diversity

MDPI

Article

Effects of Different Types of Agricultural Land Use on the Occurrence of Common Aquatic Bugs (Nepomorpha, Heteroptera) in Habitats with Slow Flowing Water in Bulgaria, Southeast Europe

Desislava Stoianova

Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, 1 Tsar Osvoboditel, 1000 Sofia, Bulgaria; d.st.stoianova@gmail.com

Abstract: Agricultural activities can have a significant impact on aquatic organisms, including aquatic insects. Most of the aquatic Heteroptera are known as moderately tolerant to low oxygen and high nutrient concentrations. Nevertheless, the complex effects of agriculture (source of both pesticides and nutrient loads) on this group are still unclear. Therefore, the relationship between six agricultural land use classes and the occurrence of common aquatic bugs in Bulgaria was studied. In order to avoid detection bias, presence-only models were applied; Maxent algorithm was used. According to the results, land use practices connected to arable land (annual crops) have stronger influence on the occurrence of the selected aquatic Heteroptera species than those connected to perennial crops (vineyards and fruit trees). Higher sensitivity to the effects of agriculture was indicated for species preferring microhabitats without macrophyte vegetation, *Aphelocheirus aestivalis* (Fabricius, 1794) and *Micronecta griseola* Horváth, 1899, compared to species preferring macrophyte dominated sites, *Nepa cinerea* Linnaeus, 1758, *Ilyocoris cimicoides* (Linnaeus, 1758) and *Sigara striata* (Linnaeus, 1758).

Keywords: eutrophication; pesticides; aquatic bugs; anthropogenic pressure; aquatic ecosystems; habitats; sensitivity

check for updates

Citation: Stoianova, D. Effects of Different Types of Agricultural Land Use on the Occurrence of Common Aquatic Bugs (Nepomorpha, Heteroptera) in Habitats with Slow Flowing Water in Bulgaria, Southeast Europe. *Diversity* **2023**, *15*, 292. https://doi.org/10.3390/d15020292

Academic Editors: Jader de Oliveira, Hélcio Reinaldo Gil-Santana and Luc Legal

Received: 28 January 2023
Revised: 11 February 2023
Accepted: 14 February 2023
Published: 17 February 2023

Copyright: © 2023 by the author. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Freshwater ecosystems are exposed to rapid environmental changes and are among the most endangered types of ecosystems worldwide [1]. The adverse effects of excessive nitrogen (N) and phosphorus (P) inputs are a major issue for water quality and ecosystem health [2,3]. Agricultural areas are among the main sources of nutrients in surface waters [4,5]. Intensive agriculture has strong influence on aquatic ecosystems, since nutrient inputs increase eutrophication [6,7]. Furthermore, agricultural areas are the major source of pesticide contamination of surface waters, which has been discussed as a major water quality problem in western Europe [8]. Thus, agricultural activities could have a significant impact on aquatic organisms, including aquatic insects [9–13]. Some groups of aquatic insects have been reported as sensitive indicators of long-term environmental changes in water and habitat quality [14]. In particular, the Ephemeroptera, Plecoptera, and Trichoptera (EPT group) species are considered good biological indicators in stream ecosystems [15]. Most of the aquatic Heteroptera (also called water bugs) have moderate tolerance to the decline in the ecological quality of water, in respect to oxygen and nutrients concentrations [16]. Following that notion, Nepomorpha representatives at the species or genus level have rarely been singled out as potential indicators in biomonitoring systems [17]. Nevertheless, significant differences in the sensitivity to organic pollution between taxa (lower than family) belonging to Nepomorpha have been well documented [18–22]. Additionally, the usage of species of the family Corixidae (Nepomorpha) as indicators of organic pollution has been proposed [21], and a methodology for water quality monitoring for lakes in Finland based on the species composition of genus *Micronecta* (Micronectidae, Nepomorpha) has been described [18]. In respect to the sensitivity of aquatic Heteroptera to the negative effects of chemical insecticides, a recent review [17] has shown that no general conclusions can be drawn based on the available data, exception being the connection between pesticide load and decline of species number. Therefore, effects of chemical insecticides, as well as the complex effects of agricultural activities (sources of both pesticide and nutrient loads) on aquatic Heteroptera need more attention.

Land use/cover variables have been among the most important factors determining the structure of Heteroptera assemblages in Greece, Southeast Europe [23]. It can be assumed that such variables, as the proportion of the area occupied by different land use classes, might be a useful approximation for the effect of agricultural land use on the occurrence of aquatic Heteroptera in Bulgaria, Southeast Europe.

In the present study, the relationship between agricultural land use and the occurrence of common aquatic bug species was analyzed with the following aims: (1) to determine whether agricultural land use impacts the occurrence of common aquatic bugs and if so, (2) which types of agricultural land use have the strongest effect, (3) and which of the target aquatic bug specie are most sensitive, in respect to their occurrence, to the effects of agricultural land use.

2. Materials and Methods

2.1. Study Area and Species Occurrence Data

Data on the occurrence of aquatic bugs was collected for all four basin districts on the territory of Bulgaria, belonging to two ecoregions: Danube River and Black Sea Districts, belonging to the Black Sea catchment and united as Ecoregion 12 (Pontic Province); East and West Aegean River Basin Districts–Ecoregion 7 (Eastern Balkans). The basin districts were delimited according to the Water Framework Directive 2000/60/EC (WFD), the ecoregions following Cheshmedjiev et al. 2010 [24]. According to the map presented on map A of WFD 2000/60/EC (www.eea.europa.eu, accessed on 11 February 2023) the Black Sea River Basin district follows in two ecoregions: its northern part in Pontic Province and its southern part, in the Eastern Balkans. Since such separation has not been based on biogeographical data [24], for the description of the study area here the ecoregions' boundaries proposed in Cheshmedjiev at al 2010 [24] were applied.

To control for the influence of habitat type on the occurrence of the species, the analysis was restricted to records of aquatic bugs collected from one habitat type, according to the European nature information system (EUNIS) classification–C2.3. Permanent non-tidal, smooth-flowing watercourses defined as "Permanent water courses with non-turbulent water and their associated animal and microscopic algal pelagic and benthic communities. Slow-flowing rivers, streams, brooks, rivulets and rills; also, fast-flowing rivers with laminar flow. The bed is typically composed of sand or mud.". The EUNIS habitat classification was chosen, since it is a comprehensive pan-European system, covering types of habitats from terrestrial to freshwater and marine; from natural to artificial (https://eunis.eea.europa.eu, accessed on 11 February 2023).

Only species with occurrence data for ten or more localities of the cited habitat type in Bulgaria were included in the following analysis.

