Short paper

Balanus glandula: a new alien barnacle from the west coast of North America, established on the northeast coast of Japan

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INTRODUCTION

A common littoral barnacle, *Balanus glandula* Darwin, 1854, (Crustacea, Cirripedia) from the west coast of North America was first reported in Mar del Plata port, Argentina in 1974 (Bastida *et al*., 1980). Further studies showed that this species established along the shore between 37°S and 47°S (Vallarino and Elías, 1997, Elías and Vallarino, 2001, Rico *et al*., 2001, Orensanz *et al*., 2002). The species was also found along the opposite side of the Pacific; in the littoral zone between 38°30'N and 42°40'N on the northeast coast of Honshu, Japan (Kado, 2003). It seems interesting that *B. glandula* was introduced in the late 1960s or afterwards in the two regions. In the case of Japan, the vectors of *B. glandula* for the introduction were inferred to be cargo-ships carrying lumber from the NW of the US, (Kado, 2003). From the first introduction to the present (probably less than 30 years), *B. glandula* successfully established in the littoral zone, especially in big commercial ports. In both regions *B. glandula* seems to have some ecological superiority over native communities. In Japan, however, the distribution is not continuous along the coast between harbours, and population densities of *B. glandula* do not always correlate with distances from invaded harbours. At some locations *B. glandula* was common, even far from these ports. These new facts suggest that local spread of this species does not depend only on its larval dispersal. This study reports on the ecological properties of *B. glandula* on the northeast coast of Honshu, Japan and investigates the role of barges, tugboats and similar vessels within Japan as likely vectors of *B. glandula* for further spread.

METHODS

Field surveys and experiments were carried out at Kamihira fishing port in Ofunato Bay, Iwate Prefecture during autumn, in the period from 2000 to 2003. Reproductive conditions were investigated monthly by checking brooding condition of a sample of barnacles. Three reproductive categories were assigned: no embryos, early embryos with yellowish colour, and late embryos with brownish colour. Parameters of water quality such as temperature, salinity and Chlorophyll-a concentration were measured at the same time by means of a mercury thermometer, a conductivity meter (LF340, WTW), and a fluorometer (Field fluorometer 10-005, Turner), respectively. Seasonality of settlement was examined using monthly immersed triplicate test plates with frosted surface. Test plates were fixed at three different sea levels: mean sea level (MSL) and 40cm above and below the MSL. Test plates were changed monthly and settled spat and juveniles on their surface were counted and recorded separately.

Settlement depth of *B. glandula* was examined by means of paired poly-vinyl chloride pipes hung vertically from the quay wall.

To estimate growth and age of the *B. glandula* population in this Bay, a growth analysis was performed for a population settled around 40cm below the MSL on the concrete mooring slope at Kamihira fishing port. Shell size was measured monthly with digital callipers, at low tide. Growth and age composition were analysed with the Solver method (packaged in MS-Excel (Microsoft)).

The hull and fenders of barges and tugboats were checked for fouling by *B. glandula*. We also collected information on locations they visited.

RESULTS

On the sheltered shores of Ofunato Bay, *Balanus glandula* had established a dense population over the whole range of the littoral zone. *Balanus albicostatus,* which is endemic to temperate Japanese and adjacent waters, was out-competed there, except for the upper fringe of the zone. On exposed rocky shores, to which *B. glandula* had just started to expand its distribution, the species was starting to compete for space with two temperate-subtropical endemics, *Tetraclita japonica* and *Chthamalus challengeri* in the mid and upper littoral fringe, and with a sub-arctic endemic, *Semibalanus cariosus* in the mid and lower littoral zone.

In Ofunato, *B. glandula* had a long breeding season throughout most of the year with monophasic

Pages 210-211. In Koike, F., Clout, M.N., Kawamichi, M., De Poorter, M. and Iwatsuki, K. (eds), *Assessment and Control of Biological Invasion Risks*. Shoukadoh Book Sellers, Kyoto, Japan and IUCN, Gland, Switzerland, 2006.

peak between February and June. It also had a longer settling season from April to July, compared to other native balanid species which settled only in July. *B. glandula* could settle on 74% of the littoral range (160cm). In the Kamihira population in Ofunato four cohorts were observed with shell size from juvenile to 20mm basal diameter.

Barges and tugboats which have Ofunato as their home port, have often been sent to other harbours and other coastal areas to construct facilities such as quays, Tsunami guards, wave-dissipating blocks, or to carry out dredging. They even visited as far as Hachinohe (ca. 190km north) and Kesen-muma (ca. 20km south). Hulls and fenders of the barges and tugboats were settled by *B. glandula*. We confirmed that *B. glandula* scraped off from fenders of the tug boats visiting Okkirai Bay on 24 April, 2003 held egg masses inside the shell, and when egg masses were put into seawater larvae hatched out.

DISCUSSION

B. glandula has many potential advantages over native barnacles and sessile animals, such as longer seasons in breeding and settling, wider range of settling, smaller size when breeding, and greater adaptability to both sheltered and exposed environments. It was also fortunate for *B. glandula* that the coastal areas where it was introduced were located on the fringes of the distribution area for both temperate, subtropical, and sub-arctic endemics, resulting in less competition. It seems, therefore, unlikely that there would be interference with *B. glandula* expanding its range to the exposed rocky shores, where indigenous biota still remains. Frequent visits of barges and tugboats from ports that are settled heavily by *B. glandula* to these new locations should also be expected to play a role given that such vessels are vectors for further spread within Japan. In addition, the greater tolerances of *B. glandula* to water temperature and salinity (Kado, unpublished) is also likely to facilitate the spread further south up to 36°N, which is a southern fringe of mid-temperate zone in the Pacific coast of Japan.

ACKNOWLEDGEMENTS

We gratefully thank the students of the Laboratory of Marine Primary Production, School of Fisheries Sciences, Kitasato University during field and laboratory work for their cooperation throughout the years. We also thank the editors for improving the manuscript.

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