# Status of *Plutella xylostella* at Marion Island six years after its colonisation

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*The distribution and status of the cosmopolitan crucifer-feeding diamondback moth,* Plutella xylostella *(Lepidoptera: Plutellidae) on Marion Island is reassessed based on a short survey of host plants undertaken during the 1991 relief voyage to the island. The original (1986) and current distribution of the species is discussed in the light of a simple thought-experiment concerning colonisation in windswept areas. This model indicates that successful colonisation by small insects of islands in regions with high wind speeds is more likely to occur on the leeward side than on the windward side of such islands. The 1986 distribution of the diamondback moth coincides with the most likely area of colonisation predicted by the model and supports the idea of natural colonisation of Marion Island by* P. xylostella.

*Die verspreiding en status van die kosmopolitaanse koolplantvretende ruitrugmot,* Plutella xylostella *(Lepidoptera: Plutellidae) op Marion-eiland word herbepaal tydens 'n kort opname van gasheerplante wat gedurende die 1991-oornamevaart na die eiland onderneem is. Die oorspronklike (1986) en huidige verspreiding van die spesies word bespreek in die lig van 'n eenvoudige gedagte-eksperiment in verband met kolonisering in winderige gebiede. Hierdie model dui aan dat suksesvolle kolonisering van klein insekte op eilande met hoë windsnelhede meer geredelik sal voorkom aan die windstilkant as op die windkant van sulke eilande. Die 1986-verspreiding van die ruitrugmot stem ooreen met die mees waarskynlike gebied van kolonisering, soos voorspel deur die model, en ondersteun die idee van natuurlike kolonisering van Marion-eiland deur* P. xylostella.

## Introduction

*Plutella xylostella* L. (Lepidoptera: Plutellidae) was first discovered feeding on the sub-Antarctic crucifer *Pringlea antiscorbutica* R. Br. (Brassicaceae), or Kerguelen cabbage, at Marion Island in 1986 (Crafford & Chown 1987). The original infestations were recorded some five kilometres south of the meteorological station at Transvaal Cove, but the moth subsequently spread to the north and north-west of the weather station reaching the Van den Boogaard River by 1988 (Crafford & Chown 1990). Although it was originally thought that the moth was introduced to the island with the twice-yearly supply of vegetables to the station (Crafford & Chown 1987), subsequent investigations revealed that *P. xylostella* is capable of spectacular long-distance migrations in polar areas (Lokki *et al* 1978, Talekar *et al* 1985) and that other continental insects have come within range of the Prince Edward Islands (Gartshore & Steele 1988, Steele & Crafford 1987) and Îles Crozet (Voisin 1975). This lead Crafford & Chown (1990) to question their earlier convictions concerning the mode of transport of *P. xylostella* to Marion Island.

Opportunistic monitoring of *P. xylostella* close to the weather station during the 1987/88 season showed that numbers peaked in the late austral summer and early winter, and that heavily infested *P. antiscorbutica* plants recovered completely by the following season (October/November). Although the long-term effects of the moth on the Kerguelen cabbage were unknown, it was considered unlikely that *P. xylostella* would severely debilitate plants (Crafford & Chown 1990). Severe cold and frost were thought to be the main factors limiting the activity of and the extent of damage caused by larvae to *P. antiscorbutica* during the latter's main growth period, providing these cold-adapted plants with a recovery period. Based on these findings, Crafford & Chown (1990) revised their earlier (1987) opinion that *P. xylostella* should be considered a potentially destructive alien invader and suggested that the moth should be considered a natural coloniser and studied as an excellent example of a founder event.

In this paper, the current (1991) status (distribution and extent of infestation) of *P. xylostella* at Marion Island is assessed and its likely mode of colonisation discussed.

## Methods

Fieldwork for this study was conducted in April/May 1991 during the annual relief voyage to Marion Island. The sites used for Crafford & Chown's (1990) opportunistic monitoring programme were revisited and the extent of *Plutella xylostella* infestation of individual, isolated *Pringlea antiscorbutica* plants and individual plants in large patches recorded. Larval counts were made on each of ten plants at both Bullard and Van den Boogaard Rivers. Infested *P. antiscorbutica* plants (individuals and stands) were mapped during a survey of the island undertaken on foot over a five-day period. In this survey only presence or absence of *P. xylostella* was recorded.

