Prospects for breeding North American freshwater catfishes (Ictaluridae) of the genus Ameiurus in European aquaculture facing climate change

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INTRODUCTION

Freshwater catfishes (Ictaluridae) are considered promising models for aquaculture facing current climate change due to their ability to thrive in small reservoirs and even in puddles, calmly endure various pollution, lack of oxygen, high concentrations of carbon dioxide, high temperature of about +37.5 °C and survive under adverse conditions by burrowing into the mud. Their juveniles feed on Chironomidae larvae and other invertebrates, serving as biological controls of blood-sucking insects carrying numerous disease agents. However, the question of the invasive potential of these species originated from America on native European fauna remains unclear. Special concern is raised for small water bodies where amphibians, fish and even larger reptiles like the *Emys orbicularis* (Linnaeus, 1758) may suffer from predation by catfish.

In this study, we focus on two Ictaluridae species:

1.The brown bullhead ***Ameiurus nebulosus*** Lesueur, 1819 with its natural range covering North America: the Atlantic basin from New Brunswick (Canada) to Alabama (USA), as well as the Great Lakes basin. This freshwater industrial demersal fish, up to 55 cm in length and up to 2 kg in weight, was introduced to many countries of Europe, in particular to Ukraine. Thanks to its ability to feed on wide list of bottom invertebrates and rarely – vertebrates, and to exist in fairly poor water it has become an invasive species throughout Europe.

2.The black bullhead ***Ameiurus melas*** Rafinesque, 1820 with the natural range covering North America from the Great Lakes basin to northern Mexico, which was introduced in Europe, and Ukraine in particular, as a part of aquaculture. This freshwater industrial demersal fish, being up to 66 cm long, also enriched the list of invasive species in Europe.

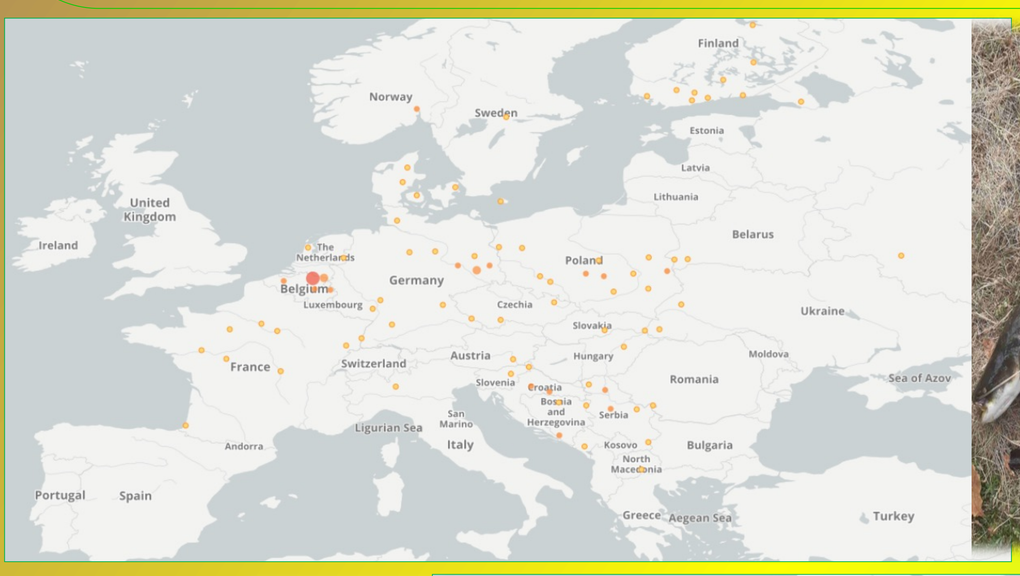

Fig. 1. *A. nebulosus* registration points obtained from GBIF and used for the study (https://doi.org/10.15468/dl.p8bypd).

Fig. 2. *A. melas* registration points obtained from GBIF and used for the study (https://doi.org/10.15468/dl.aarrev).

