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INVASION NOTE

Timber transported to Antarctica: a potential and undesirable carrier for alien fungi and insects

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Abstract Antarctica's severe climate and its geographical isolation are the factors that hinder the arrival of non-native species by natural means. However, the movement of people and cargo associated with national scientific programs and tourism render Antarctica much more accessible to exotic organisms. Both the transport routes and carriers are varied. The wide range of uses to which timber is put means that it is readily freighted to Antarctic stations. However, it can harbor numerous alien organisms. All the timber materials transported to the "Arctowski" station for the 32nd Polish Antarctic Expedition in the 2007/2008 season were scanned as a potential vector for alien species. This study focuses on the non-lichenized fungi and insects which were found on the timber. Four species of perithecia-forming Ascomycota, five species of corticioid and polyporoid Basidiomycota, four

unidentified basidiomycetes taxa in form of sterile mycelia, and two insects belonging to Cerambycidae, were detected. Most of these 'hitch-hikers' were connected with the untreated parts of the timber. Their enduring survival in harsh Antarctic conditions is regarded as highly improbable. Nevertheless, some ascocarps frequently contained vital spores, and live insect larvae and imago were found in hibernation. The results also emphasize that such organisms can be accidentally transported to Antarctica and that the elementary rules for the eventual safe transport of non-infected goods should be obeyed and respected.

Keywords Non-native · Human impact · Cargo · Wood · Removal · Antarctic conservation

Introduction

The geographic isolation and harsh climate of the Antarctic region mean that it appears to have remained the most unaltered and natural part of the world. Taken in a worldwide context, human activity in the region has been neither lengthy nor intensive. However, the current increase of human activity at research stations, transport and tourism threaten the uniqueness of the Antarctic environment. Most operations are concentrated around nearly 80 seasonal or year-round national stations and the highest density of settlements lies just south of 60° S latitude,

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in the relatively accessible area of the maritime Antarctica (Council of Managers of National Antarctic Programs (COMNAP) 2010). Owing to the relatively safe navigation and sight-seeing attractions, tourism is also focused on this area (International Association of Antarctica Tour Operators (IAATO) 2010). The maritime Antarctic is thus under particular human pressure.

According to Frenot et al. (2005), a non-native species/alien is an organism introduced to an ecosystem as a result of human activity; this includes species that arrive by natural means but are not native to a given biogeographical zone. The appearance of an alien invasive species in a natural environment might threaten the native components and has major impact on global biodiversity (e.g. Sala et al. 2000). In spite of the fact that the exploration of the Antarctica is relatively recent, the problem of the transport and introduction of non-native species by human means has also begun to affect that region and to increase in last years. The simplicity and isolation of Antarctic ecosystems render them more susceptible to alien invasion (Hughes et al. 2006). More attention is thus currently being devoted to the phenomenon of both the real and potential introduction of alien organisms to native Antarctic communities (e.g. Convey et al. 2006; Hughes and Convey 2010; Hughes and Worland 2010; Hughes et al. 2010).

The ice cover and severe climate dramatically reduce the occurrence of terrestrial organisms in Antarctica. The simplicity of the ecosystems emphasizes the fact that only two native vascular plants occur in the region and their existence is limited to the Antarctic Peninsula. Consequently, vegetation is very scarce and the Antarctic tundra is dominated by cryptogams (e.g. Olech 2004), while the invertebrate fauna mainly consists of microarthropods (Block 1984). However, the biodiversity is increasing as a result of the human presence and many non-native species from a wide range of living organisms have been introduced (Hughes and Convey 2010). The recent intensive deglaciation process and climatic changes observed over the past few years in Antarctica (Convey 2006) have reduced the severity of the climate and increased the risk of alien species becoming permanently established.

Organisms, or their propagules, can be transported by humans to Antarctica on different carriers, e.g. clothes, vehicles, aircraft and ship holds, food, cargo,

sand, aggregate, wood, and other building materials (see Whinam et al. 2005). In an area devoid of trees, wooden materials are especially valuable and timber in various forms is thus delivered to Antarctic stations.

Untreated fragments of wood, with the bark still attached, delivered to the “Arctowski” station, King George Island, South Shetland Islands, in the 2007/2008 season turned out to be a significant vector for several alien lichen species (Osyczka 2010). This paper focuses on the non-lichenized fungi and insects associated with this timber.