A simple model of wind flow patterns at Marion Island was constructed from topographical and meteorological information to examine the likely sites of colonisation of *P. xylostella* assuming it reached Marion Island without human assistance.

## Results and discussion

High numbers of *Plutella xylostella* larvae (up to 20 individuals per plant on three occasions) were found on individual plants in the Bullard River and Tafelberg areas, and plants showed signs of extensive damage. Infestation was patchy, however, with some plants almost untouched while neighbouring plants were heavily damaged. This was found to be the case in patches and where isolated plants were separated by a short distance only, although plants in patches showed less evidence of extensive herbivory. Crafford & Chown (1987, 1990) found a similar situation in their earlier studies, but never recorded larval densities above 12 individuals per plant, despite more extensive searches. *Pringlea antiscorbutica* plants marked and photographed in the Stony Ridge area during the 1987/88 season did not appear to differ in size or vigour in 1991 compared with 1987, and most of these plants supported old inflorescences and/or seeds from the previous (1990) season. In other words, there is still no evidence that the diamondback moth is capable of persistent debilitation of its sub-Antarctic host plant. *P. xylostella* larvae, or the characteristic window-like signs of larval feeding were also found at Rooks Bay, Azorella Kop, Long Ridge/Blue Petrel Bay, at the highest extents of *P. antiscorbutica* on the Van den Boogaard River and at Cape Davis. The diamondback moth has thus succeeded in colonising all but the higher altitudes of Marion Island (Fig 1).

From Fig 1 it is clear that the moth was originally not found on cabbages at Trypot Beach, Macaroni Bay, Sealers Beach (0.7, 2 and 3 km SSE of the meteorological station, respectively) or the Van den Boogaard River (1 km N of the station), but at more distant sites; Stony Ridge, at 5 km S, being the closest. At that time, the moth was found in an almost rectangular area with the apices being Hansen Point, Fred's Hill, Arthur's Hill and Green Hill. It took the moth two years to spread to *P. antiscorbutica* patches close to the base (Crafford & Chown 1990). This finding led to deliberation on the actual site of colonisation of islands by various sorts of propagules. Intuitively, it would be expected that the windward side of an island/habitat, or the side closest to the source area, or abutting the incoming currents, would be colonised. Empirical data from various sources support this idea (Diamond *et al* 1989, Howden 1977, Mikkola 1986, Noonan 1985, Rainey 1976, Roughgarden *et al* 1988, Swincer 1986) and it is probably true for all large organisms and areas not subject to high winds. However, a simple model suggests that this may not be the case for small organisms (those usually forming the so-called aerial plankton) in areas with high wind speeds, such as the sub-Antarctic.

