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Reducing the risk of inadvertent non-native species introductions associated with fresh fruit and vegetable importation to Antarctica

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Summary

In this paper SCAR reviews the science concerning the risk of non-native species introductions associated with the importation of fresh fruits and vegetables to the Antarctic region. SCAR recommends that the CEP:

- encourages Parties to implement the recommendations of the *COMNAP/SCAR checklists for supply chain managers*; and
- encourages Parties and/or COMNAP to further investigate practical, cost effective methods of reducing the risk of non-native species introductions to Antarctica associated with fresh foods.

Background

Biological invasions are a major potential threat to the integrity of native biodiversity in Antarctica as they have the potential to alter existing ecosystems irreversibly.[1,2] Increasing numbers of visitors and distribution of human activities has facilitated the introduction of non-native species within the Antarctic Treaty area,[3-5] while rapid climate change in some Antarctic areas may increase the likelihood of non-native species establishment.[6-8]

Human presence/activity is usually a prerequisite for the introduction of non-native species, either as mature specimens or propagules. Investigations have shown non-native species introductions associated with cargo, vehicles, visitors' clothing and personal equipment.[9-13] In response, CEP, SCAR and COMNAP have developed guidelines on practical methods to reduce the importation of non-native species by many of these introduction pathways.[14-16] However, until recently, little attention has been paid to the biosecurity risk associated with importation of fresh fruits and vegetables,[17] although guidelines to reduce these potential risks were included on the COMNAP/SCAR checklists for supply chain managers, endorsed by the CEP.[16]

Fresh fruits and vegetables

For visitors to Antarctica, fresh fruit and vegetables provide an important source of nutrients and make diets more varied and interesting, enhancing morale and psychological well-being. Availability of such fresh foods may be important for those spending many months or years in Antarctica, although, with dietary planning, fresh foods may not be essential nutritionally for those visiting Antarctica for a shorter period of time.

The importance of food is highlighted by its exemption from the legislation set out in Annex II, Article 4(5) (*Introduction of Non-native Species, Parasites and Diseases*) of the Protocol on Environmental Protection to the Antarctic Treaty, which establishes measures to conserve Antarctic flora and fauna. However, it should be noted that the permitted exemption for food products found within Article 4 is applicable '...provided that no live animals are imported for this purpose and all plants and animals parts and products are kept under carefully controlled conditions and are disposed of in accordance with Annex III to the Protocol and Appendix C to this Annex' where Annex III is on *Waste Disposal and Waste Management* and Annex II Appendix C *Precautions to Prevent Introductions of Microorganisms.*

Fresh foods imported regularly to Antarctic stations include fruits, vegetables and eggs. Meat is generally supplied frozen, with long-term storage at -20^{o}C likely to kill most introduced macro-organisms.[18] However, fruits and vegetables may have non-Antarctic soil on their surfaces, while non-native invertebrates and microbial decomposers may exist on the surface and/or interior of produce following harvesting and packaging. Soil in particular may contain non-native invertebrates, plant propagules and a high density and diversity of microorganisms.[12,17]

In a recent investigation carried out in order to begin to quantify propagule pressure along introduction pathways to the Antarctic region, more than 11,250 fruit and vegetable items sent to nine research stations in Antarctica and the sub-Antarctic islands, were examined for associated soil, invertebrates and microbial decomposition.[17] Fifty-one food types were sourced from c. 130 locations dispersed across all six of the Earth's inhabited continents. 12% of food items had soil on their surface, although typically in small quantities (>1g), 28% showed microbial infection resulting in rot and overall more than 56 invertebrates were recorded, mainly from leafy produce. Approximately 30% of identified fungi sampled from infected foods were not recorded previously from within the Antarctic region, although this may reflect limited knowledge of Antarctic fungal diversity. By extrapolation it is estimated that fresh foods sourced from around 750 locations may enter Antarctica each year through National Antarctic Programmes, and these location may vary from one year to the next. Fresh foods imported by the tourism industry may add to this number. Furthermore, estimates indicate that approximately 90 different soils, if not substantially more, may be introduced to the Antarctic Treaty area annually.[17]