Data on the occurrence of aquatic bugs were collected from two sources: 116 records based on published data about aquatic invertebrate composition in various water bodies in Bulgaria [25–31], 102 records based on materials part of the "Aquatic Invertebrates Collection" maintained by the Institute of Biodiversity and Ecosystem Research at the Bulgarian Academy of Sciences (IBER-BAS). The records were connected to 177 hydrobiological samples taken from 139 localities (Figure 1). Samples were collected between 2005 and 2020. Most of the materials were collected using the adapted version of the multi-habitat sampling method [32], according to the accepted standard procedures (EN 16150: 2012, EN ISO 10870: 2012).

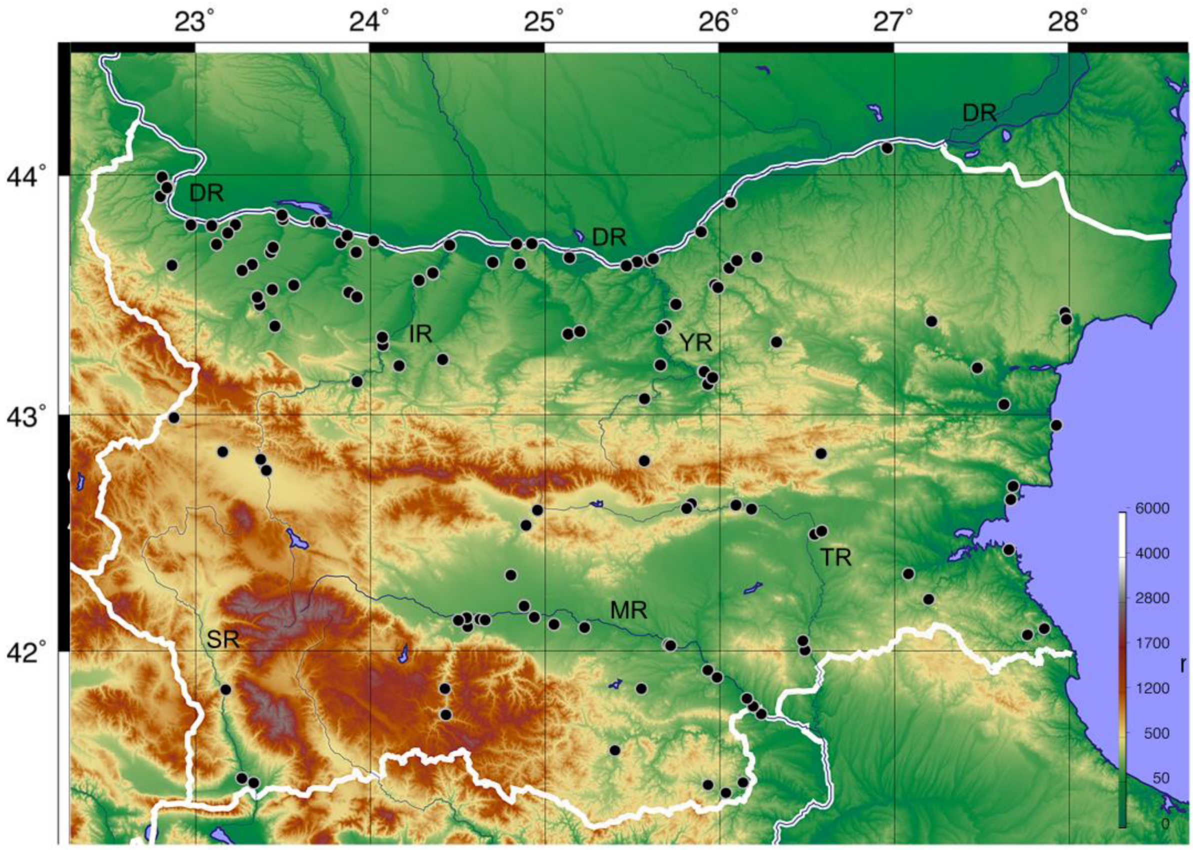

Figure 1. Heteroptera localities used in the analyze of the relationship between the agricultural land use and the occurrence of common aquatic bug species in Bulgaria. Altitude legend (m a.s.l.) is provided in the down write corner. The main rivers are marked as: DR—Danube River, IR—Iskar River, YR—Yantra River, SR—Struma River, MR—Maritsa River, TR—Tundzha River. The map base was downloaded from: https://commons.wikimedia.org/wiki/File:Topographic_Map_of_Bulgaria_Bulgaria_Blank_Without_Dots.png, accessed on 11 February 2023.

2.2. Environmental Dataset

A GIS layer consisting of river catchments in Bulgaria within Ecoregions 12 and 7, and including each catchment's respective area, minimal altitude, minimal slope, and identification code of the downstream adjacent catchment (sub-basin) was extracted from the CCM2 geodatabase [33]. This dataset is a subset of Catchment Characterization and Modelling (CCM) data version 2.1 provided by EU Joint Research Centre (JRC). The CCM2 database covers the entire European continent and includes a hierarchical set of river catchments and segments based on the Strahler order and structured hydrological feature codes based on the Pfafstetter system [33]. The Heteroptera occurrence data were added to the catchments layer attributes. The further steps of the data preparation included only catchments with minimal altitude and minimal slope, both less than or equal to their maximums among the catchments with Heteroptera records. This was done in order to ensure that only catchments connected to river sections with characteristics relatively close to these of smooth flowing water courses (such as those with Heteroptera records) would be used in the analysis.

Corine land cover (CLC) data was derived from three geodatabases (in vector format) downloaded from the official cite of Copernicus—The European Earth Observation Programme [34]: (1) containing CLC 2006 data (U2012_CLC2006_V2020_20u1.gdb); (2) containing CLC 2012 (U2018_CLC2012_V2020_20u1.gdb); (3) containing CLC 2018 (U2018_CLC2018_V2020_20u1.gdb). In order to extract the needed land cover data, the following steps were caried out using QGIS 3.16 [35]. The CLC layers as well as the catchment layer were reprojected to coordinate reference system 32635–WGS84/UTM Zone 35N, for more accurate area calculations. Then each of the CLC layers was separately combined with the catchment layer by applying the geoprocessing function "Intersection". The resulting layers consisted of polygons each of which belonged to one land use class and to one river catchment, respectively. This enabled the calculation of the cumulative area of each agricultural land cover third level classes (Table 1), as the area of a given catchment plus the areas of its tributaries' catchments and/or that of immediately upstream catchment covered by a given land cover class. The cumulative area of each agricultural land cover class was divided by the sum of the total area of the relevant catchments and then converted to percentage. Such variables (cumulative area of land cover classes) have been used in previous studies on the ecology of aquatic invertebrates on catchment scales [36,37], aquatic Heteroptera in particular [30]. The agricultural variables obtained for each of the three time periods were tested for correlation using the built-in function cor in R version 4.2.2 [38] for calculating the Kendall rank correlation coefficient. The results showed that the agricultural variables for CLC 2006 and CLC 2018 were strongly correlated with those for CLC 2012 (Kendall's Tau correlation coefficients 0.96–0.98, and 0.84–0.95, respectively, with $p < 0.000001$). Although the land cover in the studied catchments undoubtedly has changed during the sampling period (2005–2020), the proportion of their area covered with the target agricultural land cover classes seams stable enough for the purpose of the present study and the analysis of multi-year species occurrence data it involves. In further steps, the agricultural variables for CLC 2012 were used, since this period is closer to the middle of the sampling period.

