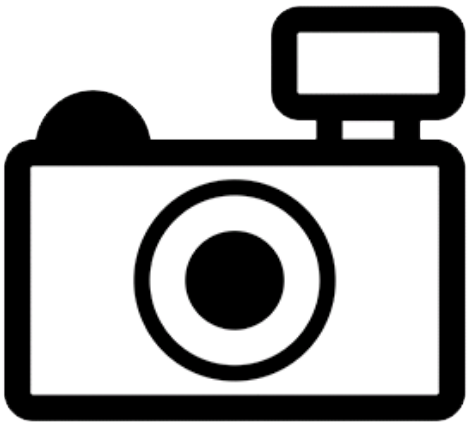
Demon Shrimp (*Dikerogammarus haemobaphes*)

Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, September 2016
Revised, January 2018
Web Version, 7/6/2018



No Photo Available

1 Native Range and Status in the United States

Native Range

From Baker et al. (2015):

"Ponto-Caspian basin"

Status in the United States

From Baker et al. (2015):

"Not established in North America, including the Great Lakes"

Means of Introductions in the United States

From Baker et al. (2015):

"Not established in North America, including the Great Lakes"

Remarks

From Baker et al. (2015):

"Common Name: Scud"

"Synonyms and Other Names:
Small-humped scud, *Dikerogammarus villosus balatonicus* Ponyi, *Gammarus haemobaphes*"

From CABI (2017):

"Preferred Common Name
demon shrimp"

From Aldridge (2013):

"Historically, there has been some confusion with the identity of the *Dikerogammarus* spp. across Europe. *D. haemobaphes* appears to be synonymous with *Dikerogammus fluviatilis* (Jazdzewski, 1980). Molecular studies by Muller et al. (2002) has confirmed the taxonomic status of three distinct species: *D. haemobaphes*, *D. villosus*, *D. bispinosus*."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From GBIF Secretariat (2018):

"Kingdom Animalia
Phylum Arthropoda
Class Malacostraca
Order Amphipoda
Family Gammaridae
Genus *Dikerogammarus* Stebbing, 1899
Species *Dikerogammarus haemobaphes* (Eichwald, 1841)"

"SPECIES ACCEPTED"

Size, Weight, and Age Range

From Baker et al. (2015):

"Adult male: average 16 mm (range 9-21 mm); adult female: average 11 mm (range: 7-15 mm); stage 2 egg: average 0.43 mm (Bacela et al. 2009, Kinzler et al. 2009)."

"Size: to 21mm"

Environment

From Baker et al. (2015):

"Although Grigorovich et al. (2003) listed *D. haemobaphes* as occurring naturally in waters of 17 ppt salinity, this species is most likely restricted to 0-8 ppt (Ponomareva 1976). It is most commonly found near mouths of freshwater rivers (typically 1-1.5 PSU, practical salinity units) than in more saline waters (2-8 PSU) (Grabowski et al. 2006; Jazdzewski et al. 2002, 2004, 2005). The lethal minimum oxygen concentration for *D. haemobaphes* is 0.345 mg O2/L; while such conditions are considered hypoxic, several other Ponto-Caspian amphipods invaders in the Baltic Sea can tolerate even lower oxygen concentrations (Dedyu 1980)."

Climate/Range

From Baker et al. (2015):

"It is able to tolerate a relatively wide temperatures range (6-30°C) (Kiticyna 1980)."

It is unknown whether the above temperature range refers to air or water.

Distribution Outside the United States

Native

From Baker et al. (2015):

"Ponto-Caspian basin"

Introduced

According to DAISIE (2016), *D. haemobaphes* has been introduced to Belgium (current status unknown), the European part of Russia (current status unknown), France (established but cryptogenic), Germany (established), Poland (established), Switzerland (established), and Ukraine (no information on status).

