Aquaculture of Asian fish species *Ctenopharyngodon idella*: prospects for adaptation in Eastern Europe in the context of climate change

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INTRODUCTION

Object of the study: grass carp *Ctenopharyngodon idella* (Valenciennes, 1844). Typical habitat: freshwater; brackish; benthopelagic; 0-35 °C.
Subject of the study: distribution and its changes with changing climate.
Natural distribution: 50°N - 23°N, 100°E - 142°E; Asia: Eastern China and Russia in eastern Siberia, Amur River system. Several countries report adverse ecological impact after introduction.
Adults occur in lakes, ponds, pools and backwaters of large rivers, preferring large, slow-flowing or standing water bodies with vegetation. Tolerant of a wide range of temperatures from 0° to 38°C, and salinities to as much as 10 ppt and oxygen levels down to 0.5 ppm. Feed on higher aquatic plants and submerged grasses; takes also detritus, insects and other invertebrates. One of the world's most important aquaculture species and also used for weed control in rivers, fish ponds and reservoirs. Spawn on riverbeds with very strong current.

MATERIAL AND METHODS

In order to investigate the prospects for aquaculture of cyprinids in the north of Eastern Europe, we carried out GIS modeling of distribution *C. idella* on a global scale.

For modeling, we collected data on the distribution of *C. idella* fish – 2240 points (by filtering the occurrence data in advance: non-duplicate, no autocorrelation, Fig. 1). Distribution points were used not only from the natural area, but also used the data of introductions on other continents.

GIS modeling was used to explore the potential distribution of each species in the world. Modeling and calculations were carried out using Maxent v3.3.3 software with 25 replicates (Phillips 2005) and employing 35 bioclimatic variables (CliMond; Kriticos et al. 2014; https://www.climond.org/ (accessed 27 December 2020)).