Microorganisms associated soil and fresh food associated

Unsterilized soils in any amount pose a biosecurity risk to Antarctic microbial systems due to the large number and biodiversity of microorganisms they contain (i.e. bacteria, fungi, protozoa, viruses).[19] Each gramme of soil could contain over a billion bacteria[20] with up to several tens of thousands of species potentially identifiable.[21,22] Many fungi isolated from fresh foods can liberate air borne asexual spores (e.g. *Penicillium* sp.) leading to a high possibility of subsequent dispersion into the Antarctic environment.[23] The consequences of microbial introductions are largely unknown, but may impact upon existing microbial community structure,[24] with associated implications for biogeochemistry and ecosystem functioning, and have the potential to cause disease in native plants and invertebrates.[19,25,26] Lateral gene transfer may also occur between indigenous and introduced species leading to 'genetic pollution' of Antarctic microbial communities.[27] Potential microbial impacts likely depend upon the physical, chemical and biological characteristics of the location where the microorganism are introduced. For example, the fungus *Botryotinia fuckeliana* (conidial state: *Botrytis cinerea*) was probably introduced to sub-Antarctic Marion Island on fresh vegetables and subsequently identified as the pathogen associated with the apparent decline of *Pringlea antiscorbutica* (Kerguelen cabbage) on the island.[1,28]

Invertebrates

Invertebrates, including insects and other groups, may be transported in association with fresh foods to research stations by both aircraft and ship[1,17]. Fresh foods transported by ships are generally refrigerated, but this practice is generally not possible on aircraft. Though few formal reports exist, many of the non-native invertebrates present on the sub-Antarctic islands are thought to have been imported in association with food stores.[1,29] However, fresh food supplies that remain on ships can also present a biosecurity risk. For example, the non-native parasitoid wasp *Aphidius matricariae* was introduced to sub-Antarctic Marion Island seven years after a ban on fresh produce was introduced.[30] It is thought that the source of the wasp was parasitized aphids on fresh produce that remained aboard the resupply ship, but which subsequently colonized the island when the ship was at anchor near the island.[31] Invertebrates can also be transported to the Antarctic with fresh foods. In one example, a close link was found between the numbers of live non-native flying insects at Rothera Research Station and the level of logistic activity whereby foodstuffs are transported to the station.[17] In separate incidents, *Lycoriella* sp. (black fungus midge) were introduced to Casey and Rothera Research Stations, where they were able to establish synanthropically within the sewage system and alcohol bond, respectively.[32] The midge has been successfully eradicated at Rothera Research Station, while on-going eradication measures at Casey Station mean the midge is restricted to defined sub-floor regions of the station. Insects are capable of transmitting fungal plant pathogens[33,34] and it is possible that introduced invertebrates could carry microbial pathogens that may impact on native Antarctic biota.[35]

Conclusions

If obligations to conserve and protect indigenous Antarctic biota are to be fulfilled, as stipulated by the Environmental Protocol, then routes by which anthropogenic introductions occur need to be examined,

quantified and effective mitigation measures adopted. Before fresh fruit and vegetables are imported to a specific Antarctic location, it may be useful to consider the likelihood and consequences of non-native species establishment in that particular area (for example, risks may be negligible at stations located on the continental ice sheets, but high at climatically warmer, ice-free areas). Although the only way to reduce propagule pressure to as close to zero as possible along the fresh fruit and vegetable pathway would be to stop the transport of fresh produce into a region (as has been done at the sub-Antarctic Prince Edward Islands and Heard Island), such a practise might prove unsuitable under many scenarios. However, the risks of introductions associated with the fresh food pathway can be substantially mitigated if aspects of the sourcing, transportation, storage and disposal of fruits and vegetables are undertaken following a reasonably circumscribed, evidence-based set of mitigation measures.