From Aldridge (2013):

"It was found [in the U.K.] in preserved samples collected on 14th May 2012 from the River Severn at Tewkesbury […]. Preserved material collected on the same date yielded more specimens from the River Severn at Cheltenham […]. Subsequent field surveys up to 12 November 2012 revealed *D. haemobaphes* in The River Severn and Trent catchments and associated canals; these locations are spread over a wide area and give an indication of the potential extent of the population. The species has also been found at sites on the Foss Dyke, on the River Witham in Anglian Region and over a 12km reach of the Thames"

"The species has invaded much of Western Europe. It was first reported outside its native Ponto-Caspian range in Lake Balaton, Hungary, in 1955 after which it continued to spread along the Southern Corridor (connecting the Danube and Rhine rivers) (Bij de Vaate et al., 2002). The first record for the upper Danube in Germany was 1976, followed by observations in the Main-Danube Canal in 1993 (Schleuter et al., 1994), the German Rhine in 1994, and the Dutch Rhine

in 2000 (Bij de Vaate et al., 2002). The species also spread along the Central Corridor (connecting the rivers Dneiper, Vistula, Elbe and Rhine), with first records in the Vistula, Poland, in 1997 (Konopacka, 1998)."

Means of Introduction Outside the United States

From Baker et al. (2015):

"*Dikerogammarus haemobaphes* has been proposed to be able to survive partial to complete ballast water exchange due to one reported natural occurrence in 17 ppt salinity waters (Grigorovich et al. 2003)"

"It was intentionally stocked in large European rivers prior to the 1970s to enhance the fish fauna (Karpevich 1975, Jazdzewski 1980, bij de Vaate et al. 2002)."

"*Dikerogammarus haemobaphes* was first observed in a non-native location in 1976, when it migrated up the Danube River through the southern corridor and arrived in the German section of the upper Danube (Tittizer 1996). It was subsequently observed in the Main-Danube canal in 1993 (Schleuter et al. 1994), through which it migrated to the North Sea basin via the Rhine River (Schöll et al. 1995). In 1997, this species was first discovered in Poland in the Vistula River (Konopacka 1998). Around this time, it was also discovered in the Notec and Bug rivers, tributaries of the Oder and Vistula rivers, respectively (Jazdzewski and Konopacka 2000, 2002; Jazdzewski et al. 2002). *Dikerogammarus haemobaphes* was observed in the central and southern corridors of the Volga River, as well as the upper Volga basin, for the first time around the year 2000 and quickly became abundant (L'vova et al. 1996, Jazdzewski et al. 2004). It is now also present in the Great Masurian Lakes (Jazdzewski 2003) and in a small mesotrophic lake in the Vistula valley (Grabowski and Bacela 2005)."

From Jazdzewski et al. (2002):

"[…] in European waters, after breaking physical barriers, migrations through canals and along the brackish Baltic Sea littoral waters were the most important way of range extensions [of alien gammarid species]."

"The construction of canals connecting different drainage areas is one of the fundamental reasons of the penetration of particular species into sometimes distant regions. Another factor, often connected with the former one, are intentional introductions of species aimed at the enrichment of fish food resources (Karpevich 1975, Arbaciauskas 2002)."

"One should consider of course, also the possibility of introductions of alien gammarids, for instance by the transfer of aquatic plants […]"

"The ballast water transport also cannot be excluded as a factor accelerating gammarid range extensions and, in the case of transatlantic invasions of freshwater or oligohaline species […] such transport seems to be the major possibility."

From Aldridge (2013):

"The discovery of specimens in two canals adjacent to the River Severn, separated by many locks, suggests it may be distributed with boat traffic. The association of the species with macrophytic vegetation (Musko, 1990) suggests that overland transport may be possible on contaminated outboard engines and fishing gear."

Short Description

From Baker et al. (2015):

"*Dikerogammarus haemobaphes* has a laterally compressed, curled, and semi-transparent whitish body consisting of a head (cephalon), thorax (pereon), and abdomen. Its head contains one pair of eyes, mouthparts (gnathopods), and two pairs of antennae, each with peduncle (broad stalk, connected to head) and flagellum (narrow, outer tip). Its pereon consists of seven segments, each with a pair of walking legs (pereopods). Its abdomen consists of six segments divided into two three-segment parts: pleosome (anterior) with brush-like limbs known as pleopods, and urosome (posterior) with shorter, immobile rod-like limbs called uropods."