Table 1. Corine land cover nomenclature for Agricultural areas [34].

<table>
<tr><th>LEVEL 1</th><th>LEVEL 2</th><th>LEVEL 3</th></tr>
<tr><td rowspan="7">2. Agricultural areas</td><td>2.1. Arable land</td><td>2.1.1. Non-irrigated arable land</td></tr>
<tr><td rowspan="2">2.2. Permanent crops</td><td>2.2.1. Vineyards</td></tr>
<tr><td>2.2.2. Fruit trees and berry plantations</td></tr>
<tr><td>2.3. Pastures</td><td>2.3.1. Pastures</td></tr>
<tr><td rowspan="2">2.4. Heterogeneous agricultural areas</td><td>2.4.2. Complex cultivation patterns</td></tr>
<tr><td>2.4.3. Land principally occupied by agriculture, with significant areas of natural vegetation</td></tr>
</table>

The data obtained for the analysis (including the CLC 2006 variables) are available in Table S1, and the related metadate in File S1.

2.3. Modeling the Response of the Selected Species to the Agricultural Land Use Variables

Prior to the modeling, the correlation among the catchment's variables (area, minimal altitude, minimal slope and the agricultural variables was evaluated, using the built-in function cor in R version 4.2.2 [38] for calculating Spearman's rank correlation coefficient.

Predictions of the occurrence probability for each of the nine aquatic bug species on catchments scale were built, based on each of the target land cover variables used individually by Maxent version 3.4.3 [39] and following the method described by Elith et al. (2011) [40], with settings as outlined in the next paragraphs. Maxent software requires input of environmental data for all locations (here scaled to catchment) in the studied area. Our choice for applying this algorithm was based on its good performance when used for presence-only models [40–43]. A presence-only approach was selected in order to avoid detection bias—smaller species, for example, those of genera *Micronecta* Kirkaldy, 1897 and *Plea* Leach, 1818, may go unnoticed in a given locality much easier than more conspicuous water bugs (such as *Nepa* Linnaeus, 1758 and *Ranatra* Fabricius, 1790).

The input for the analyzed species were spreadsheet-like summaries of environmental variables in two comma separated value (CSV) files ("Sample file" and "Background file"). The "Sample file" included all of the catchments with records of the respective species, while the "Background file" included all catchments with minimal altitude and minimal slope, both less than or equal to their maximums among the catchments with records of the respective species, and also area of the catchment greater than or equal to its minimum in the "Sample file". The described restrictions to the background data were applied in order to control for these three non-target parameters, each of which might exert strong influence on the occurrence probability of the analyzed aquatic Heteroptera, masking the effects of the target agricultural variables.

All of the environmental variables were continuous. Following Elith et al. (2011) [40], the default settings for features and regularization were used and the output was set to be logistic. For obtaining out-of-sample estimates of predictive performance and estimates of uncertainty around fitted functions, a ten-fold cross-validation was used. The maximum number of background points for each of the species was set to the respective number of catchments in its "Background file", instead of the default 10,000. The algorithm was run ten times for each species-variable combination. To measure the amount of variation in the response curves of the single variable models, for each of the species-variable combination standard deviation over the ten respective models (runs) was calculated.

Model performance was evaluated based on the area under the curve (AUC) of a receiver operating characteristic plot [44]. According to Elith et al. (2006) [41]: "AUC values can be interpreted as indicating the probability that, when a presence site and an absence site are drawn at random from the population, the first will have a higher predicted value than the second". The value of AUC could be used for assessing the ability of maxent models' predictions to discriminate presence from background locations (catchments in our case). For example, AUC value < 0.5 shows that the given model performs in predicting the species occurrence worse than a random model would [41]. In contrast, models with AUC values greater than 0.9 could be considered excellent in predicting a species' occurrence based on the given data.

3. Results

The relationship between six agricultural land use variables and the occurrence of nine common aquatic bug species was analyzed. The selected species represent seven Heteroptera families: Aphelochiridae—*Aphelocheirus aestivalis* (Fabricius, 1794); Noucoridae *Ilyocoris cimicoides* (Linnaeus, 1758); Nepidae—*Nepa cinerea* Linnaeus, 1758; Micronectidae—*Micronecta griseola* Horváth, 1899; Corixidae—*Sigara iactans* Jansson, 1983, *Sigara lateralis* (Leach, 1817) and *Sigara striata* (Linnaeus, 1758); Notonectidae—*Notonecta glauca* (Linnaeus, 1758); Pleidae—*Plea minitissima* Leach, 1817.

Among the best models (averaged over the ten runs) for each of the species the AUC varied between 0.52 and 0.74 (Figure 2). Among the 54 created models there were 21 with noticeably high standard deviation—75% of the predicted probability values were with standard deviation (over the ten models) above 0.1 (Figure 3). Such models, as well as those with AUC lower than 0.6 (Figure 2), were excluded from further comments on the effect of land cover type on the occurrence of the selected aquatic Heteroptera species.

Pasture area was the most informative (compared to the other five variables) in respect to the occurrences of *Aphelocheirus aestivalis* and *Sigara iactans*, while non-irrigated arable land (Figures 2 and 3) of *Ilyocoris cimicoides* and *Micronecta griseola*. Land principally occupied by agriculture was the best predictor for *Nepa cinerea* and *Sigara striata*.

