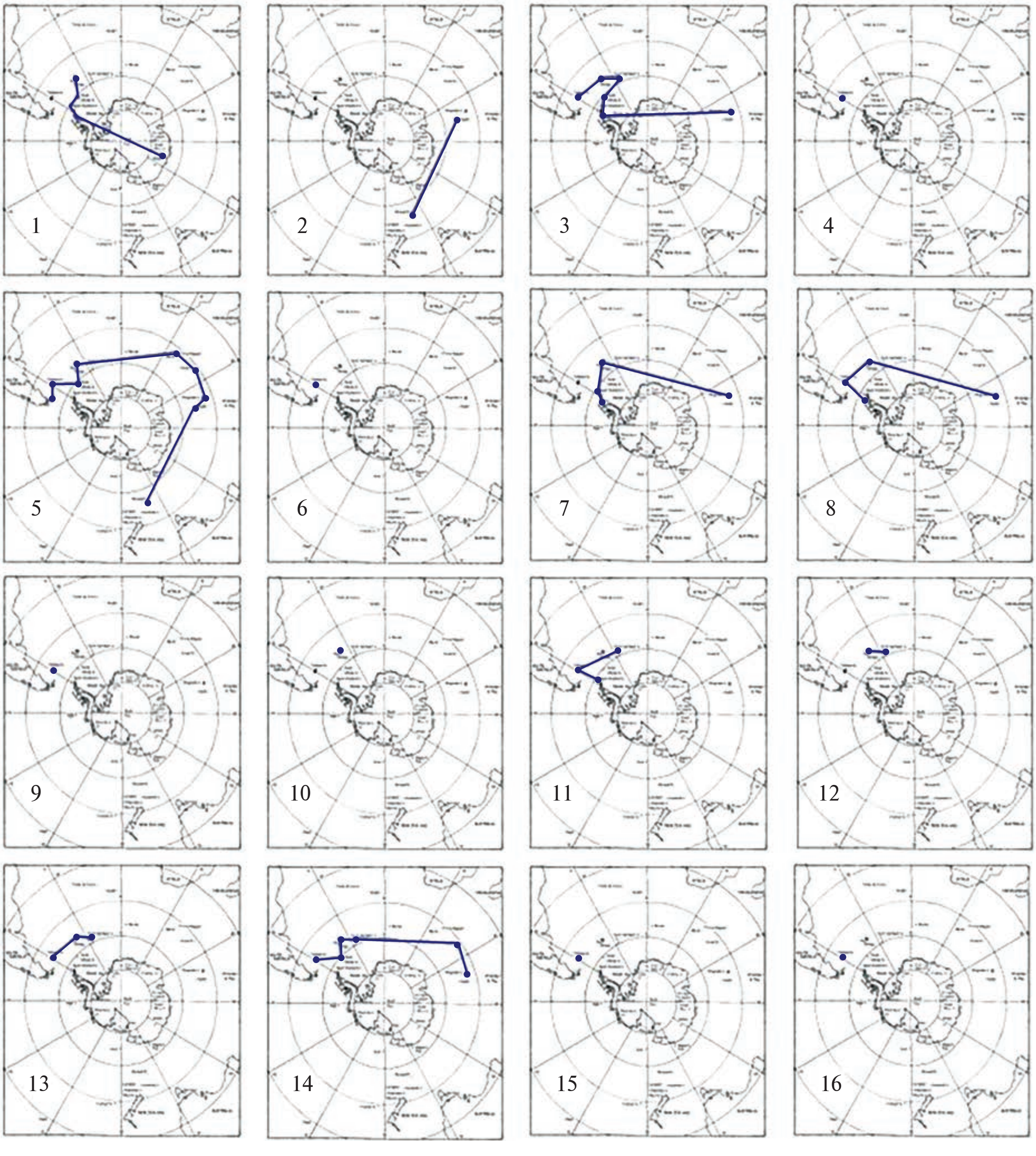

Figure C1. Individual tracks for mite species included in the present study. 1) *Alaskozetes antarcticus*; 2) *Alaskozetes antarcticus grandjeani*; 3) *Alaskozetes antarcticus intermedius*; 4) *Anomaloppia dispariseta*; 5) *Austroppia crozetensis*; 6) *Ceratoppia* sp.; 7) *Ceratozetella antarcticus*; 8) *Ceratozetella processus*; 9) *Crotonia* sp., 10) *Edwardzetes australis*; 11) *Edwardzetes dentifer*; 12) *Edwardzetes elongatus*; 13) *Eobrachychthonius oudemansi*; 14) *Globoppia intermedia*; 15) *Globoppia maior*; 16) *Granizetes curvatus*