"This species can be distinguished from other *Dikerogammarus* species by morphological features of the second (lower) pair of antennae and of the first and second urosomal segments. In *D. haemobaphes*, the peduncle and flagellum of antenna 2, as well as the gnathopods, are characterized by short bristles rather than dense, long bristles. Urosomes 1 and 2 of *D. haemobaphes* have a shallow dorsal protuberance tipped with two spines instead of the pointed dorsal protuberance seen in other species of *Dikerogammarus*. Additionally, in contrast to the morphologically similar *D. villosus*, no color variation is exhibited by this species (Müller et al. 2002). However, these distinguishing features apply mainly to adult males and are less diagnostic in females and juveniles."

Biology

From Baker et al. (2015):

"*Dikerogammarus haemobaphes* is euryoecious (adapted to varied ecological conditions), preferring to inhabit solid substrates, macrophytes, and filamentous algae in large rivers and lakes (Kiticyna 1980, Muskó 1994)."

"*Dikerogammarus haemobaphes* is a dietary generalist (bij de Vaate et al. 2002), feeding on detritus, sediments, unicellular and filamentous algae, and other small crustaceans. Its predation intensity on animal food sources such as chironomids, oligochaetes, crustaceans, and mayflies increases during the summer months when water temperatures are higher (van der Velde et al. 2009). Cannibalism within this species is significantly higher (~50%) than that of other European gammarid species (Kinzler et al. 2009)."

"*Dikerogammarus haemobaphes* is frequently found in association with another Ponto-Caspian mass invader, *Dreissena polymorpha*, preferring to settle on living zebra mussel shells over other substrate types (Kobak et al. 2009, Muskó 1993, bij de Vaate et al. 2002, Wawrzyniak-Wydrowska and Gruszka 2005). Dreissenid shell surface properties are thought to attract *D.*

haemobaphes, with a distinct preference shown for living mussels over empty shells as well as clean shells over varnished shells (Kobak et al. 2009). Additionally, the living mussel shells serve as a better habitat for prey items, including chironomids (Botts et al. 1996, Mörtl and Otto-Rothhaupt 2003, Ricciardi et al. 1997, Stewart et al. 1998)."

"The reproductive period of *D. haemobaphes* lasts from April to October, with the production of spring, summer, and autumn (overwintering) generations, each with 3-5 cohorts (Bacela et al. 2009, Mordukhai-Boltovskoi 1949). The autumn (overwintering) generation begins to reproduce in April, and by mid May its progeny (spring generation) appear. At this point, population size structure is strongly bimodal due to the presence of the parental generation. In June, the spring generation begins to reproduce and the autumn generation dies off. In early July, the summer generation is released and rapidly matures, giving rise to the next autumn generation. As in many other gammarid species, mean size of mature individuals, mean size of breeding females, and fecundity declines over subsequent generations (autumn to spring to summer) (Bacela et al. 2009, Kura[n]dina 1975, Muskó 1993)."

"Male to female sex ratios are generally close to 1:1, with intersex individuals (able to both lay and fertilize eggs in a brood pouch) representing roughly 1% of the population (Bacela et al. 2009). […] Clutch size varies from 5 to 128 eggs, with mean estimates ranging from 20-52 eggs (Bacela et al. 2009, Briskina 1950, Gudkova and Melnikova 1969, Kiticyna 1980, Kurandina 1975, Muskó 1993). Clutch size has been observed to increase with female body length according to a log-linear relationship, with both clutch and body size varying in different habitats (e.g., mean brood sizes of 35 and 52 in river and reservoir populations, respectively) (Bacela et al. 2009). The partial fecundity index (mean clutch size/female size) for *D. haemobaphes* reported in this same study is relatively high, with values of 3.3 for river females and 4.3 for reservoir females. These variations in size and fecundity based sampling location are possibly due to differences in predation pressure and/or hydrological conditions such as water velocity (Adams et al. 1989)."

Human Uses

From Baker et al. (2015):

"*Dikerogammarus haemobaphes* constitutes a food base for perches, gobies, and eels (Grabowska and Grabowski 2005; Kelleher et al. 1998, 2000; Kostrzewa and Grabowski 2003). It was intentionally stocked in large European rivers prior to the 1970s to enhance the fish fauna (Karpevich 1975, Jazdzewski 1980, bij de Vaate et al. 2002)."

