SPIXIANA	44	1	9–10	München, November 2021	ISSN 0341-8391

Scientific note

Sudden southward spread of the cryptogenic anemone *Anemonia alicemartinae* caused by climate change, poor monitoring effort or introduction from Northern Chile?

(Cnidaria, Anthozoa)

Vreni Häussermann, Felipe Arraya, Günter Försterra & Elisa Montti

Since its first description in 2001 (Häussermann & Försterra 2001), the origin, distribution and dispersal mechanisms of the cryptogenic sea anemone *Anemonia alicemartinae* were discussed in several publications (López et al. 2013, Canales-Aguirre et al. 2015, Pinochet et al. 2019, Glon et al. 2020). This anemone was first mentioned for Chilean waters from Iquique in 1975/76 and has been common in Coquimbo since at least 1980. It was first found in the intertidal zone of Cocholgué, Concepcion (36°34'S, 72°58'W) in 1998/99, where its populations barely grew during the following three years. At that time, it was very abundant in Northern Chile, but between Tongoy (30°14.841'S, 71°30.027'W) and Cocholgüé only confirmed for the intertidal zone (Häussermann & Försterra 2001). In 2010, it was found at Lirquen (36°43'8.10''S, 72°59'6.59''W) (López et al. 2013). In 2014, it was detected at numerous sites in the intertidal between Cobquecura (36°8.264'S, 72°48.553'W) and Concepcion Bay including Tumbes Peninsula (36°44.151'S, 72°59.729'W), but, despite two-hour intertidal searches, was not found at several sites down to 38°21'S (Pinochet et al. 2019). Recent observations have confirmed the abundant presence of the species in the shallow subtidal between Pichidangui (32°7.960'S, 71°31.975'W) and Concepción (P. Gonzalez & R. Sanchez, in litt. 2021). On 1st of September 2021, FA and EM observed several dozens of specimens of *A. alicemartinae* in small groups of up to five individuals between boulders of an exposed bay at Huiro (39°57.434'S, 73°38.590'W) in 3–5 m depth, a site where the species was not present in February 2020 (Fig. 1). The area covered by the anemones reached approximately 50 m². Despite regular dives, the team has not observed the species at any other site in the area between Pilolcura (39°39.359'S, 73°21.380'W) and a site approximately 1.5 km south of Caleta Huiro (39°57.843'S, 73°39.479'W) between 2018 and 2021. The fact that *A. alicemartinae* was found about 370 km south of the last confirmed record in 2014 could have the following explanations: 1) the southward spread of *A. alicemartinae* was accelerated in a punctuated manner due to elevated water temperatures and enforced southward currents during the strong ENSO phenomenon in 2015/2016 (see Strub et al. 2019 and Mardones et al. 2021), 2) the species was moving southward constantly between 2014 and 2021, but was not registered at the coast between Concepción and Valdivia (the city of Temuco, which is situated between both of these cities, is located off the coast and no scientific diving nor sport diving is practiced in the area), 3) *A. alicemartinae* was brought to the area with long lines of the sea squirt *Pyura chilensis*, which is cultivated in the community of Huiro since 2019 in a project from the Universidad Católica del Norte, Coquimbo. The project executive claims that young sea

Fig. 1. *Anemonia alicemartinae* at Huiro, 4 m depth (photo: F. Arraya). Pedal disc diameter of anemones 3–4 cm.

Vreni Häussermann, Facultad de Economía y Negocios, Universidad San Sebastián, Puerto Montt, Chile; e-mail: v.haussermann@gmail.com
Vreni Häussermann & Günter Försterra, Huinay Foundation, Chile
Felipe Arraya & Elisa Montti, Vuelve al Oceano, Huiro/Valdivia, Chile
Günter Försterra, Facultad de Recursos Naturales, Escuela de Ciencias del Mar, Pontificia Universidad Catolica de Valparaıso, Avda. Brasil 2950, Valparaıso, Chile

squirts collected from La Herradura Bay were kept in containers for five days and washed underwater with a saltwater jet before the transport to Huiro. The lines were brought from Coquimbo and deployed in the little bay where *A. alicemartinae* is found now. Another species that has not been sighted before in the area is the sea urchin *Tetrapygus niger*, which was observed for the first time by the team on May 5, 2021, on the long lines where *P. chilensis* is cultivated. Both species are very common around Coquimbo, North Chile.

Hypothesis 1 is supported by the fact that besides the variance in sea surface salinity, the variance of sea surface temperature is one of the two variables that mainly contributed to the predicted distribution of *A. alicemartinae*, following the ecological niche model applied by Pinochet et al. (2019). In the mentioned model, the area of Valdivia, however, is predicted as hardly suitable to not suitable (Pinochet et al. 2019); if the model was correct and the species introduced from Coquimbo, it could be expected that it will not spread further in the area but rather maintain its population or even disappear over time.