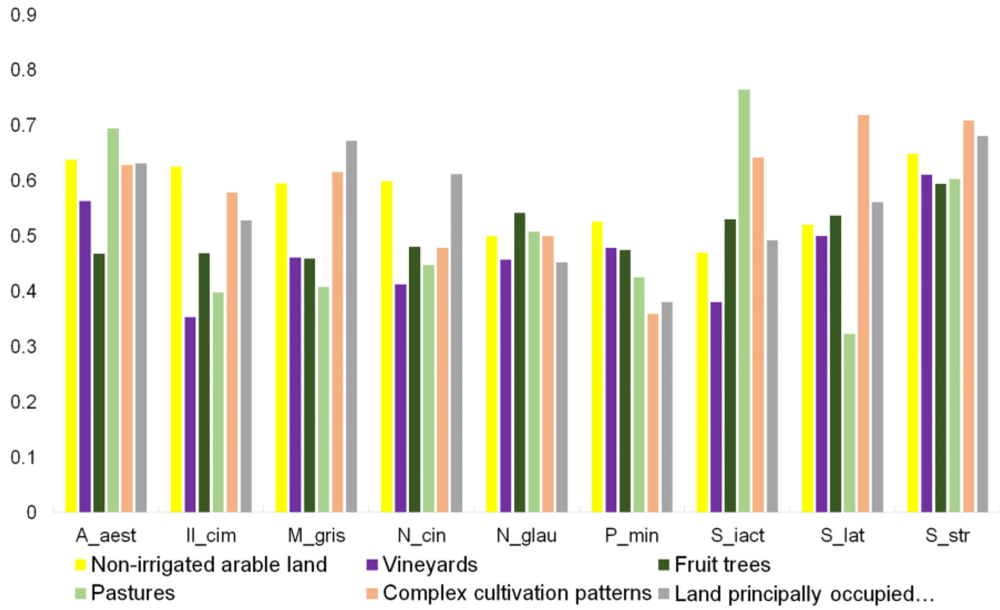

Figure 2. AUC averaged over the ten models for each of the predictor variables (vertical axis). The following abbreviations are used *Aphelocheirus aestivalis*—A_aest; *Ilyocoris cimicoides*—Il_cim; *Micronecta griseola*—M_gris; *Nepa cinerea*—N_cin; *Notonecta glauca*—N_glau; *Plea minutissima*—P_min; Sigara iactans—S_iact; *Sigara lateralis*—S_lat; *Sigara striata*—S_str.

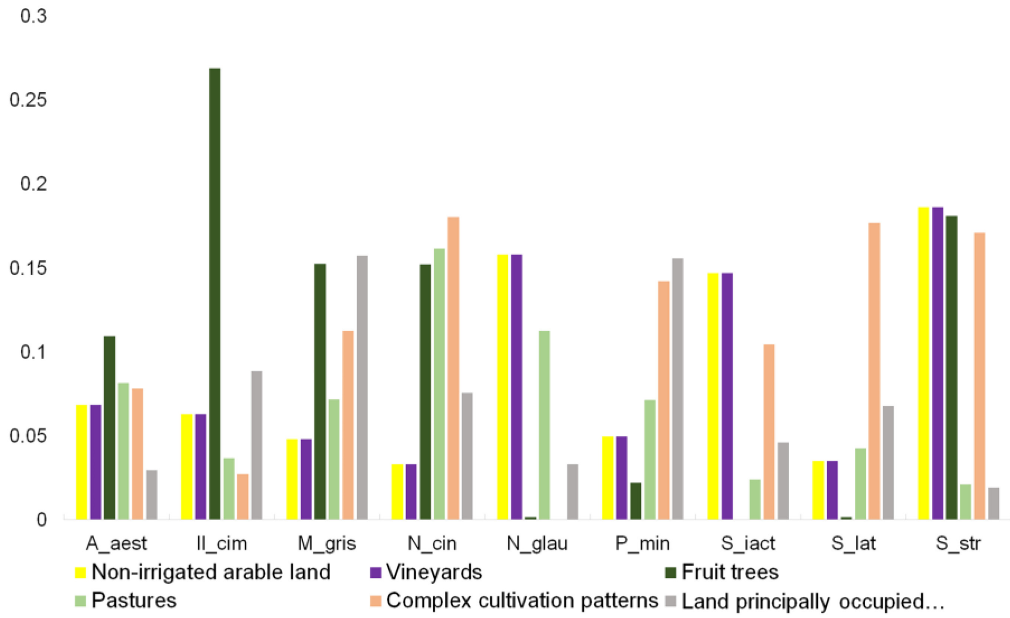

Figure 3. Third Quantile of the standard deviation (vertical axis) calculated for the predicted occurrence probability over the response curves of ten models. For abbreviations of the species names see Figure 2.

The models created for *Notonecta glauca*, *Plea minutissima* and *Sigara lateralis* had either low AUC or high standard deviation, therefore, the response curves connected to these models were not commented on below.

There was an increase in the respective probability of occurrence for each of the two species, *Ilyocoris cimicoides* and *Nepa cinerea*, with the increase of the area occupied by non-irrigated arable land (Figure 4A), and only for *Nepa cinerea* with the increase of the proportion of the land principally occupied by agriculture (Figure 4F).