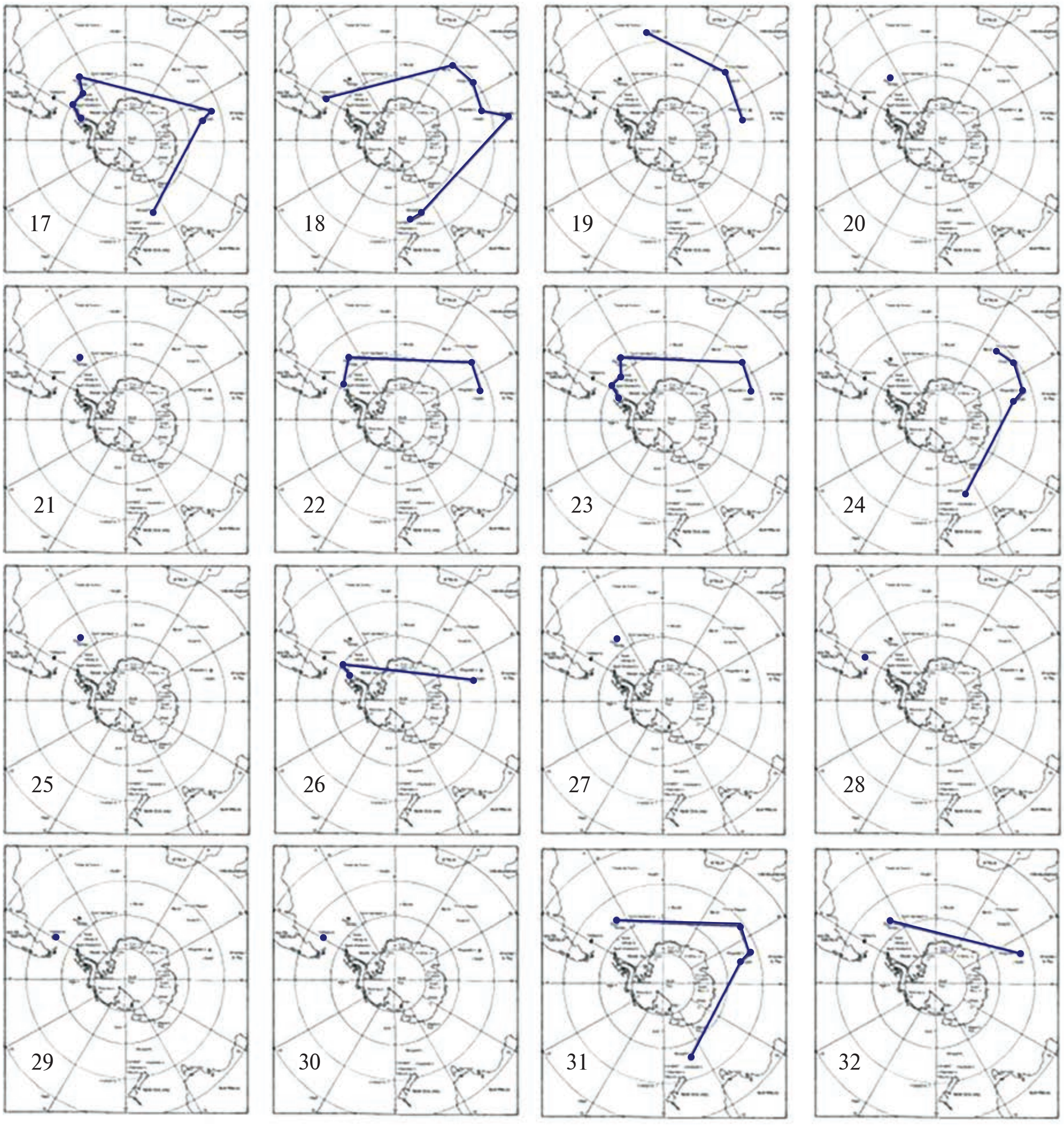

Figure C1. (cont). 17) *Halozetes belgicae*; 18) *Halozetes crozetensis*; 19) *Halozetes marionensis*; 20) *Heminothrus skottsbergi*; 21) *Lanceoppia elegantula*; 22) *Liochthonius australis*; 23) *Liocthonius mollis*; 24) *Macquarioppia striata*; 25) *Malaconothrus flagelliformis*; 26) *Membranoppia loxolineata*; 27) *Membranoppia scotiae*; 28) *Nanhermannia