Materials and methods

Sampling area (station)

The “Arctowski” is an all-year-round medium sized station located on the west shore of Admiralty Bay at 62°09'S and 58°27'W. Detailed specifications can be found on the station's official website, at <http://www.arctowski.pl/index.php?p=196>. The whole Admiralty Bay comes under Antarctic Specially Managed Area (ASMA) No. 1. In addition, Antarctic Specially Protected Area (ASPA) No. 128 was established to the south of the station; this being the former Site of Special Scientific Interest (SSSI) No. 8.

Sampling and specimen examination

The shipment put together for the 32nd Polish Antarctic Expedition in the 2007/2008 season contained various timbered structures, such as planks, scantlings, stumps, stiffen bundles, wooden pallets, and cages and crates, as well as the remnants of branches or twigs hidden in crates of fruits and so forth. Once they had been unloaded, all these elements, stored inside or outside the station buildings, were successively scanned, with particular attention being paid to the parts still covered with the remains of the bark. All the fruit bodies of fungi were gathered with substrate, air dried and packed into envelopes. Insect larvae and imago were placed in vials with 70% ethanol. All the samples were then taken back to Poland.

The fungal material, larvae and imago were examined with the aid of dissecting and light-microscopes and identified using the appropriate

and standard methods. All the specimens have been preserved in the Lichenological Herbarium of the Institute of Botany at the Jagiellonian University (KRA) and are available upon request.

Results

The timber brought to the “Arctowski” station from Poland turned out to be an undesirable harbor and carrier for several alien fungi and two species of insects. Under this study, four species of Ascomycota and five species of Basidiomycota, together with four unidentified basidiomycete taxa, were apprehended and peritecia-forming ascomycetes and corticioid and polyporoid forms of basidiomata were found to be present. The sterile mycelia of unidentified basidiomycetes were also detected. One species of insect was represented by both the larva and imago (female), while the second one was only caught in larva form. All the pieces of timber gathered and examined were hardwood. Table 1 provides detailed information on the taxonomic affiliation of the species, their global distribution, the potential or real vitality of the individual specimens taken and the number of specimens detected.

Discussion

The harsh environmental conditions of Antarctica do not support the development of a diverse ascomycete or basidiomycete biota and entomofauna (see: Vernon et al. 1998; Bridge et al. 2010). Some fungi have a range of morphological and physiological adaptations, such as the capacity to dehydrate, and to produce antifreeze compounds, a freezing tolerance, survival under anoxia and resistance to high UV radiation, which allow them to exist in the Antarctic region (Magan 2007; Ruisi et al. 2007). Currently, around 500 species of fungi are known from the area south of 60° S; what is important, however, is that only 2–3% are considered to be truly endemic (Bridge and Hughes 2010). The majority of recorded taxa are microfungi belonging, predominantly, to Ascomycota. Fruiting bodies-forming Basidiomycetes are represented by only few species connected with mosses or organic debris (e.g. Pegler et al. 1980). To date, no species of fungi producing large

fruit bodies on wood have been reported from Antarctica (Bridge et al. 2010). Some insects, which are able to survive the formation of ice in their tissues, are characterized by freezing tolerance but, generally speaking, an indigenous, free-living entomofauna is extremely rare to Antarctica (Vernon et al. 1998). Only two native ‘higher’ insect species are present in areas of the northern Antarctic Peninsula (Block 1984).

Nevertheless, the recent climate changes, which are ameliorating environmental conditions, combined with intensified human activities, are promoting a rapid increase of biodiversity in Antarctica. Numerous observations have been published on unintentional import of alien fungi and insects which survive and become in association with Antarctic research stations (e.g. Hughes et al. 2005). Moreover, the fungi, including ascomycetes, present in the intestines of larvae have been quoted as example of potential multiple introduction from a single invertebrate importation (Bridge and Denton 2007).

Most of the alien lichens accidentally transported to the “Arctowski” station in the 2007/2008 season were associated with untreated timber (Osyczka 2010). It turns out that non-lichenized fungi and insects can also be transported in this way. In this paper, we present data on thirteen fungal and two insect taxa which were thus imported. It can be assumed that the basidiocarps mentioned in the paper developed either in Poland or during shipping. The latter possibility is suggested by the colorless, fertile specimens of *Chondrostereum purpureum* and *Bjerkandera adusta* which had clearly formed in the absence of solar light, for example, in the ship’s hold. The same could probably be said for ascocarps. However, in this case, the possibility that they might also have developed, or continued developing, after arrival to the station cannot be excluded. Vital spores found inside the said ascocarps suggest this eventuality. Nonetheless, it is also possible that some basidiocarps and ascocarps were already dead when they arrived in Antarctica.