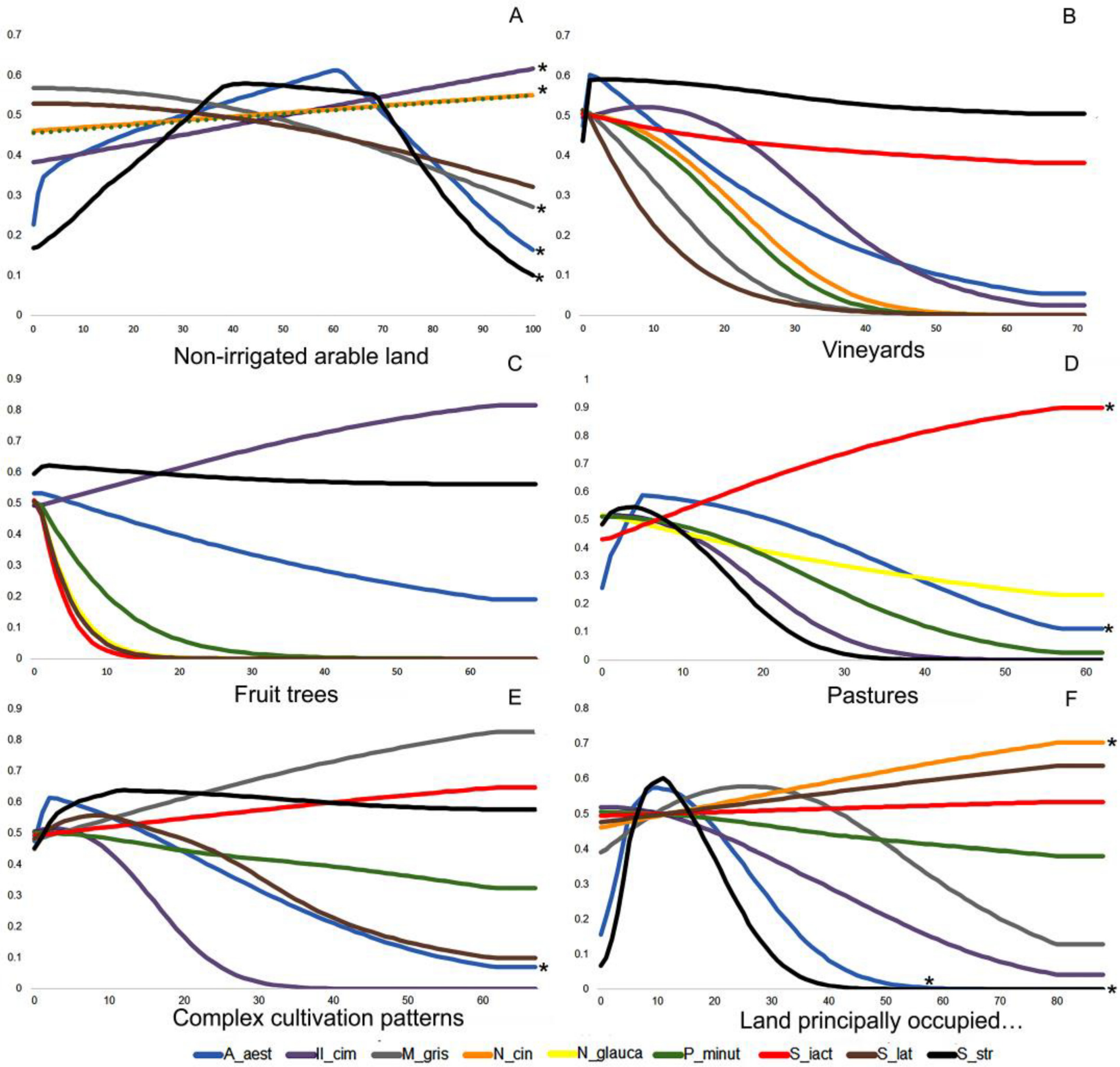

Figure 4. Response curves averaged over the ten models for each of the predictor variables. The vertical axis—predicted probability of presence; horizontal axis—range of a given land use variable: (**A**) Non-irrigated arable land; (**B**) Vineyards; (**C**) Fruit trees and berry plantations; (**D**) Pastures; (**E**) Complex cultivation patterns; (**F**) Land principally occupied by agriculture, with significant areas of natural vegetation. For abbreviations of the species names see Figure 2. Response curves, which does not show change (probability of occurrence stays at 0.5), are omitted from the charts, but included in Table S2. Response curves with standard deviation below 0.1, and based on models with AUC higher than 0.6 are marked with *.

The model for *Sigara iactans* showed an increase in probability with the increase of the area occupied by pastures (Figure 4D). The occurrence probability of *Sigara striata* peaked between 38% and 69%, and at 11% in connection with non-irrigated arable land and land principally occupied by agriculture (Figure 4A,F), respectively. The probability of occurrence of *Aphelocheirus aestivalis* was influenced negatively by each of the four agricultural variables when their values were higher than certain levels: non-irrigated arable land—above 60%; pastures—above 5%; complex cultivation patterns (Figure 4E)—above 2%; land principally occupied by agriculture—above 9%.

In respect to the non-irrigated arable land, the model for *Micronecta griseola* showed a decline of the occurrence probability with the increase of the cumulative percent (Figure 4A).

The six agricultural land use variables did not show strong intercorrelations, nor correlations with the other three variables in the dataset (area, minimal altitude and minimal slope); correlation coefficients were below 0.7.

4. Discussion

The results indicated influence on the occurrence of common aquatic bugs in connection to the percent of the area occupied by four of the six agricultural land use classes: non-irrigated arable land, pastures, complex cultivation patterns and land principally occupied by agriculture. Nevertheless, among these four agricultural variables, the cumulative area of the non-irrigated arable land seems to be the one with the most prominent effect on the distribution of the selected aquatic Heteroptera, since our results indicate its influence on the occurrence of four of the nine species. Such results could be expected, as this type of land use has been connected to higher yearly loads (higher export coefficient) of phosphorus in comparison with the other three classes mentioned above [45]. Furthermore, larger areas occupied by arable land in a given stream's catchment has been linked to higher nitrogen compound concentrations in the waters of the given stream [46]. In the present study, the area occupied by vineyards and by fruit trees and berries plantations were the two variables with the least importance as predictors of the analyzed species. This outcome might be explained by the lower significance of these two types of land use as sources of nutrients for the aquatic habitats, suggested by the results of Łaszewski et al., 2022 [46]. Additionally, the most frequently detected pesticides in waters of vineyard regions are not insecticides but fungicides, according to a study in Spain [47]. Generally, perennial crops, pastures, and trees might be more sustainable agricultural productions than annual crops [48].

The tendencies indicated by the response curves should be treated with caution, as each of the models they represent is based on one variable but shows not only the dependence of the predicted occurrence probability on that given variable, but also the dependencies induced by correlations between the given variable and other variables [49]. The correlation analysis carried out not only for the land use variables but also for those variables and three other catchment variables (area, minimal altitude, minimal slope), indicated low correlation (coefficients below 0.7). It could be inferred that the tendencies shown by the response curves (presented above) bear some relevance to the relationships between the analyzed agricultural variables and the selected aquatic heteropteran species.