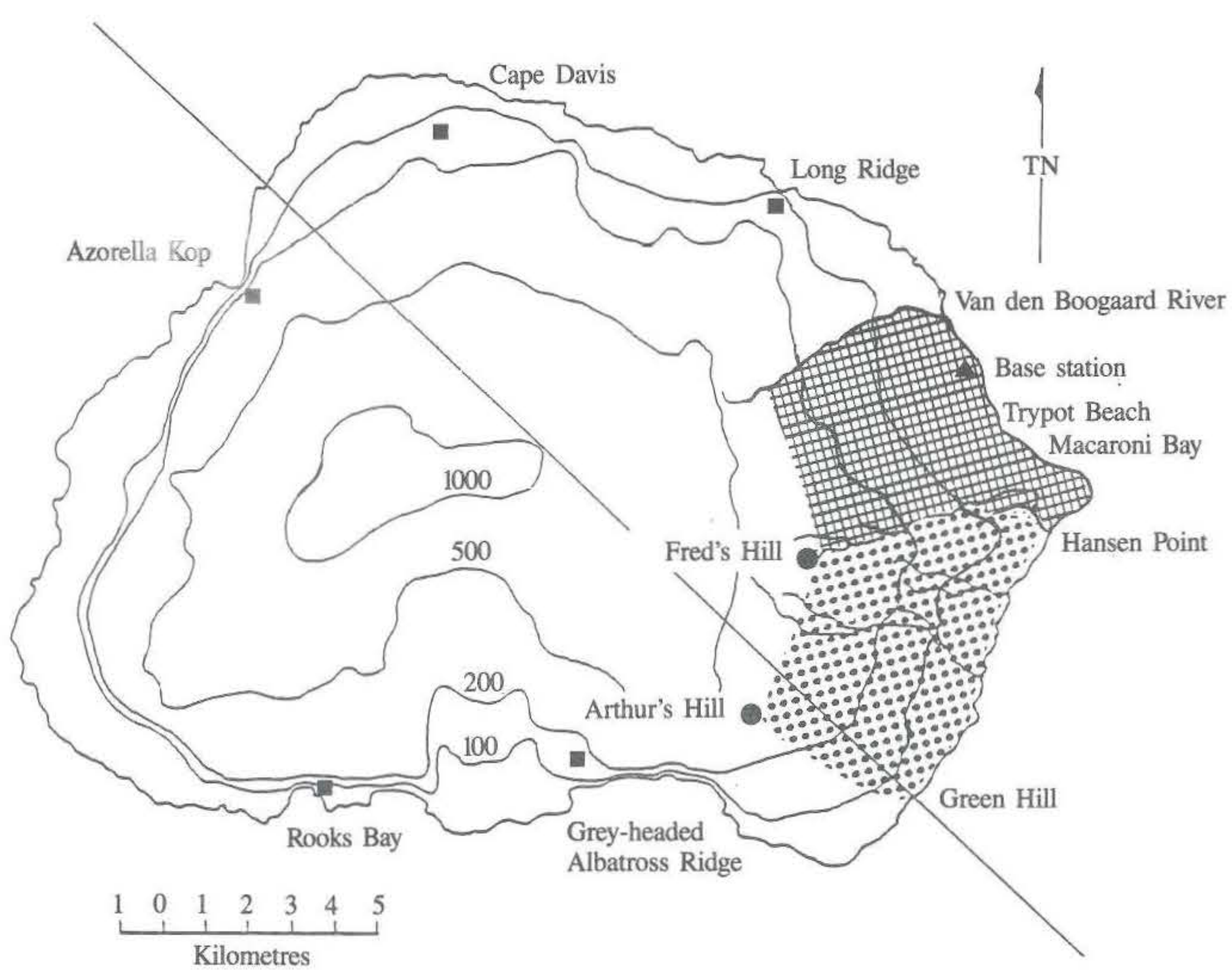


*Fig 1: Topographic map of Marion Island showing the 1986 distribution of* P. xylostella *( ∷ ), the additional area colonised by 1988 ( ▦ ) and areas added to its range since then ( ■ ). The position of the meteorological station, various localities at which* Pringlea antiscorbutica *populations were examined and the line along which the cross-section in Fig 2 was taken are indicated*



In Fig 2, a diagram of wind direction frequency recorded at the meteorological station is presented, and a vertical cross-section of the island taken along the straight line in Fig 1 is shown. This line is parallel to the longest line in the wind direction frequency diagram. Superimposed on the cross-section is an idealised pattern of airflow. Admittedly this pattern is dependent on many physical factors such as wind speed gusting and the "texture" or irregularity of the surface. However, just as is the case in any obstruction to fluid flow, e g a sand dune in a desert, the air reaching the topographic obstruction would tend to rise over it, lifting higher any material carried in the column, and thus over the windward side of the island. Then, due to the decrease in depth of the air column and the contact of the lower layers of the air column with an irregular medium in a different state, these layers would decrease in speed relative to the upper layers. This would cause turbulence at the highest point of the island (or shallowest area in terms of the air column), subsequent vertical mixing and deposition of any material carried in the air column on the leeward side of the island (see Drake & Farrow (1988) and references therein for a discussion of the influence of topographic obstructions on airflow patterns). This happens on a smaller scale with barchan dunes (Stanley 1989) and explains the presence of detritus on the leeward side of such dunes in the Namib Desert (Holm & Scholtz 1980). Of course, this would not take place if the material was carried at altitudes higher than the planetary boundary layer, i e above 2 km (Drake & Farrow 1988). Eddying around the "sides" of the island could have a similar effect.