Diseases

From Baker et al. (2015):

"*D. haemobaphes* is a vector of gregarines, a group of unicellular parasites that infect the intestines of invertebrates (Codreanu-Balcescu 1995). However, the transfer of these parasites to native species is unknown (Grabowski et al. 2007b)."

No OIE-reportable diseases have been documented for this species.

Threat to Humans

From Baker et al. (2015):

"There is little or no evidence to support that *Dikerogammarus haemobaphes* has the potential for significant socio-economic impacts if introduced to the Great Lakes."

3 Impacts of Introductions

From Baker et al. (2015):

"*D. haemobaphes* has outcompeted and displaced native European gammarids, but it has also experienced declines in European waterways following expansion of the related invasive amphipod *Dikerogammarus villosus* (Jazdzewski et al. 2004, 2005; Kinzler et al. 2009)."

"Upon introduction to new waterways, *D. haemobaphes* has outcompeted native European gammarids, including displacing *Chaetogammarus ischnus* in the lower Vistula Lagoon (Jazdzewski et al. 2004, 2005)."

From Olenin et al. (2010):

"Ecological impact: community dominance (Jazdzewski et al. 2004; Jazdzewski, Konopacka 2002; Wawrzyniak-Wydrowska, Gruszka 2005), competition (Jazdzewski et al. 2004), food-prey"

From Jazdzewski et al. (2002):

"[…] *D. haemobaphes* has conquered nearly the entire Vistula river, occurring usually as an only gammarid species as far upstream as about 100 km below Cracow."

"Populations of native gammarid species […] were only recorded in some tributaries."

"Serious studies on the ecological impact of alien [gammarid] species upon the native fauna in the Vistula and Oder systems are still not undertaken. Quantitative studies on the fish and invertebrates diet are urgently needed to estimate this impact."

From Grabowski et al. (2006):

"During the last decades of the twentieth century, the alien gammarid species *Gammarus tigrinus*, *Dikerogammarus haemobaphes*, *Pontogammarus robustoides* and *Obesogammarus crassus* invaded the lower Vistula River and its deltaic, partly brackish regions. In brackish waters of the Vistula Lagoon the native Atlantic-boreal species *Gammarus zaddachi* and *Gammarus duebeni* have been replaced or at least outnumbered by the aliens. As compared to our earlier studies, through the years 1998–2004 we could observe nearly total decline of the native gammarid populations along the coasts of the Lagoon, and overdomination of the North-American *G. tigrinus* in most places."

"Generally, all sampling sites in the southern part of the Lagoon were clearly overdominated by PontoCaspian aliens: *O. crassus* and *P. robustoides* in most cases and by *D. haemobaphes* near the freshwater mouth of Nogat, with North-American *G. tigrinus* also being quite abundant."

From Jazdzewski et al. (2004):

"At the beginning of the 20th century, in the freshwater flow of the Vistula River, the native *G. pulex* (and possibly also *G. varsoviensis*) was replaced by the Ponto-Caspian invader, *C. ischnus*. By the end of the millennium, a new Ponto-Caspian invader, *Dikerogammarus haemobaphes*, using the same corridor (i.e. the Pripet-Bug canal), had to a large extent replaced *C. ischnus*, the former being now the dominant species in the lower Vistula (including its deltaic area) and also having entered the Vistula Lagoon at least its saline part."

From Bacela-Spychalska and Van der Velde (2013):

"We found the adults of *P. robustoides* and *D. haemobaphes* to be much more effective predators than those of *G. fossarum*. Chironomid larvae and oligochaetes were most heavily preyed upon; these animals are relatively easy to catch as they are not very mobile and are buried in the substratum. Although our experiment did not use any type of substratum, these Ponto-Caspian gammarids are known to dig into the substratum, so hidden prey can easily be caught (Zaiko & Olenin, 2004; Platvoet et al., [2009]; Poznanska et al., 2012). Feeding on nutritious (in terms of energy and nutrients) and vulnerable prey results in rapid growth and early maturity, as well as in high fecundity. All of this leads to a rapid population growth by the invasive species, which can result in other taxa being outcompeted for resources, such as shelter against predators (Van Riel et al., 2007; Platvoet et al., [2009]). Hence, if these Ponto-Caspian species coexist with the native *G. fossarum*, the indigenous species may be outcompeted (Bacela & Konopacka, 2005; Bacela et al., 2009)."