MATERIALS AND METHODS

To study the prospects for the development by 2050 of aquaculture of catfish of the genus Ameiurus in Europe, we used the GBIF database, literature sources and personal observations for *A. nebulosus* (4220 points, Fig. 1) and *A. melas* (5787 points). We used species distribution bioclimatic modeling Maxent software (25 replicates, test 25%). Of the 35 CliMond bioclimatic variables (https://www.climond.org/ for current, and 2050, average) we selected 16 that were the least correlated. To account for sampling bias, we used the nearest neighbor distance ('ntbox' package in R; Osorio-Olvera et al., 2020) method for thinning the data. Occurrence points that were ≤0.1 units away from each other were removed to avoid errors due to spatial autocorrelation. Modeling and calculations were carried out using Maxent v3.3.3 software with 25 replicates (Phillips 2005)

After creating models of catfish distribution in Europe, we went through all the stages of model fitting, assessment (AUC>0.85) and prediction.

RESULTS AND DISCUSSION

It was found out that potentially suitable area for *A. nebulosus* is 2 times larger than for *A. melas* (a more southern species). In Eastern Europe, catfish have more promising territories in the basin of large rivers (i.e. the Dnieper, Danube rivers). For both species, the Highest weekly radiation (Bio21) factor turned out to be the most important. However, we have identified trends that are common for most invasive aquatic species in Europe – a shift in fish range by more than 300 km to the North of Europe (to the Baltic countries) by 2050. The fact that the possibility of the emergence of potentially suitable territories on the Scandinavian Peninsula is of particular interest. This prediction is supported by recent records of these catfish in northernmost countries such as Finland. Moreover, the perspective territories are quite similar for both brown and black bullhead (R2=58%) while the number of possible joint territories will increase over time by 64%.