With this model in mind, it does not seem unreasonable to suppose that any small, long-distance migrants, being carried in the planetary boundary layer, would be deposited on the leeward side of an island in a region that continually experiences high wind speeds. If propagules survive an oversea migration, deposition on the more favourable, leeward side of an island would most probably increase their chances of survival. Therefore, in the case of Marion Island, and probably other sub-Antarctic or windswept islands, successful colonisation of the leeward side of the island seems more probable than colonisation of the windward side. The original (1986) distribution of *P. xylostella* (Fig 1) corresponds almost exactly to the area of colonisation predicted for Marion Island by the model. In addition, on Île aux Cochons, Voisin (1975) found the long-distance migrant *Vanessa cardui* on the lee of the island, together with a single specimen of a moth he identified as a *Plutella* species (Voisin *in litt* 1992). Also on Inaccessible Island in the Tristan da Cunha archipelago the rare *Peperomia berteroana* Miq. (Piperaceae) occurs only in a valley on the lee of the island (Valdebinito *et al* 1990), while on Gough Island (352 km SSE of Tristan da Cunha) *Sophora macnabiana* Grah. (Fabaceae) is found in a small

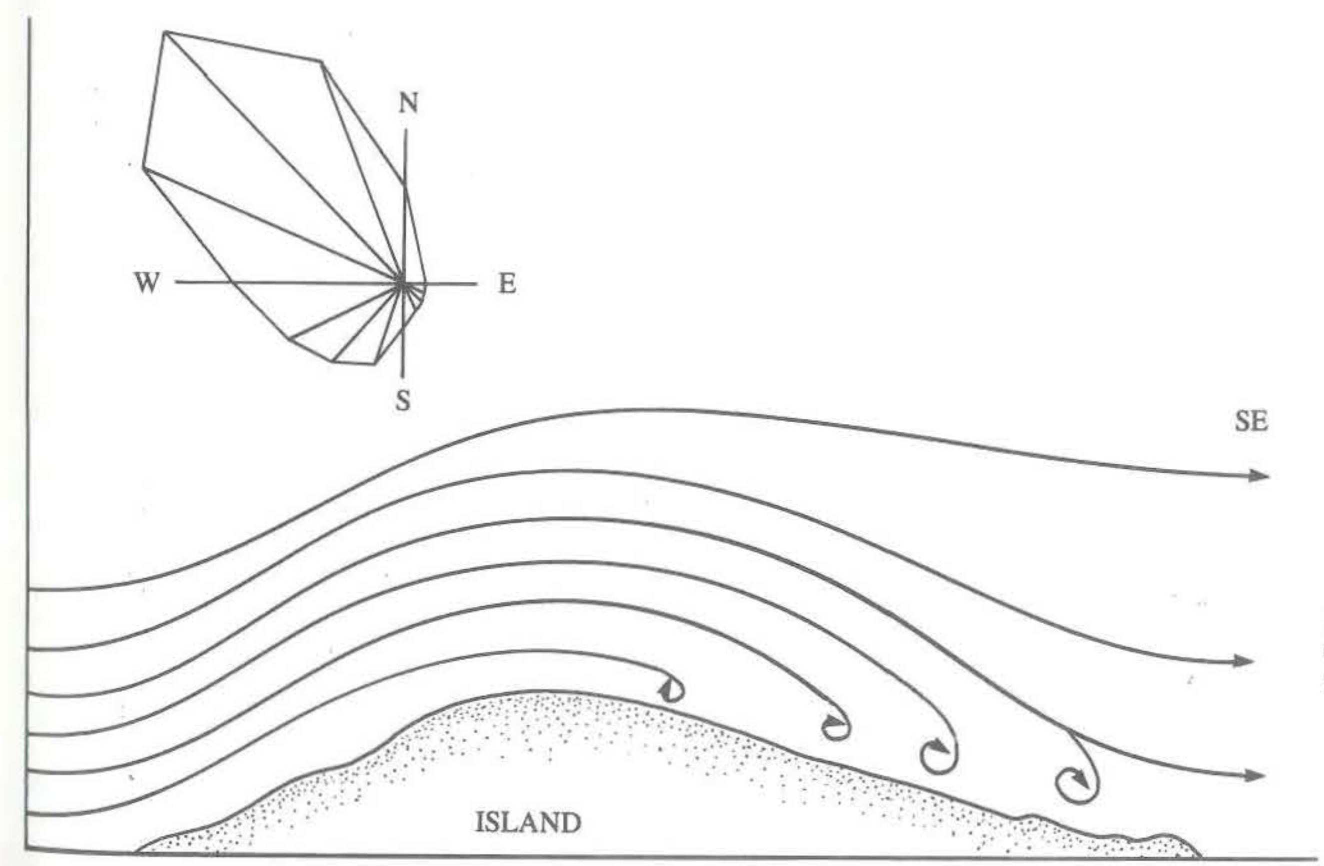


*Fig 2: Wind direction frequency diagram for Marion Island (after Gremmen 1981) and vertical cross-section of Marion Island with idealised airflow patterns superimposed. Vertical scale is 3X*

patch in a leeward valley (Wace 1961). Both plants have their closest relatives in the South American region, although they are not necessarily capable of wind-mediated dispersal.