"As yet we cannot draw direct conclusions about the impact of *P. robustoides* and *D. haemobaphes* on invaded communities, but both species are known to have established very abundant populations at invaded sites (Bacela & Konopacka, 2005; Grabowski et al., 2007[b]). Based upon the studies showing the dramatic influence of *D. villosus* on colonised assemblages via predation (e.g. Dick & Platvoet, 2000; Krisp & Maier, 2005; MacNeil & Platvoet, 2005; Van Riel et al., 2006; Platvoet et al., [2009]; Van der Velde et al., 2009; Stoffels et al., 2011), as well as by its other biological traits (Grabowski et al., 2007a; Pöckl, 2009), we may also expect such strong pressure from the two Ponto-Caspian species used in our study. They occupied a similar trophic position as *D. villosus*, being equally effective predators. Further, they have a similarly high fecundity, each has three to four generations per year and matures fast (summarised in Bacela et al., 2009). In addition, they are the equally tolerant to environmental conditions (summarised in Grabowski et al., 2007a). These two species, disturbing balance in the invaded communities, could also have an influence on key ecosystem processes, such as leaf decomposition, as has been already demonstrated in the case of the 'killer shrimp' (MacNeil et al., 2011; Piscart et al., 2011)."

From Constable and Birkby (2016):

"In these experiments, we showed that the leaf shredding activity of the invasive amphipod *D. haemobaphes* was notably lower than the native amphipod *G. pulex*. […] This is supported by Bacela-Spychalska and van der Velde (2013), who examined amphipod food preference and diets, and observed that *D. haemobaphes* consumed no decaying plant material and favoured live prey (chironomids and oligochaetes). A potential consequence of the significant disparity in leaf litter consumption between *D. haemobaphes* and *G. pulex* could be a considerable reduction in leaf litter breakdown and recycling within rivers, in situations where the invading species displaces the native. […] This displacement of the native could therefore have a significant impact on leaf litter recycling, which is important for facilitating nutrient and energy transfer to the wider food web (Vannote et al. 1980)."

"In the presence of *D. haemobaphes*, a tendency towards decreased leaf litter consumption by *G. pulex* was observed […] The results indicated a mild impact on *G. pulex* shredding efficiency, which might be a response to predator avoidance creating a trade-off between feeding and risk of predation (Pettersson and Brönmark 1993; Viherluoto and Viitasalo 2001)."

"Although *D. haemobaphes* is known to be a predator (Kinzler et al. 2009; Bovy et al. 2015), our experiment showed a small but non-significant predation impact upon *G. pulex*."