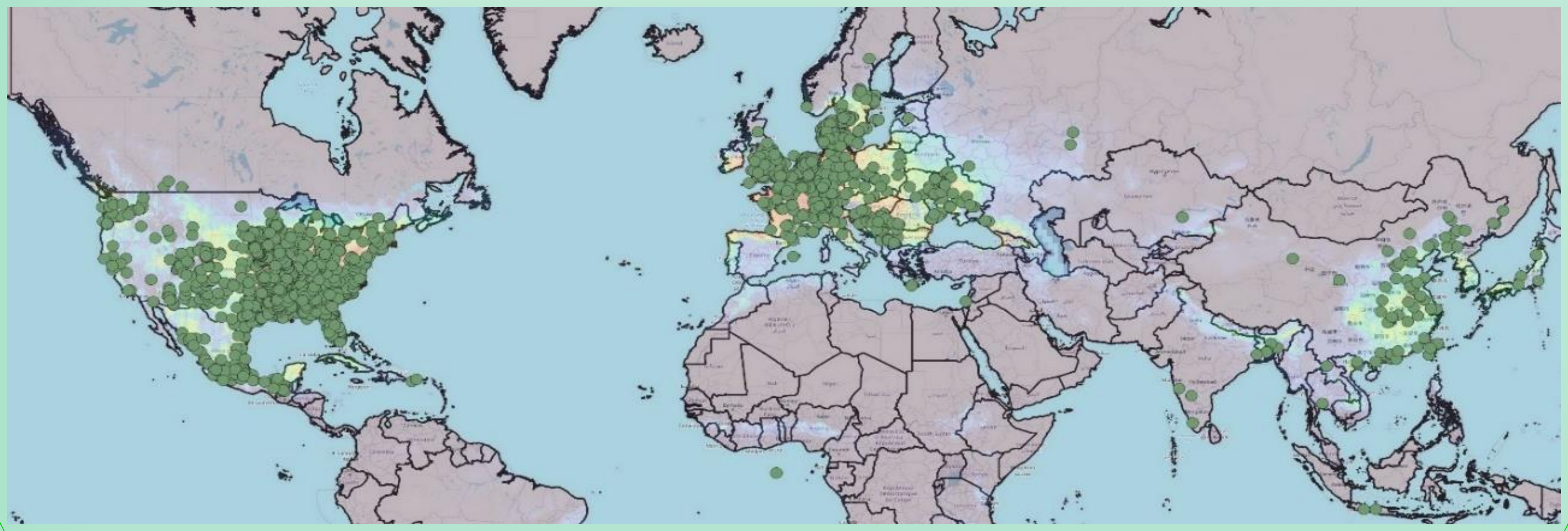

Fig. 1. Distribution of records of *C. idella* (2240 points).

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RESULTS AND DISCUSSION

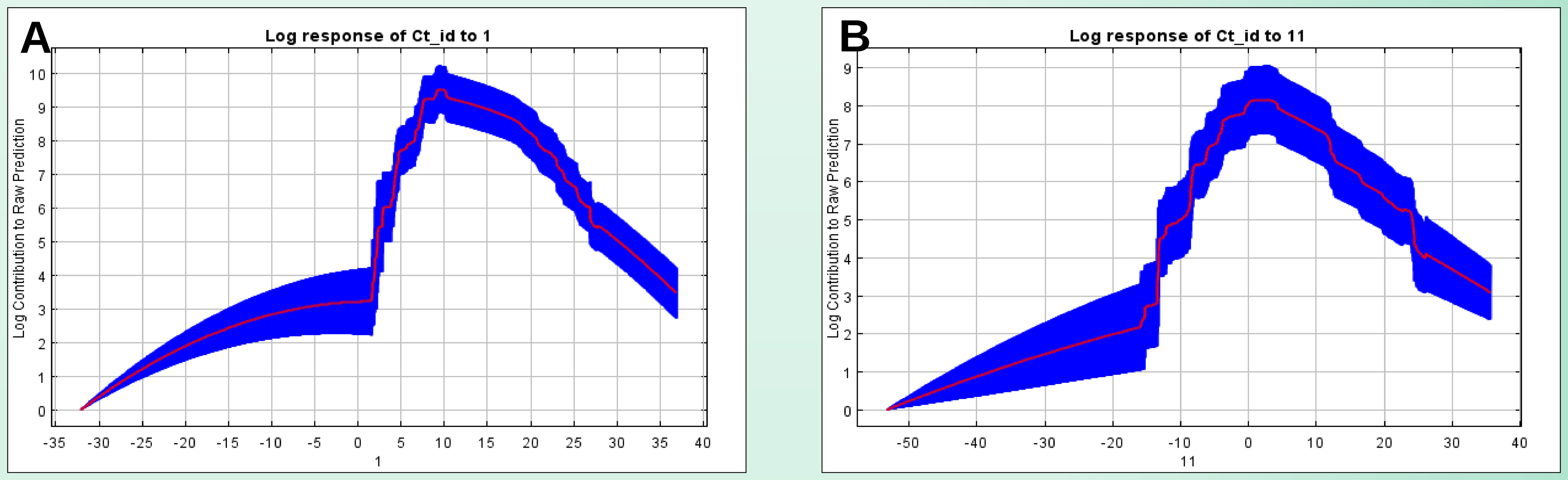

Fig. 2. Response curves generated by Maxent of *C. idella* for the variable: A) Bio1.Annual mean temperature (°C); B) Bio11.Mean temperature of coldest quarter (°C)

In terms of discrimination accuracy the Maxent model (CliMond) showed acceptable performance: AUC=0.92.

The distribution of this species around the world is influenced by the most important 6 factors out of 35 (CliMond). Especially important is the factor associated with Bio1Annual mean temperature (°C) – 29.5% contribution due to the fact that reproduction and growth of juveniles depends on warm water (Table 1).

Table 1. Results of modeling the spread of *C. idella* (CliMond, Maxent).