Recommendations

SCAR recommends that the CEP:

- encourages Parties to implement the recommendations of the *COMNAP/SCAR checklists for supply chain managers*;
- encourages Parties and/or COMNAP to further investigate practical, cost effective methods of reducing the risk of non-native species introductions to Antarctica associated with fresh foods.

References

1. Frenot, Y., Chown, S.L., Whinam, J., Selkirk, P.M., Convey, P., Skotnicki, M., Bergstrom, D.M., 2005. Biological invasions in the Antarctic: extent, impacts and implications. Biol. Rev. 80, 45-72.
2. Hughes, K.A., Convey, P., 2010. The protection of Antarctic terrestrial ecosystems from inter- and intra-continental transfer of non-indigenous species by human activities: a review of current systems and practices. Global Environ. Change 20, 96–112.
3. ATCMXXXIV IP050 Colonisation status of known non-native species in the Antarctic terrestrial environment (updated 2011)
4. Council of Managers of National Antarctic Programs (COMNAP), 2011. Antarctic facilities. https://www.comnap.aq/
5. International Association of Antarctica Tour Operators (IAATO), 2011. Tourism statistics. http://iaato.org/tourism_stats.html
6. Turner, J., Colwell, S.R., Marshall, G.J., Lachlan-Cope, T.A., Carleton, A.M., Jones, P.D., Lagun, V., Reid, P.A., Iagovkina, S., 2005. Antarctic climate change during the last 50 years. Int. J. Climatol 25, 279-294.
7. Steig, E.J., Schneider, D.P., Rutherford, S.D., Mann, M.E., Comiso, J.C., Shindell, D.T., 2009. Warming of the Antarctic ice-sheet surface since the 1957 International Geophysical Year. Nature 457, 459-462.
8. ATCMXXXII IP005 SCAR's Antarctic Climate Change and the Environment (ACCE) review report
9. Whinam, J., Chilcott, N., Bergstrom, D.M., 2005. Subantarctic hitchhikers: expeditioners as vectors for the introduction of alien organisms. Biol. Conserv. 121, 207-219.
10. Lee, J.E., Chown, S.L., 2009a. Breaching the dispersal barrier to invasion: quantification and management. Ecol. Appl. 19, 1944-1959.
11. Lee, J.E., Chown, S.L., 2009b. Quantifying the propagule load associated with the construction of an Antarctic research station. Antarct. Sci. 21, 471-475.
12. Hughes, K.A., Convey, P., Maslen, N.R., Smith, R.I.L., 2010. Accidental transfer of non-native soil organisms into Antarctica on construction vehicles. Biol. Invasions 12, 875-891.
13. ATCMXXXIII WP004 Preliminary Results from the International Polar Year Programme: Aliens in Antarctica
14. ATCMXXXII IP004 SCAR's environmental code of conduct for terrestrial scientific field research in Antarctica
15. ATCMXXXIII WP008 Draft procedures for vehicle cleaning to prevent transfer of non-native species into and around Antarctica
16. ATCMXXXIV WP012 Raising awareness of non-native species introductions: Workshop results and checklists for supply chain managers
17. Hughes, K.A., Lee, J.E., Tsujimoto, M., Imura, S., Bergstrom, D.M., Ware, C., Lebouvier, M., Huiskes, A.H.L., Gremmen, N.J.M., Frenot, Y., Bridge, P.D., Chown, S.L., 2011. Food for thought: risks of non-native species transfer to the Antarctic region with fresh produce. Biol. Conserv. 144, 1682–1689
18. Sherman, R.A., Goth, K., Sherman, J., Tran, M., Ng, D., 2006. Effects of food storage and handling on blow fly (*Lucilia sericata*) eggs and larvae. J. Food Sci. 71, 117-120.
19. Cowan, D.A., Chown, S.L., Convey, P., Tuffin, M., Hughes, K.A., Pointing, S., Vincent, W. F. 2011. Non-indigenous microorganisms in the Antarctic - assessing the risks. Trends Microbiol., in press. DOI: 10.1016/j.tim.2011.07.008

20. Whitman, W.B., Coleman, D.C., Wiebe, W.J., 1998. Prokaryotes: the unseen majority. Proc. Nat. Acad. Sci. 95, 6578–6583.