4 Global Distribution

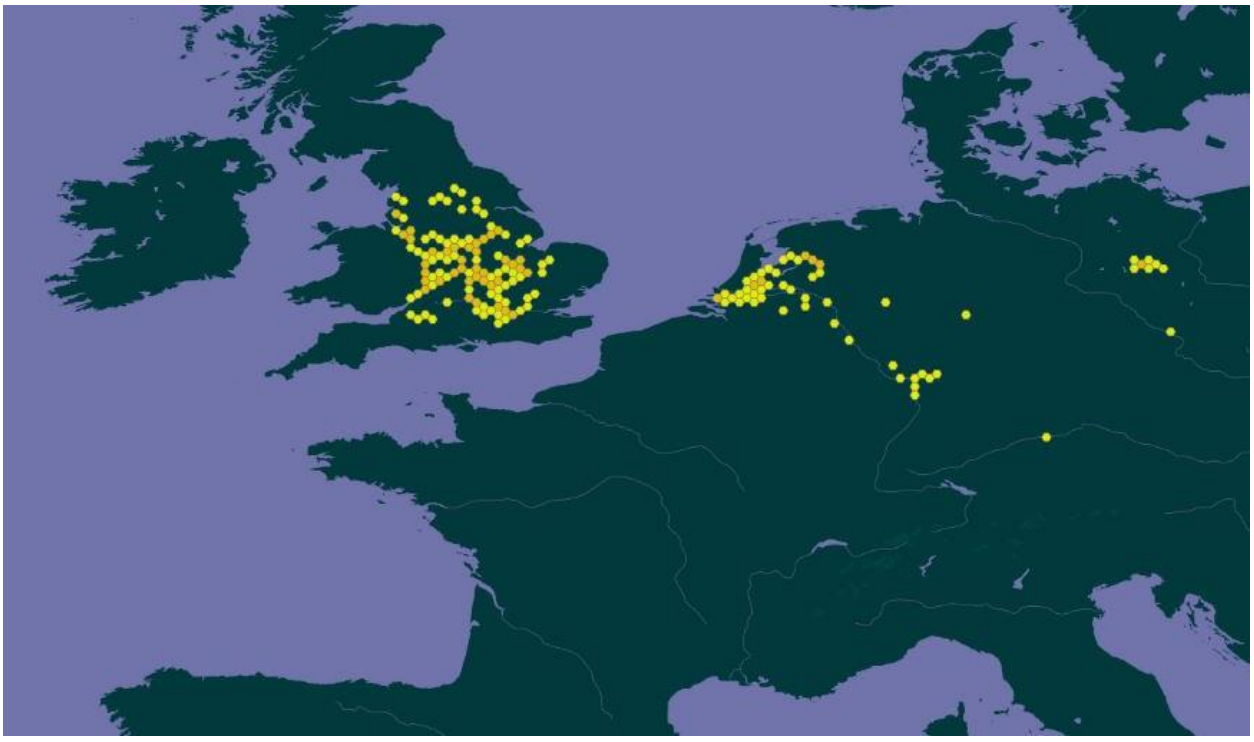


Figure 1. Known global distribution of *Dikerogammarus haemobaphes*, reported from the United Kingdom and northern continental Europe. Map from GBIF Secretariat (2018). Location in the Baltic Sea was excluded from the extent of this map because it was incorrectly located.

5 Distribution Within the United States

This species has not been reported in the United States.

6 Climate Matching

Summary of Climate Matching Analysis

The Climate 6 score (Sanders et al. 2014; 16 climate variables; Euclidean distance) for the Continental U.S. was 0.032, which is a medium match. The climate match was high in Michigan, New York, Ohio, and Pennsylvania. An area of medium-high climate match was located near the Great Lakes. The climate match was low along the Gulf and West Coasts. The climate match was medium to low across most of the interior U.S.