Bioclimatic Variable	Percent contribution	Permutation importance
Bio1. Annual mean temperature (°C)	29.5	34.5
Bio17. Precipitation of driest quarter (mm)	13.9	0.7
Bio14. Precipitation of driest week (mm)	9.5	0.6
Bio27. Radiation of coldest quarter ($W\ m^{-2}$)	8.5	3.1
Bio4. Temperature seasonality (C of V)	6.5	3.1

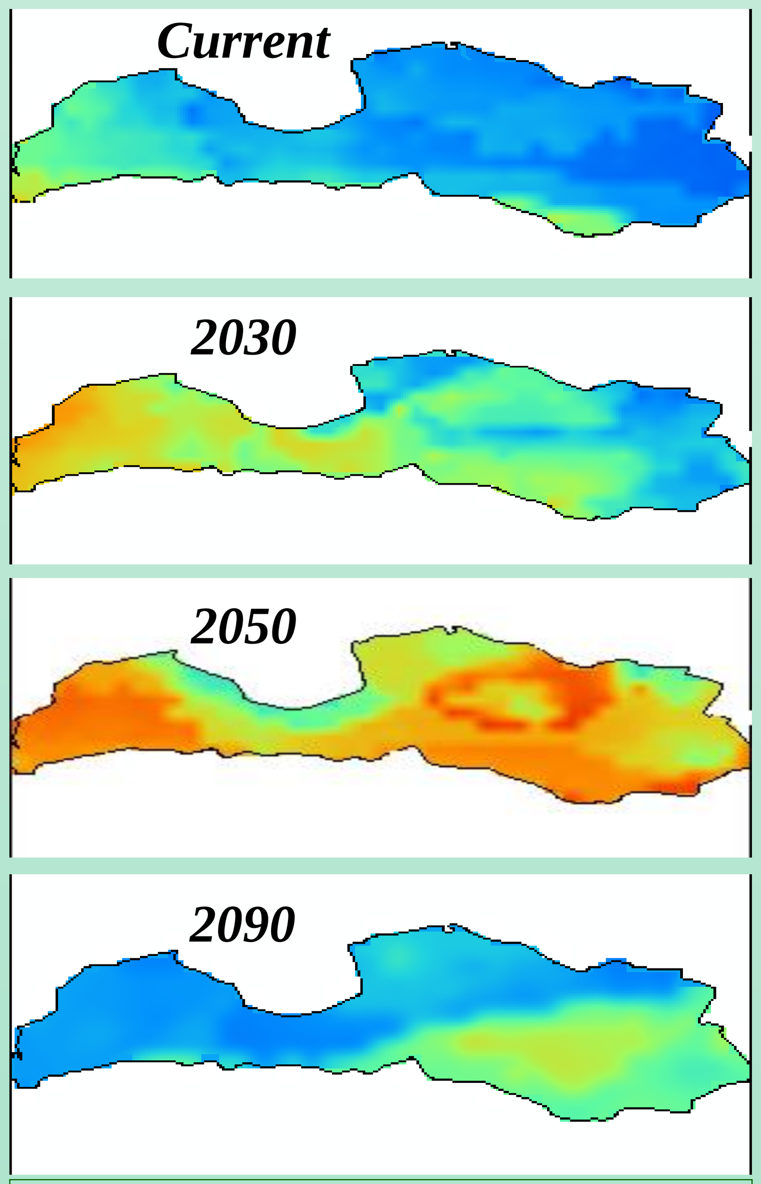

Fig. 4. Potential (probabilistic) model of *C. idella* expansion built in the Maxent program in Latvia of based on dataset CliMond (SAGA, red color > 0.5).