We have assumed that the probability of that imported fungi and insects will become established and spread can be considered as rather negligible. In all cases, they have a temperate distribution pattern (see Table 1). The production of fruit bodies by all the recorded fungi, and life cycles of insects, are associated directly with bark. Even if the insects were to

Table 1 Fungi and insects accidentally transported with timber via a shipment to the “Arctowski” station during the 2007/2008 season

Affiliation	Species	Number of specimens	Potential or real vitality	Distribution pattern
Fungi				
Ascomycota	<i>Hypoxylon fragiforme</i> (Pers.) J. Kickx f.	Several stromata in different stages of development	Vital spores	Northern Hemisphere
	<i>Nectria coccinea</i> (Pers.) Fr.	Several groups of perithecia	Status undefined (probably no vital spores)	Europe, Asia, introduced to North America and to Australia
	<i>Neonectria punicea</i> (J.C. Schmidt) Castl. & Rossman	4 groups of perithecia	Status undefined (probably no vital spores)	Europe, North America, introduced to New Zealand and Australia
	<i>Quaternaria quaternata</i> (Pers.) J. Schröt.	Several perithecia	Vital spores	Europe, North America
Basidiomycota (corticoid basidiomata)	<i>Cylindrobasidium evolvens</i> (Fr.) Jülich	4 specimens at early stages of development, single or in patches	Status undefined, fertile	Europe, Asia and North America, South America (Argentina)
	<i>Peniophora cinerea</i> (Pers.) Cooke	30 orbicular, primordial basidiomata at small distance apart and some partly confluent	Status undefined, young and sterile	Europe, Asia, Africa, New Zealand, North and South America
Basidiomycota (corticoid, stereoid basidiomata)	<i>Chondrostereum purpureum</i> (Pers.: Fr.) Pouzar	3 specimens grown up in the absence of light	Status undefined, fertile	Cosmopolitan (except Antarctica)
	<i>Stereum hirsutum</i> (Willd.: Fr.) Gray	2 specimens	Status undefined, sterile	Cosmopolitan (except Antarctica)
Basidiomycota (polyporoid basidiomata)	<i>Bjerkandera adusta</i> (Willd.) P. Karst.	5 fragments of basidiomata, one of them evidently grown up in the absence of light	Status undefined, fertile	Cosmopolitan (except Antarctica)
Basidiomycota	Unidentified basidiomycete 1	Several hyphal strands on bark	Vegetative structures	
	Unidentified basidiomycete 2	Several hyphal strands on bark	Vegetative structures	
	Unidentified basidiomycete 3	1 small patch	Vegetative structures	
	Unidentified basidiomycete 4	4 small patches	Vegetative structures	
Insects				
Cerambycidae	<i>Rhagium mordax</i> De Geer	1 larva, 2 imago (female)	Live, all in hibernation	Europe
	<i>Callidium violaceum</i> Linnaeus	1 larva	Live, in hibernation	Palaearctic, Near East, Oriental region

survive for a period of time in the indoor conditions of a station, they would be unable to complete their life cycle without bark and cannot establish a stable population if decorticated wood is either the only, or the predominant, wood present. The same applies to fungi. Even if some, in particular, ascomycetes, were able to form anamorphic structures and spread in this form, the probability of this situation's arising is low.

No representatives of such anamorphic genera as *Cylindrocarpon*, *Nodulisporium* or *Libertella* (anamorphic stages of *Hypoxylon*, *Nectria* and *Quaternaria*), have been recorded from Antarctica to date (Bridge et al. 2010). Moreover, only soft rot fungi has been observed in the decomposition of wooden structures, mostly old huts, in Antarctica (Blanchette et al. 2004) and it was concluded that the harsh

climate conditions preclude the development of white and brown rot fungi. This would exclude all wood decomposing Basidiomycota from the biota of Antarctica. None of the recorded fungal taxa is known to cause a soft rot of wood.

It should be pointed out that we can perceive fruit bodies of fungi on the bark relatively easily; however, the presence of fungal hyphae would also be likely inside of the core of the wood, where they might well also spread. This is one of the reasons why only recently prefabricated timber, which has been protected from external factors, should be transported to Antarctic stations, with wood treated in any other way being excluded. The Protocol on Environmental Protection to the Antarctic Treaty states that no species non-native to the Antarctic Treaty area shall be introduced and that every precaution should be taken to prevent the importation of alien organisms (Antarctic Treaty Consultative Parties 1991). Keeping this in mind, the transport of untreated and insecure timber to the Antarctic stations would appear not to be best practice. The management of the “Arctowski” station was informed about the problem and requested to take this into account when preparing supplies for the station.

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