

Boone Grant Winner

Grant winner Dieta Hanson is currently finishing her Master's degree and has written the article below. She thanks the HCS for its generous support.

Alien Invaders: *Haminoea japonica* in North America and Europe
By Dieta Hanson

Haminoea japonica is a small yellow brown opisthobranch (sea slug), also known as the Japanese Paper Bubble Snail, that was first described based on shell morphology by Pilsbry in 1895 as a variety of *H. binotata*. In 1952, a more reliable description based on radular morphology was published by Habe. Starting in the 1980s, the species has been reported from South Korea, Washington State, Northern California, British Columbia in Canada, Italy, Spain, and France. *H. japonica* appears to have a negative impact on the native *Haminoea* species in the US (*Haminoea vesicula*), where populations have decreased significantly in areas where *H. japonica* has flourished. *H. japonica* also has been found to carry a non-native parasite that has caused swimmer's itch in humans exposed to seawater in San Francisco Bay.

For my master's thesis, I wanted to answer two questions. First, is *H. japonica* really native to Japan? Since the first verifiable description was published shortly after the major expansion of Japanese forces during WWII, it is possible that the slug had been brought to Japan from other areas of Asia accidentally in ship ballast water or other means. Second, if it did come from Japan, specifically where in Japan? This may help us answer how the slug was transported to North America and Europe; if it was through ship ballast, we would expect that they probably came from an area with high shipping traffic, such as Tokyo or Hiroshima. Alternatively, if it came from an area with low shipping traffic but high oyster production, transport with oyster spat (seed) is the most likely mechanism, as proposed by Terry Gosliner and David Behrens in their 2006 paper published in the Proceedings of the California Academy of Sciences.

To answer these questions, I looked at the DNA of *H. japonica* specimens from their entire range—Japan, North America, and Europe—to see how much variety in the DNA there was in these different locations, and also to “match” DNA types—much like DNA is used in humans to identify close relatives. Through the generosity of the Houston Conchology Society and other sponsors, I was able to travel to Japan and Washington State in summer 2011 to collect material. Because of the earthquake and tsunami four months earlier, a large part of the north-east coast of Japan was not sampled, however Japanese colleagues were able to supply me with

specimens collected before the disaster. Specimens from Europe were borrowed from museums or collected by colleagues.

When looking at the DNA in a gene called CO1, I found that there were very high levels of genetic (DNA) diversity in Japan that were also highly structured in association with the different ocean currents that surround the islands. For example, individuals collected from different locations in the Sea of Japan were more closely related to one another than they were to individuals from Tokyo Bay. This structure and diversity answered my first question; *H. japonica* was definitely a native species in Japan, although that does not preclude other regions in Asia from also being within the range of the species. Malacologists in China and Russia that I have contacted have said that they have not found the slug in their respective countries, but thorough surveys would need to be made to confirm.

In the invasive range, North America and Europe, all the individuals were very closely related, with very low genetic diversity and structure. Furthermore, they were also closely related (exact match in the CO1 gene) to individuals from the north-eastern Japanese prefectures of Miyagi, Fukushima, and Ibaraki. This region of Japan does not have any major international shipping ports and moreover is of major importance in historical and modern oyster export. The first oysters brought to North America from Japan were from this region. All the other slugs from Japan (south, west, and north coasts) were very distantly related to those in the invasive range. This evidence, taken with historical data on oyster transport between Japan, North America, and Europe, supports the hypothesis that *H. japonica* was transported to its invasive range through exports of oyster spat from north-eastern Japan, in answer to my second question.

Since oyster spat is still transported all over the world, including between European countries, Washington state, California, Oregon, Canada and Hawaii, there is a very real possibility that *H. japonica* could spread even further to places where it is not currently found, such as Southern California. If slugs carrying the swimmer's itch-causing parasite were transported to Southern California and flourished, it would be disastrous for the local beach-tourism economy, in addition to the effects on local native species. The results of this study, therefore, provide important data for the development of policies and regulations aimed to prevent further spread of this species.