In view of *P. xylostella's* original distribution on Marion Island, the implications of the above model, and its exceptional migratory abilities (1 000 km.day$^{-1}$ (Lokki *et al* 1978, Talekar *et al* 1985), Crafford & Chown's (1990) hypothesis of oversea colonisation appears to be reasonable, leaving the issue of *P. xylostella's* mode of transport to the islands unresolved. A biochemical (allozyme of mtDNA) comparison of the population on Marion Island with populations from the farms where the produce for the station was purchased would resolve this issue. However, Crafford & Chown's (1990) suggestion that the moth should be considered a natural coloniser, irrespective of its mode of transport, and that the founder event should be followed, remains pertinent.

Finally, the model has important implications for the siting of pollen traps and other devices that are used for monitoring propagule arrival in the sub-Antarctic and other windswept areas. As such, it is relevant to the Biological Investigations of Terrestrial Antarctic Systems (BIOTAS) programme of the Scientific Committee on Antarctic Research (SCAR) (Lewis Smith 1988). Monitoring colonisation events, and relative catches in propagule traps, located at specific sites on sub-Antarctic Islands, could also provide evidence capable of falsifying the hypothesis.

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# Feeding biology of *Acantholatris monodactylus (Pisces: cheilodactylidae)* at Tristan da Cunha and Gough Island, South Atlantic

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*The feeding biology of the fivefinger,* Acantholatris monodactylus *from Tristan da Cunha and Gough Island is described. Comparison of stomach and hindgut contents indicates that stomachs are more suitable for dietary analysis in this species. It is apparent that a slight shift in diet may occur with size and season. Comparison of the diets of fishes collected at Nightingale and Gough Islands with those collected at Tristan Island indicate that locality plays an important role in determining the diet of this species. Significant differences in sea surface temperatures between Tristan da Cunha and Gough Island suggests that this physical parameter is of prime importance in regulating the availability of food items and therefore diet in* A. monodactylus.