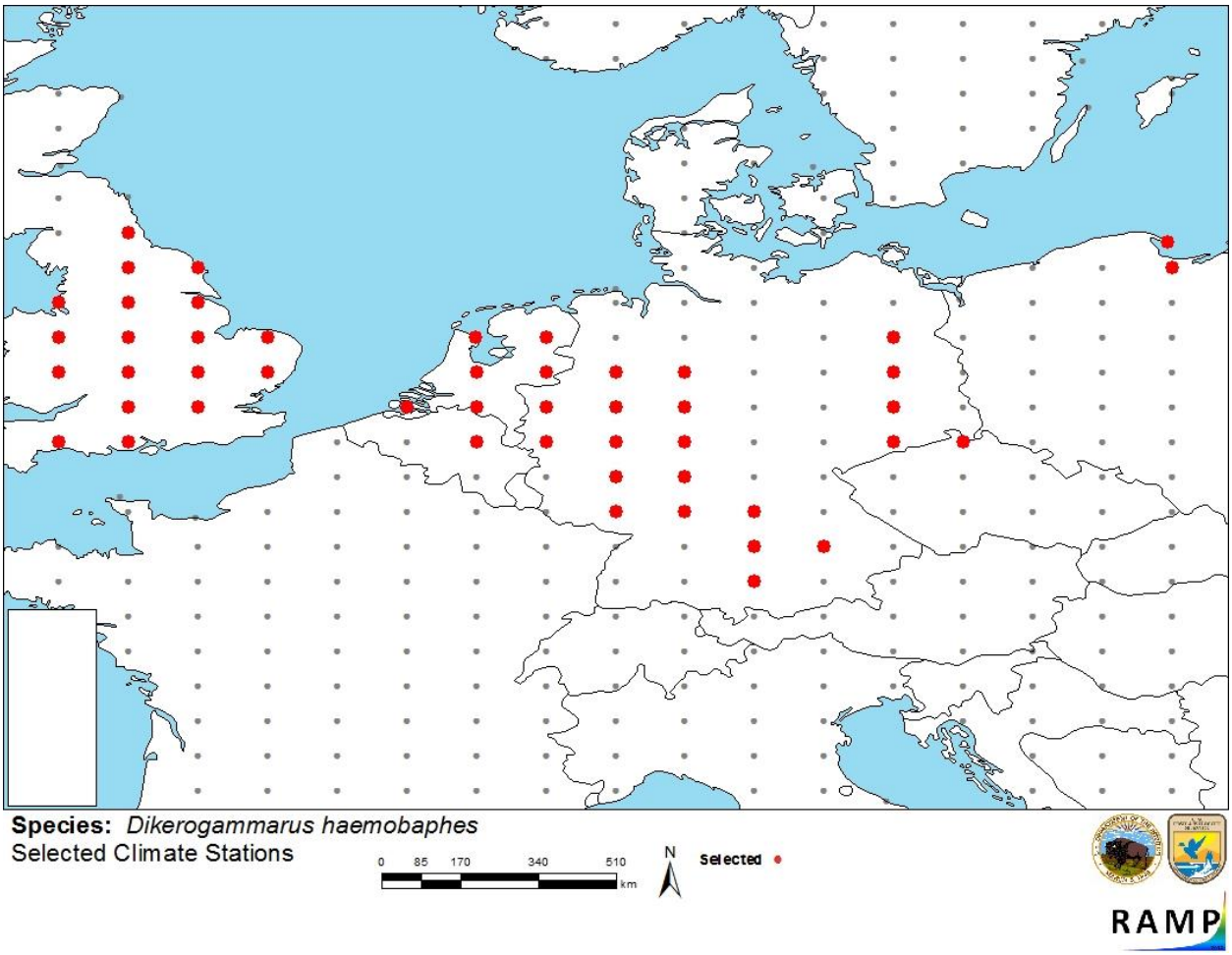


Figure 3. RAMP (Sanders et al. 2014) source map showing weather stations in Europe selected as source locations (red; United Kingdom, Belgium, Netherlands, Germany, Czech Republic, Poland) and non-source locations (gray) for *Dikerogammarus haemobaphes* climate matching. Source locations from GBIF Secretariat (2018).