Pastures might act as biogeochemical barriers due to the permanence of vegetation cover and soil rich in organic matter [46,50,51], but their effect on water quality may vary greatly, due to differences in their management and agricultural practices (fertilizing, mowing, and grazing), which could induce significant impact on water quality [52,53]. Therefore, models involving the pasture variable are treated as ambiguous and are not commented on in the sense of species sensitivity. The results concerning the rest of the analyzed land use variables suggest that sensitivity increases in the following order: *Nepa cinerea* (positively connected to two agricultural land use variables) and *Ilyocoris cimicoides* (positively connected to one agricultural land use variable) < *Sigara striata* (negative connection with higher values of two agricultural land use variables) < *Aphelocheirus aestivalis* (negative relation with higher values of three agricultural land use variables) and *Micronecta griseola* (negatively connected to an agricultural land use variable). This grouping coincides with the level of preference of these aquatic insects to macrophyte vegetation. The three less sensitive species *Nepa cinerea*, *Ilyocoris cimicoides* and *Sigara striata*, all have preference for macrophyte dominated microhabitats [54]. In contrast, the two species with highest sensitivity to the effects of agricultural land use (present study), are more closely connected to microhabitats characterized with the absence of macrophytes—sand or fine to medium-sized gravel substratum [54]. Furthermore, aquatic and riparian vegetation have been among the main factors influencing the structure of aquatic Heteroptera assemblages in other regions [23,55–58]. Therefore, it could be assumed that the main effects of the diffuse pollution from agricultural land use on the selected species are most likely connected to changes in the macrophyte cover in the given microhabitats. Nevertheless, the direct influence of pollution should not be excluded, especially in the case of *Aphelocheirus aestivalis*, which has been often listed as an indicator species sensitive to organic pollution (used, for example, in Germany, Austria, Czech Republic, Slovakia) based on the categorizations in [54], and in EU-STAR (2005) [59]. In Bulgaria, according to the broadly applied adapted version of the Biotic index (as described in Cheshmedjiev et al. (2013) [60]), *Aphelocheirus aestivalis* belongs to the second most sensitive group of macroinvertebrates, while the rest of the aquatic Heteroptera are assigned to the third group (out of five)— "relatively tolerant" taxa. The higher sensitivity of *Aphelocheirus aestivalis* to anthropogenic pressure is indicated in the present study as well, at least compared to *Nepa cinerea*, *Ilyocoris cimicoides* and *Sigara striata*. In some European countries, *Aphelocheirus aestivalis* has been included in local and national Red Lists or Red Data Books as endangered species [61]. Pollution from industrial and agricultural sources and watercourses regulation are pointed at as the main threats for the subpopulations [30,62] of this species. The higher sensitivity of *Aphelocheirus aestivalis* to polluted waters (characterized by lower oxygen concentrations) could be explained by its mode of respiration. The species is a plastron breather, meaning it relies only on diffused oxygen in the water, while most of the other representatives of Nepomorpha have bimodal breathing with gas bubbles carried on their body surface functioning both as gas stores and physical gills [63]. Additional implications for the conservation of *Aphelocheirus aestivalis* come from its low dispersion ability [61] and low genetic diversity [64]. Taking these facts into account, the results of the present study concerning this species might be of help for its conservation.

Interestingly, besides *Aphelocheirus aestivalis*, one more species showed prominent negative response to arable land use, *Micronecta griseola*. In different parts of its range, *Micronecta griseola* has been discussed both as tolerant to pollution and as a relatively sensitive species, respectively. In Finland, the species has been included in a proposed methodology for water quality monitoring of lakes based on the species composition of genus *Micronecta* [18]; the dominance of *Micronecta griseola* (together with *Micronecta minutissima*) has been indicative of strongly eutrophicated waters. In contrast, in regions with milder climatic conditions—Poland, Germany, Hungary—*Micronecta griseola* has been commented as a species sensitive to water pollution [22,65–67]. The differences in the tolerance of this species to polluted waters (often with low concentration of dissolved oxygen) observed between "colder" and "warmer" parts of its range might be connected to the hypothesis that the heat tolerance of aquatic insects is strongly influenced by the availability of oxygen [68–71]. Therefore, the sensitivity of *Micronecta griseola* to the combination of pollution and high ambient temperatures needs further investigation, especially in the conditions of climate changes and because the species has been listed as vulnerable in other regions [72]. A recent review recommends the use of *Micronecta* species composition for biomonitoring purposes [17]. The results of the present study confirm the need for reassessment of genus *Micronecta* as potential indicators of water quality. It should be mentioned that *Micronecta* species (especially larvae and females) are difficult to identify due to their small size (about 2 mm) and similar morphology. The high potential of DNA barcoding as a tool for the identification of aquatic Heteroptera has been demonstrated in a large-scale study in Germany and adjacent regions [73]. Further application of this technology might solve the identification problem occurring with genus *Micronecta*. Species of this genus, although very small in size, can produce distinct sounds by stridulation [74]. For example, *Micronecta griseola* has been reported to generate a very conspicuous high-pitch sound, detectable at distances of a few meters [74]. The production of such sounds (with characteristics differing between species) could enable the use of *Micronecta* species in ecoacoustics studies. An approach involving underwater acoustic monitoring could become a non-invasive alternative to hydrobiological sampling for monitoring of freshwater ecosystems [74], especially in localities where hydrobiological sampling is not recommended (for example, protected areas).

In the present study, the models built for three of the target species (*Notonecta glauca*, *Plea minutissima* and *Sigara lateralis*) had very low accuracy and/or high variation. One explanation could be that agricultural land use has negligible effect on the occurrence of these three species. Such an interpretation is in line with previous observations on the biology and ecology of these aquatic bugs. Two of them—*Notonecta glauca* and *Sigara lateralis*, have very good ability to disperse by flight [75] and high rates of migration might be masking the effect of the anthropogenic pressures on these species. Furthermore, *Sigara lateralis* has been found in polluted waters [76,77] and is among the few species of Corixidae occurring in eutrophic habitats even with muddy waters [75]. Both *Notonecta glauca* and *Plea minutissima* prefer macrophyte dominated habitats [75], and *Plea minutissima* has been often found in water bodies characterized, in summer, by low levels of dissolved oxygen [78]. Furthermore, the resilience and ferociousness of Notonectidae and Pleaidae species make them important biological mosquito control agents [79].

5. Conclusions

The results of the present study indicate that the land use variables connected to arable land (and annual crops) have a stronger influence on the occurrence of the selected aquatic Heteroptera species than variables connected to perennial crops. Species with preference to microhabitats without macrophyte vegetation can be more sensitive (in respect, at least, to their occurrence) to the effect of the agricultural activities on the ecological quality of the water than species preferring macrophyte dominated microhabitats. Therefore, agricultural activities influence the occurrence of the selected aquatic Heteroptera, most likely by inducing changes in riverine microhabitats. The present study was limited to the analysis of occurrence data and land cover data, due to the unavailability of data on other relevant variables (such as pH, conductivity, nitrogen and phosphorus compound concentrations). The main findings presented here are preliminary in nature but could help the initiation of detailed studies on aquatic Heteroptera species in respect to their sensitivity to anthropogenic pressure in Bulgaria, as well as in other regions of Southeast Europe. The use of physical as well as chemical variables in further studies on the topic is necessary. Focused research on the ecology of Micronectidae species is much needed.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/d15020292/s1, Table S1: The land use data and the occurrence data used for analysis; Table S2: Probabilities of occurrence (averaged over ten models) used for the construction of the response curves; File S1: metadata about the dataset.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Data Availability Statement: The land use data and the occurrence data used for analysis are available in the Supplementary files accompanying the present paper. The hydrobiological samples, used for obtaining unpublished occurrence data for aquatic Heteroptera are part of the "Aquatic Invertebrates Collection" maintained by the Institute of Biodiversity and Ecosystem Research at the Bulgarian Academy of Sciences (IBER-BAS).