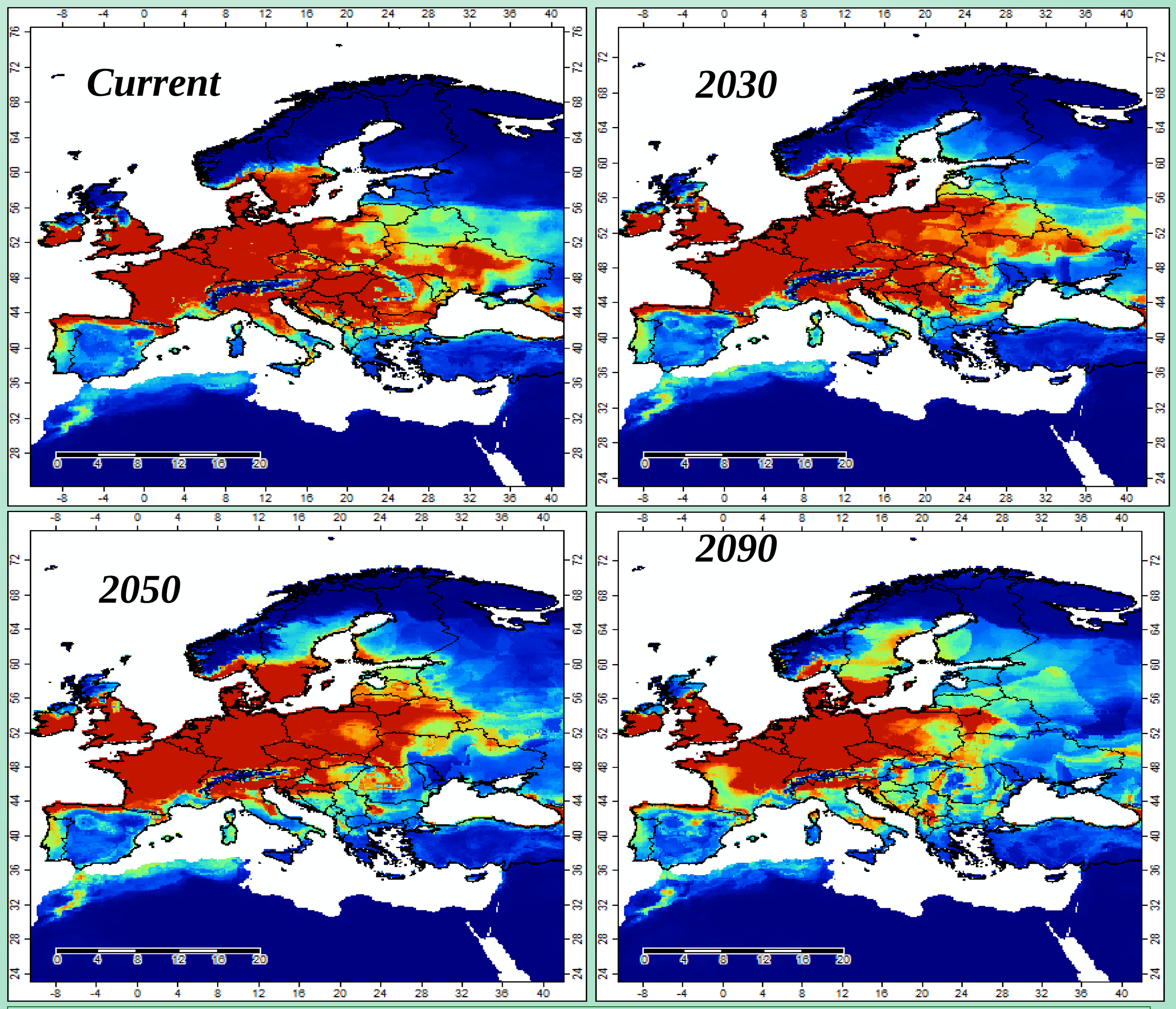

Fig. 3. Potential (probabilistic) model of *C. idella* expansion built in the Maxent program in Eastern Europe of based on dataset CliMond (SAGA, red color > 0.5).