elegantissima*; 29) *Oribatella palustris*; 30) *Hermannia falklandica*; 31) *Podacarus auberti*; 32) *Pseudantarcticola georgiae*

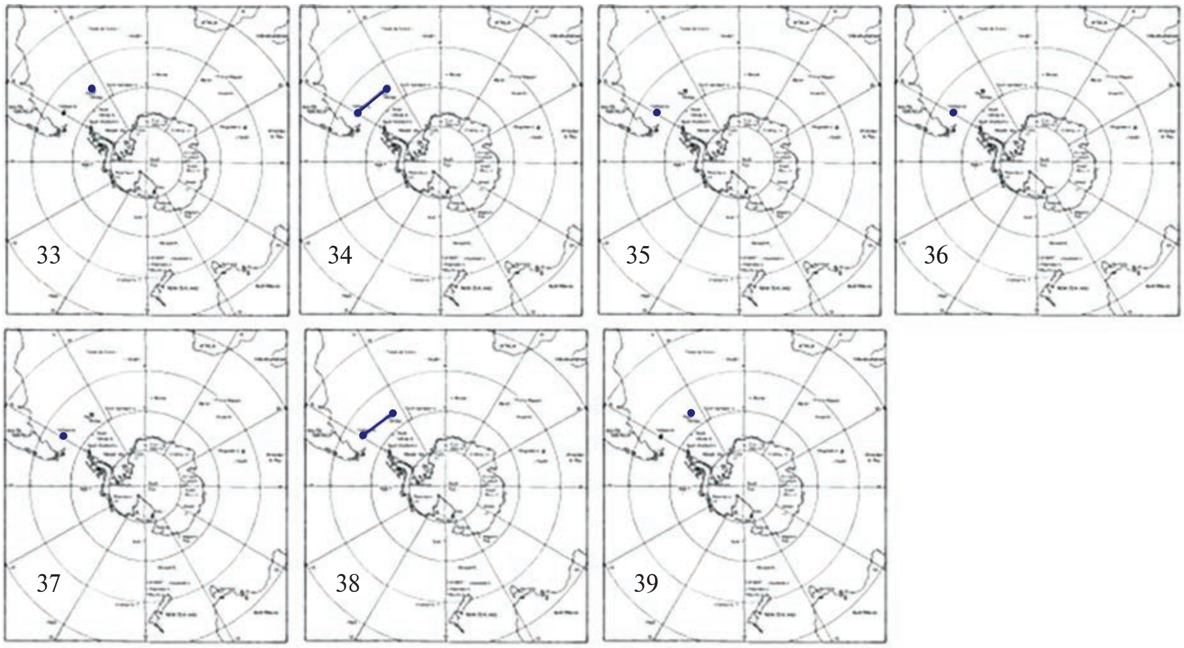

Figure C1. (cont). 33) *Sandenia georgiae*; 34) *Sphaerozetes quadrilobatus*; 35) *Tectocepheus velatus*; 36) *Totobates breviporosus*; 37) *Tuxenia manantialis*; 38) *Tyrphonothrus translamellatus*; 39) *Tyrphonothrus wallworki*