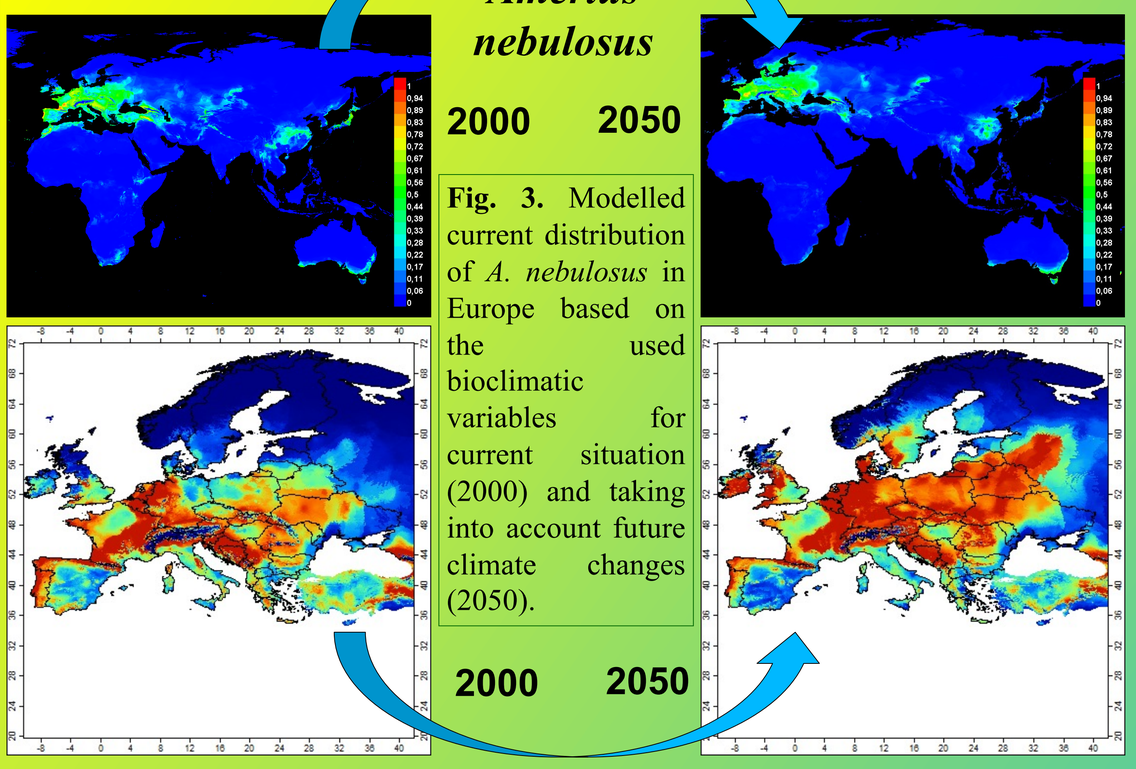

Fig. 3. Modelled current distribution of *A. nebulosus* in Europe based on the used bioclimatic variables for current situation (2000) and taking into account future climate changes (2050).

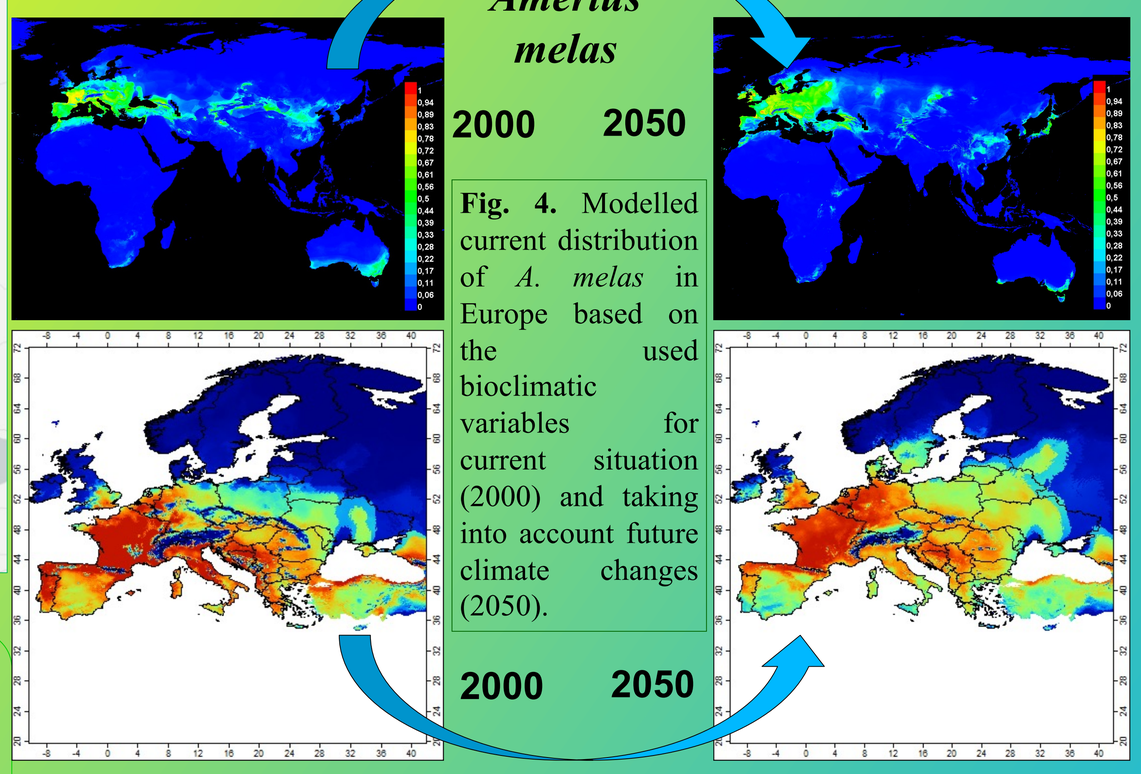

Fig. 4. Modelled current distribution of *A. melas* in Europe based on the used bioclimatic variables for current situation (2000) and taking into account future climate changes (2050).

Therefore, our results suggest that in the nearest future catfish may be quite promising objects for aquaculture in Northern and Eastern Europe. However, such shifts of the range to the north are observed in many native species of amphibians and aquatic reptiles, and therefore their encounter with such unpretentious invasive species in the north of the range, where they are most vulnerable, is dangerous. Therefore, it is necessary to conduct long-term monitoring programs and prevent the spread of any type of catfish in the wild.

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