Hypothesis 2 is supported by the fact that other species such as the invertebrates *Heliaster helianthus* (Lamarck, 1816), *Patiria chilensis* (Lutken, 1859), *Meyenaster gelatinosus* (Meyen, 1834), and tuna fish have also been observed to spread southward in the last decades (Häussermann et al. 2021). This is probably due to elevated water temperatures due to climate change (Saurral et al. 2018), which can be measured in areas without upwelling.

To date, *A. alicemartinae* has been observed in habitats down to 25 m depth with temperatures between 13 and 23 °C and salinities between 33 and 36 ‰ (Glon et al. 2020). It attaches and re-attaches fast to different substrata. So far only female specimens have been observed, and the species reproduces through frequent longitudinal fission (Häussermann & Försterra 2001). The presented distribution history in South America together with genetic results (Canales-Aguirre et al. 2015) support the idea that *A. alicemartinae* is an invader, which was introduced to South America in southern Peru from the Indo-West Pacific or from the Atlantic (Glon et al. 2020). There is no other species of the genus *Anemonia* described from the Eastern Pacific (see GBIF.org), and the southward extension displayed by *A. alicemartinae* has not been described from other species. Thus, a human-mediated southward transport, e. g. in ship hull biofouling, is the most probable explanation for its presence in Chile (Canales-Aguirre et al. 2015).

Hypothesis 3 would be supported if a clear disjunct distribution exists, which would require confirmation by a survey between Valdivia and Concepción. In this case, elevated sea surface temperatures due to climate change could be responsible to have created a suitable habitat for *A. alicemartinae* in Valdivia, to where it was transferred together with the sea squirt cultures.

References

Canales-Aguirre, C. B., Quiñones, A., Hernández, C. E., Neill, P. E. & Brante, A. 2015. Population genetics of the invasive cryptogenic anemone, *Anemonia alicemartinae*, along the southeastern Pacific coast. Journal of Sea Research 102: 1–9.

Glon, H., Daly, M., Carlton, J. T., Flenniken, M. M. & Currimjee, Z. 2020. Mediators of invasions in the sea: life history strategies and dispersal vectors facilitating global sea anemone introductions. Biological Invasions 22: 3195–3222.

Häussermann, V. & Försterra, G. 2001. A new species of sea anemone from Chile, *Anemonia alicemartinae* n. sp. (Cnidaria: Anthozoa). An invader or an indicator for environmental change in shallow water? Organisms Diversity & Evolution 1: 211–224.

– – , Ballyram, S. A., Försterra, G., Cornejo, C., Ibáñez, C. M., Sellanes, J., Thomasberger, A., Espinoza, J. P. & Beaujot, F. 2021. Species that fly at a higher game: patterns of deep-water emergence along the Chilean coast, including a global review of the phenomenon. Frontiers in Marine Science 8: 688316. doi:10.3389/fmars.2021.688316

López, D. N., Arancibia, P. A. & Neill, P. E. 2013. Potential dispersal mechanisms of the cryptogenic anemone *Anemonia alicemartinae*. Revista Chilena de Historia Natural 86: 369–372.

Mardones, J. I., Paredes, J., Godoy, M., Suarez, R., Norambuena, L., Vargas, V., Fuenzalida, G., Pinilla, E., Artal, O., Rojas, X., Dorantes-Aranda, J. J., Lee Chang, K. J., Anderson, D. M. & Hallegraeff, G. M. 2021. Disentangling the environmental processes responsible for the world's largest farmed fish-killing harmful algal bloom: Chile, 2016. Science of the Total Environment 766: 144383. doi:10.1016/j.scitotenv.2020.144383.

Pinochet, J., Rivera, R., Neill, P. E., Brante, A. & Hernández, C. E. 2019. Spread of the non-native anemone *Anemonia alicemartinae* Häussermann & Försterra, 2001 along the Humboldt-current large marine ecosystem: an ecological niche model approach. PeerJ 7: e7156. doi:10.7717/peerj.7156

Saurral, R. I., Doblas-Reyes, F. J. & García-Serrano, J. 2018. Observed modes of sea surface temperature variability in the South Pacific region. Climate Dynamics 50: 1129–1143.

Strub, P. T., James, C., Montecino, V., Rutllant, J. A. & Blanco, J. L. 2019. Ocean circulation along the southern Chile transition region (38°–46° S): Mean, seasonal and interannual variability, with a focus on 2014–2016. Progress in Oceanography 172: 159–198.