Acknowledgments: I want to express my deep gratitude to all those fellow researchers who allowed me to examine materials used in their publications and to all those who have contributed with unpublished materials to the "Aquatic Invertebrates Collection" maintained by IBER-BAS. Among them I want to thank especially to Borislava Gyosheva, Boris Velkov, Dimitar Kaynarov, Emilia Varadinova, Georgi Georgiev, Lyubomir Kenderov, Lyubomir Pehlivanov, Mila Ihtimanska, Maria Kerakova, Milen Marinov, Maria Naumova, Milena Pavlova, Monika Sabeva, Milcho Todorov, Pencho Ivanov, Pencho Pandakov, Rabia Soufi, Stoyan Beshkov, Svetoslav Cheshmedzhiev, Stefan Kazakov, Tihomir Stefanov, Teodora Trichkova, Vesela Evtimova, Violeta Tyufekchieva, Yanka Vidinova, Zdravko Hubenov.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Monroe, J.B.; Baxter, C.V.; Olden, J.D.; Angermeier, P.L. Freshwaters in the Public Eye: Understanding the Role of Images and Media in Aquatic Conservation. *Fisheries* **2009**, *34*, 581–585. [CrossRef]
2. Carpenter, S.R.; Caraco, N.F.; Correll, D.L.; Howarth, R.W.; Sharpley, A.N.; Smith, V.H. Nonpoint Pollution of Surface Waters with Phosphorus and Nitrogen. *Ecol. Appl.* **1998**, *8*, 559. [CrossRef]
3. Vitousek, P.M.; Aber, J.D.; Howarth, R.W.; Likens, G.E.; Matson, P.A.; Schindler, D.W.; Schlesinger, W.H.; Tilman, D.G. Human Alteration of the Global Nitrogen Cycle: Sources and Consequences. *Ecol. Appl.* **1997**, *7*, 737–750. [CrossRef]
4. Bouraoui, F.; Grizzetti, B. Long Term Change of Nutrient Concentrations of Rivers Discharging in European Seas. *Sci. Total Environ.* **2011**, *409*, 4899–4916. [CrossRef]
5. Windolf, J.; Thodsen, H.; Troldborg, L.; Larsen, S.E.; Bøgestrand, J.; Ovesen, N.B.; Kronvang, B. A Distributed Modelling System for Simulation of Monthly Runoff and Nitrogen Sources, Loads and Sinks for Ungauged Catchments in Denmark. *J. Environ. Monit.* **2011**, *13*, 2645–2658. [CrossRef] [PubMed]
6. Schindler, D.W. Recent Advances in the Understanding and Management of Eutrophication. *Limnol. Oceanogr.* **2006**, *51*, 356–363. [CrossRef]
7. Cheng, C.; Zhang, F.; Shi, J.; Kung, H.-T. What Is the Relationship between Land Use and Surface Water Quality? A Review and Prospects from Remote Sensing Perspective. *Environ. Sci. Pollut. Res.* **2022**, *29*, 56887–56907. [CrossRef]
8. Huber, A.; Bach, M.; Frede, H. Pollution of Surface Waters with Pesticides in Germany: Modeling Non-Point Source Inputs. *Agric. Ecosyst. Environ.* **2000**, *80*, 191–204. [CrossRef]
9. Genito, D.; Gburek, W.J.; Sharpley, A.N. Response of Stream Macroinvertebrates to Agricultural Land Cover in a Small Watershed. *J. Freshw. Ecol.* **2002**, *17*, 109–119. [CrossRef]
10. Lenat, D.R.; Crawford, J.K. Effects of Land Use on Water Quality and Aquatic Biota of Three North Carolina Piedmont Streams. *Hydrobiologia* **1994**, *294*, 185–199. [CrossRef]
11. Riley, R.H.; Townsend, C.R.; Niyogi, D.K.; Arbuckle, C.A.; Peacock, K.A. Headwater Stream Response to Grassland Agricultural Development in New Zealand. *New Zeal. J. Mar. Freshw. Res.* **2003**, *37*, 389–403. [CrossRef]
12. Allan, J.D. Landscapes and Riverscapes: The Influence of Land Use on Stream Ecosystems. *Annu. Rev. Ecol. Evol. Syst.* **2004**, *35*, 257–284. [CrossRef]
13. Probst, M.; Berenzen, N.; Lentzen-Godding, A.; Schulz, R.; Liess, M. Linking land use variables and invertebrate taxon richness in small and medium-sized agricultural streams on a landscape level. *Ecotoxicol. Environ. Saf.* **2005**, *60*, 140–146. [CrossRef] [PubMed]
14. Johnson, R.K.; Wiederholm, T.; Rosenberg, D.M. Freshwater Biomonitoring Using Individual Organisms, Populations, and Species Assemblages of Benthic Macroinvertebrates. *Freshw. Biomonitoring Benthic Macroinvertebrates* **1993**, *40*, 40–158.
15. Rosenberg, D.M.; Resh, V.H. *Freshwater Biomonitoring and Benthic Macroinvertebrates*; Springer: New York, NY, USA, 1993; ISBN 978-0-412-02251-7.
16. Lock, K.; Adriaens, T.; Van De Meutter, F.; Goethals, P. Effect of Water Quality on Waterbugs (Hemiptera: Gerromorpha & Nepomorpha) in Flanders (Belgium): Results from a Large-Scale Field Survey. *Ann. Limnol.-Int. J. Limnol.* **2013**, *49*, 121–128. [CrossRef]
17. Bakonyi, G.; Vásárhelyi, T.; Szabó, B. Pollution Impacts on Water Bugs (Nepomorpha, Gerromorpha): State of the Art and Their Biomonitoring Potential. *Environ. Monit. Assess.* **2022**, *194*, 1–25. [CrossRef]
18. Jansson, A. Micronectae (Heteroptera, Corixidae) as Indicators of Water Quality in Two Lakes in Southern Finland. *Proc. Ann. Zool. Fenn.* **1977**, *14*, 118–124.
19. Biesiadka, E.; Tabaka, K. Badania Nad Pluskwiakami (Heteroptera) Wodnymi Jezior Szczycieńskich (Woj. Olsztyńskie). *Fragm. Faun.* **1990**, *33*, 45–69. [CrossRef]
20. Savage, A. The Distribution of Corixidae in Relation to the Water Quality of British Lakes: A Monitoring Model. *Freshw. Forum* **1994**, *4*, 32–61.
21. Sládecek, V.; Sládecková, A. Corixidae as Indicators of Organic Pollution. *Freshw. Forum* **1994**, *4*, 211–213.
22. Vásárhelyi, T.; Bakonyi, G. Seven Decades of Monitoring the Aquatic Bug Fauna of Lake Balaton (Heteroptera: Nepomorpha). *Aquat. Insects* **2012**, *34*, 33–43. [CrossRef]
23. Karaouzas, I.; Gritzalis, K.C. Local and Regional Factors Determining Aquatic and Semi-Aquatic Bug (Heteroptera) Assemblages in Rivers and Streams of Greece. *Hydrobiologia* **2006**, *573*, 199–212. [CrossRef]
24. Cheshmedjiev, S.D.; Karagiozova, T.L.; Michailov, M.A.; Valev, V.P. Revision of River & Lake Typology in Bulgaria within Ecoregion 12 (Pontic Province) and Ecoregion 7 (Eastern Balkans) According to the Water Framework Directive. *Ecol. Balk.* **2010**, *2*, 75–96.
25. Stoyanova, T.; Traykov, I.; Bogoev, V.; Yaneva, I.; Vidinova, Y.; Tyufekchieva, V.; Kenderov, L. Composition of the Macrozoobenthos in Semi-Mountainous River in South-Western Bulgaria. *Nat. Montenegrina* **2013**, *12*, 803–811.
26. Stoyanova, T.; Traykov, I. Assessment of the Ecological Status of Ogosta River, Northwestern Bulgaria, Based on the Macrozoobenthos and the General Physical and Chemical Quality Elements. *Acta Zool. Bulg.* **2014**, (Suppl. 7), 173–178.