*Die voedingsbiologie van die "fivefinger",* Acantholatris monodactylus, *afkomstig van Tristan da Cunha en Gough-eiland word beskryf. Vergelyking van maag- en derminhoud dui aan dat maaginhoud meer geskik is vir dieetanaliese in hierdie spesies. Dit blyk dat effense verskille in die dieet voorkom met grootte en seisoen. Vergelyking van die diëte van visse wat op Nightingale- en Gough-eiland versamel is, met dié van Tristan-eiland dui aan dat lokaliteit 'n belangrike rol speel in die samestelling van die dieet van hierdie spesies. Betekenisvolle verskille in see-oppervlaktemperature tussen Tristan da Cunha en Gough-eiland dui aan dat hierdie fisiese parameter van primêre belang is met betrekking tot die beskikbaarheid van voedsel en dus die dieet van* A. monodactylus.

## Introduction

The fivefinger *Acantholatris monodactylus* is a fish species that occurs only at oceanic islands and seamounts in the south Atlantic and south Indian Oceans. The species has been reported from Tristan da Cunha, Gough Island and Vema Seamount in the south and south-east Atlantic Ocean (Penrith 1967), and from St Paul and Amsterdam Islands (Sauvage 1879), Walters Shoal and various seamounts (Duhamel 1984, Collette & Parin 1991) in the south Indian Ocean. Little has been published on the biology of *A. monodactylus*. Beurois (1976) carried out a dietary study on the species at Amsterdam Island as part of an investigation on the marine resources of that island group.

The Tristan da Cunha group consists of Tristan, Nightingale and Inaccessible Islands, which lie on the eastern slopes of the Mid-Atlantic Ridge at 37°05'S, 12°17'W. Gough Island lies approximately 200 nautical miles to

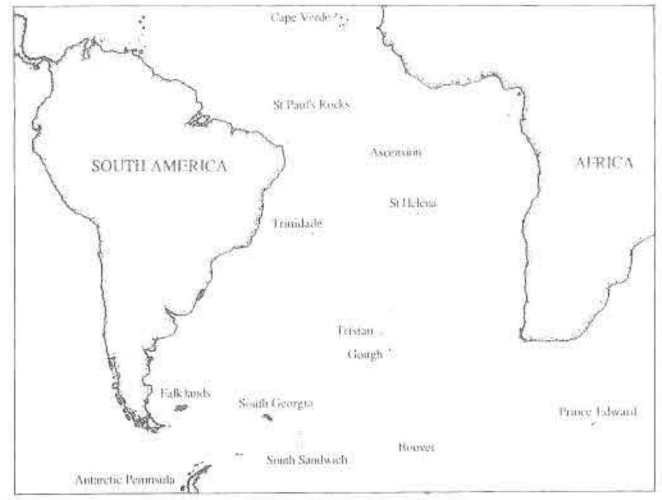


*Fig 1: The position of Tristan da Cunha and Gough Islands in the South Atlantic Ocean*

the south-east at 40°19'S, 12°17'W (Fig 1). All the islands have relatively narrow shelf areas (e g extending a maximum of about 1.5 nautical miles to sea at Tristan Island) that then drop off into abyssal depths (Fig 2).

All evidence to date suggests that these islands lie within the influence of the Subtropical Convergence (STC) (Lutjeharms *et al* in press, Andrew *et al* 1993). It has been suggested that seasonal changes in stratification in the ocean around the islands may lead to increased nutrient availability and therefore higher primary productivity during the summer months (Allanson *et al* 1981, Andrew *et al* 1993). Fig 3 shows insolation-related differences in the sea surface temperatures at Tristan and Gough Islands (from all available data up to 1980).

At Tristan da Cunha the fivefinger is an important food and bait fish and constitutes the largest percentage in terms of weight and numbers of species caught by handline. Approximately 18.5 tonnes are taken each year (unpublished data from present study). Juvenile and adult fivefingers occur supra-benthically in a wide variety of habitats and in depths from about 1.5 m to at least 200 m. The larval stage can last up to 12 months and is spent in the pelagic zone. Larvae metamorphose into supra-benthic juveniles at a size of about 70 mm Total Length (TL). The species grows to a size of at least 670 mm TL and a weight of 4 kg and reaches an age of at least 25 years (Sivertsen 1945, Andrew *et al* 1993).

It has been found that growth and reproduction are tem-