21. Dunbar, J., Barns, S.M., Ticknor, L.O., Kuske, C.R., 2002. Empirical and theoretical bacterial diversity in four Arizona soils. Appl. Environ. Microbiol. 68, 3035-3045.

22. Schloss, P.D., Handelsman, J., 2006. Toward a census of bacteria in soil. PLoS Comput. Biol. 2: e92. doi:10.1371/journal.pcbi.0020092

23. Pearce, D.A., Bridge, P.D., Hughes, K., Sattler, B., Psenner, R., Russell, N.J. 2009. Microorganisms in the atmosphere over Antarctica. *FEMS Microbiology Ecology* 69: 143-157.

24. Yergeau, E., Newsham, K.K., Pearce, D.A., Kowalchuk, G.A. 2007. Patterns of bacterial diversity across a range of Antarctic terrestrial habitats. Environ. Microbiol. 9, 2670-82.

25. Wynn-Williams, D.D., 1996. Antarctic microbial diversity: the basis of polar ecosystem processes. Biodivers. Conserv. 5, 1271-1293.

26. Cowan, D.A., Ah Tow, L., 2004. Endangered Antarctic microbial communities. Annu. Rev. Microbiol. 58, 649–690.

27. Smith, J.J., McFeters, G.A., 1998. Microbiological issues of sewage disposal from Antarctic bases: dispersion, persistence, pathogens, and "genetic pollution", in: Kerry, K., Riddle, M., Clark, J. (Eds.), Disease of Antarctic wildlife: a report on the 'workshop on diseases of Antarctic wildlife'. Australian Antarctic Division, Kingston, Tasmania, pg 56-57.

28. Klopper, F.J., Smith, V.R., 1998. First report of *Botryotinia fuckeliana* on Kerguelen cabbage on the sub-Antarctic Marion Island. Plant Dis. 82, 710.

29. Hänel, C., Chown, S.L., Davies, L., 1998. Records of alien insect species from sub-Antarctic Marion and South Georgia Islands. Afr. Entomol. 6, 366-369.

30. Anonymous, 1996. Prince Edward Islands Management Plan. Department of Environmental Affairs and Tourism, Pretoria

31. Lee, J., Slabber, S., Jansen van Vuuren, B., van Noort, S., Chown, S.L., 2007. Colonisation of sub-Antarctic Marion Island by a non-indigenous aphid parasitoid *Aphidius matricariae* (Hymenoptera, Braconidae). Polar Biol., 30, 1195-1201.

32. Hughes, K.A., Walsh, S., Convey, P., Richards, S., Bergstrom, D.M., 2005. Alien fly populations established at two Antarctic research stations. Polar Biology 28, 568–570.

33. Jarvis, W.R., Shipp, J.L., Gardiner, R.B., 1993. Transmission of *Pythium aphanidermatum* to greenhouse cucumber by the fungus gnat *Bradysia impatiens* (Diptera, Sciaridae). Ann. Appl. Biol. 122, 23 - 29.

34. Harris, M.A., Gardner, W.A, Oetting, R.D., 1996. A review of the scientific literature on fungus gnats (Diptera: Sciaridae) in the genus *Bradysia*. J. Entomol. Sci. 31, 252–276.

35. Stock, S.P., Glazer, I., Boemare, N., Vandenberg, J. 2009. Insect pathogens: molecular approaches and techniques. CABI publishing, Wallingfor