INVASIVE POTENTIAL OF DIKEROGAMMARUS VILLOSUS (SOWINSKY) BASED ON CLIMATE-MATCH SCORE

PAVLINA KURIKOVA, LUKAS KALOUS, JIRI PATOKA
Department of Zoology and Fisheries
Czech University of Life Sciences Prague
Kamycka 129, 165 21 Praha
CZECH REPUBLIC
patoka@af.czu.cz.cz

Abstract: Killer shrimp (Dikerogammarus villosus) is omnivorous amphipod native to the Ponto Caspian region. When human-mediately or spontaneously invaded new area, it can rapidly reproduce and spread, prey on wide spectrum of benthic macroinvertebrates and fish, and affect the entire ecosystems. Killer shrimp spreads in Europe and no effective eradication methods are available. Since the temperature is limited factor for survival of this species, we processed climate matching to evaluate its establishment probability on the world. Based on this analysis the world's most at risk regions were highlighted. It follows that killer shrimp is most risky especially in temperate zone within Europe, North America and Asia including Japanese Archipelago.

Key Words: invasive species, biological invasion, killer shrimp, temperature

INTRODUCTION

Biological invasions by alien species often lead to niche competition between exotic and indigenous species and cause species replacement and biodiversity loss over the world (Lodge 1993). Eradication of invaders is in many cases difficult or impossible and hence prevention of new introductions is crucial (Kolar and Lodge 2001). One way to identify potential invasive species is modelling of climatic similarity between region of origin of these species and potentially threatened area (Bomford et al. 2009); this method is known as climate matching.

Amphipod gammarid crustacean Dikerogammarus villosus (Sowinsky) also called the killer shrimp is omnivorous species native to the Ponto Caspian region (Casellato et al. 2006). It undergoes rapidly spread over large distances in a short time and affects entire freshwater ecosystems by alternation of food webs through its exceptional predatory capabilities (Dick et al. 2002). According to its common name, this species is able to voraciously and extremely aggressively prey upon and replace other amphipods, isopods and other benthic macroinvertebrates and also previously introduced non-native species on localities which invaded (Dick and Platvoet 2000, Buřič et al. 2009). It exhibited predatory behaviour also towards small fish (Casellato et al. 2007). Furthermore, killer shrimp frequently dominate benthic faunal assemblages by its early maturation and high fecundity (Pöckl 2009) and can be perceived as “perfect invader” (Panov et al. 2009; Rewicz et al. 2014).

Killer shrimp established population in many European waterbodies occurring usually in high densities (e.g. Bij de Vaate and Klink 1995, Jazdzewski et al. 2002, Casellato et al. 2006, Bącela et al. 2008, Berezina and Ďuriš 2008) and it is one of the 100 worst alien species in Europe (DAISIE 2009). Killer shrimp can spread spontaneously but human-mediated translocations also exist (Martens and Grabow 2008, Bącela-Spychalska et al. 2013). Moreover, Bruïjs et al. (2001) demonstrated that killer shrimp survived at salinities up to 10‰ and adapted to salinities of up to 20‰. Moreover, it is able to survive for circa one week out of water (Martens and Grabow 2008). Thus not only inland regions are endangered but also islands including Great Britain where this species was recorded for first time at the River Great Ouse catchment in eastern England in 2010 (MacNeil et al. 2010). Since methods of its effective eradication are not available (Madgwick and Aldridge 2011), the continuous spread in regions like North American Great Lakes is expected (Ricciardi and Rasmussen 1998, Rewicz et al. 2014).
Killer shrimp does not exhibit a wider tolerance range for temperature and conductivity than indigenous gammarid species (Wijnhoven et al. 2003). Nevertheless, the prediction of its spread according to climatic conditions has been evaluated locally (see Gallardo et al. 2012). Therefore, in this study, we considered to process climate matching in world context to highlight the most at risk regions with high probability of killer shrimp establishment.

**MATERIAL AND METHODS**

**Climate matching**

Climatic conditions were represented in our analysis by temperature during the coldest, warmest, driest and warmest quarter of the year as variables and we opted Euclidean algorithm. The climate match between source and target area was compared using the Climatch tool (v.1.0; Invasive Animals Cooperative Research Centre, Bureau of Rural Sciences). We used region of native geographic range of killer shrimp as the source area. The target region was defined as rest of the world. For this purpose, data from 18,967 meteorological stations from database of WordClim project (Hijmans et al. 2005) were utilized. Where the climate match between the source area and the climatic station in the target area reached score ≥ 7.0, this was interpreted as there is high probability to establishment of killer shrimp.

*Figure 1 Maps showing climate match of killer shrimp (Dikerogammarus villosus). Scores of ≥ 7 are interpreted as regions with high probability of its establishment.*

Legend: a = Europe without Russia, b = Oceania, c = North America, d = South America, e = Asia with Russia, and f = Africa and Madagascar
RESULTS AND DISCUSSION

In the total of all evaluated meteorological stations, score of 7 reached 477 stations, score of 8 reached 310 stations, score of 9 reached 132 stations. Score of 10 reached 10 stations and most of them are located in the defined source area. Obviously, most threatened worldwide regions where killer shrimp has a high probability to become established when introduced lay in temperate zone (Figure 1).

With not numerous exceptions, Africa, South America and Oceania seem to be sub-optimal according to climatic suitability for killer shrimp establishment (Figure 1b, d, f). Only small regions in North Africa and South-East Australia can be perceived as more threatened in this regard.

As was expected, highest suitability for the killer shrimp represent Europe and North America (Figure 1a, c), the continents where killer shrimp is already present or was previously predicted to be introduced in future (Rewicz et al. 2014). In Europe, the most threatened region hitherto without occurrence of killer shrimp are Spain and Portugal. Moreover, there are overlooked regions with high probability of killer shrimp establishment in Asia including the Japanese Archipelago (Figure 1e).

Besides biological and genetic features, successful invasion of alien animal species depends not only on climatic conditions, but is determined by complex of various factors like resource availability, stability or disruption of the environment, propagule pressure, and many other biotic and abiotic factors (Stohlgren and Schnase 2006 and citations therein). It follows that climate matching is to a certain degree an estimation and therefore the reality can occasionally be different. This is the reason why the killer shrimp successfully invaded England (MacNeil et al. 2010) which seems not serving so much possibilities to establish its wild populations in our modelling. Despite mentioned limitation, the method of climate matching is widely used and respected as appropriate tool to prediction of species invasions (Bomford et al. 2009, Kalous et al. 2015).

CONCLUSION

In light of the fact that killer shrimp is listed as one of the 100 worst alien species in Europe and has been cited as a species constituting a high risk in terms of spread, establishment and environmental threat in global scale, our findings poses a contribution for conservationists, policymakers and other stakeholders who engages in wild life management. We strongly recommend adding of killer shrimp into the Black List of European Union (Regulation 2016/1141) where this species surprisingly absents. Also aforementioned Asian regions should increase attention and ensure prevention of possible introduction of this “perfect invader”.

ACKNOWLEDGEMENTS

The research was financially supported by the Internal Grant Agency of the Czech University of Life Sciences Prague “CIGA” (No. 20152007).

REFERENCES