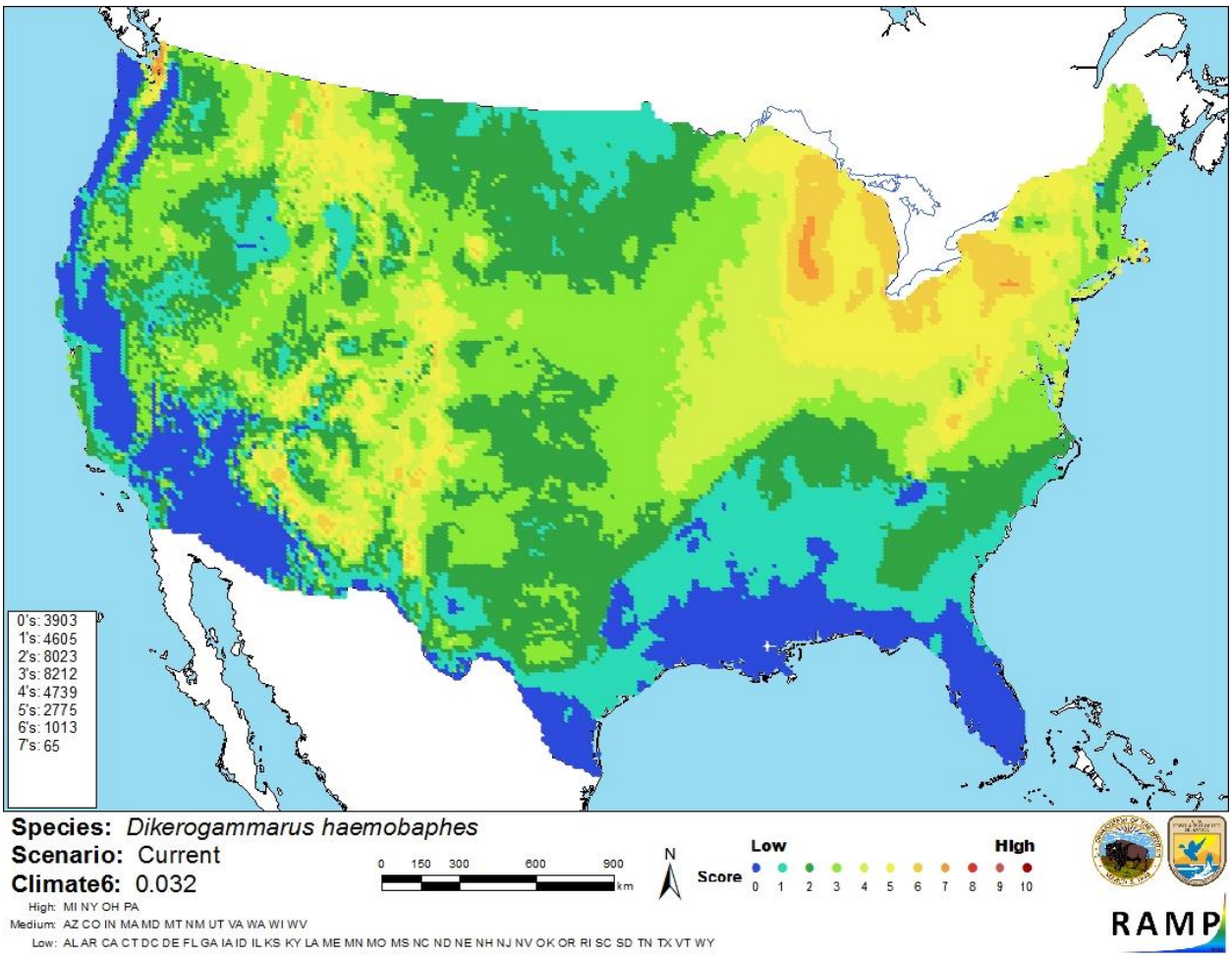


Figure 4. Map of RAMP (Sanders et al. 2014) climate matches for *Dikerogammarus haemobaphes* in the contiguous United States based on source locations reported by GBIF Secretariat (2018). 0= Lowest match, 10=Highest match. Counts of climate match scores are tabulated on the left.

Climate 6: Proportion of (Sum of Climate Scores 6-10) / (Sum of total Climate Scores)	Climate Match Category
0.000≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

7 Certainty of Assessment

The peer-reviewed literature on *D. haemobaphes* is dominated by research on species distribution and abundance in its introduced range, with relatively little research completed on ecological impacts of introduction. At the same time, *D. haemobaphes* is a recent invader in parts of Europe, so its distribution may still be expanding and some established locations may have yet to be reported. Little distributional information is available for the species native range. For these reasons, the certainty of this assessment is medium.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Dikerogammarus haemobaphes has expanded its range through several European countries in recent decades. In some areas, the species has displaced native amphipods and a recent study from Great Britain showed potential for *D. haemobaphes* invasion to influence leaf litter breakdown and nutrient cycling in streams. Climate match to the contiguous U.S. is medium, with highest climate match occurring in the Great Lakes region. Overall risk for this species is high.

Assessment Elements

- **History of Invasiveness (Sec. 3): High**
- **Climate Match (Sec.6): Medium**
- **Certainty of Assessment (Sec. 7): Medium**
- **Remarks/Important additional information: Often associated with *Dreissena polymorpha* (zebra mussel).**
- **Overall Risk Assessment Category: High**

9 References

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in Section 10.

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Note: The following references are cited within quoted text within this ERSS, but were not accessed for its preparation. They are included here to provide the reader with more information.

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