27. Borisova, P.; Varadinova, E.; Yzunov, Y. Contemporary State of the Bottom Invertebrate Communities of the Tundzha River Basin (South-East Bulgaria). *Acta Zool. Bulg.* **2013**, *65*, 75–87.
28. Kazakov, S. *Structural and Functional Parameters of the Hydrozoocenosys in the Lower Danube Wetlands*; Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences: Sofia, Bulgaria, 2017.
29. Vidinova, Y.; Tyufekchieva, V.; Varadinova, E.; Stoichev, S.; Kenderov, L.; Dedov, I.; Uzunov, Y. Taxonomic List of Benthic Macroinvertebrate Communities of Inland Standing Water Bodies in Bulgaria. *Acta Zool. Bulg.* **2016**, *68*, 147–158.
30. Stoianova, D.; Evtimova, V.; Kenderov, L.; Varadinova, E.D.; Kerakova, M.Y.; Ihtimanska, M.K.; Stefanov, T.; Soufi, R.A.; Tyufekchieva, V.; Vidinova, Y. New Localities and Habitat Suitability Modelling for the Riverine Water Bug *Aphelocheirus Aestivalis* (Fabricius, 1794) (Heteroptera: Aphelocheiridae) in Northern and Eastern Bulgaria. *Acta Zool. Bulg.* **2018**, *70*, 415–431.
31. Park, J.; Sakelarieva, L.; Varadinova, E.; Evtimova, V.; Vidinova, Y.; Tyufekchieva, V.; Georgieva, G.; Ihtimanska, M.; Todorov, M. Taxonomic Composition and Dominant Structure of the Macrozoobenthos in the Maritsa River and Some Tributaries, South Bulgaria. *Acta Zool. Bulg.* **2022**, *in press*.
32. Cheshmedjiev, S.; Soufi, R.; Vidinova, Y.; Tyufekchieva, V.; Yaneva, I.; Uzunov, Y.; Varadinova, E. Multi-Habitat Sampling Method for Benthic Macroinvertebrate Communities in Different River Types in Bulgaria. *Water Res. Manag.* **2011**, *1*, 55–58.
33. Joint Research Centre—European Commission CCM River and Catchment Database, Version 2.1 (CCM2). Available online: https://ossf.denny.one/tw/resourcecatalog/GIS/Map-Data/catchment-characterisation-and-modelling-ccm/visit.html (accessed on 11 February 2023).
34. Copernicus—The European Earth Observation Programme. Available online: https://land.copernicus.eu/copernicus-the-european-earth-observation-programme (accessed on 26 January 2023).
35. QGIS Association QGIS Geographic Information System 2020. Available online: https://qgis.org/ (accessed on 11 February 2023).
36. Kuemmerlen, M.; Schmalz, B.; Guse, B.; Cai, Q.; Fohrer, N.; Jähnig, S.C. Integrating Catchment Properties in Small Scale Species Distribution Models of Stream Macroinvertebrates. *Ecol. Modell.* **2014**, *277*, 77–86. [CrossRef]
37. Kuemmerlen, M.; Stoll, S.; Sundermann, A.; Haase, P. Long-Term Monitoring Data Meet Freshwater Species Distribution Models: Lessons from an LTER-Site. *Ecol. Indic.* **2016**, *65*, 122–132. [CrossRef]
38. R CoreTeam R: A Language and Environment for Statistical Computing 2022. Available online: https://www.r-project.org (accessed on 11 February 2023).
39. Dudik, M.; Phillips, S.; Schapire, R. Maxent 2020. Available online: https://biodiversityinformatics.amnh.org/open_source/maxent/ (accessed on 11 February 2023).
40. Elith, J.; Phillips, S.J.; Hastie, T.; Dudik, M.; Chee, Y.E.; Yates, C.J. A Statistical Explanation of MaxEnt for Ecologists. *Divers. Distrib.* **2011**, *17*, 43–57. [CrossRef]
41. Elith, J.; Graham, C.H.; Anderson, R.P.; Dudík, M.; Ferrier, S.; Guisan, A.; Hijmans, R.J.; Huettmann, F.; Leathwick, J.R.; Lehmann, A.; et al. Novel Methods Improve Prediction of Species' Distributions from Occurrence Data. *Ecography (Cop.)* **2006**, *29*, 129–151. [CrossRef]
42. Phillips, S.J.; Dudík, M.; Schapire, R.E. A Maximum Entropy Approach to Species Distribution Modeling. In Proceedings of the Twenty-First International Conference on Machine Learning, Banff, AB, Canada, 4–8 July 2004; p. 83.
43. Phillips, S.J.; Dudík, M. Modeling of Species Distributions with Maxent: New Extensions and a Comprehensive Evaluation. *Ecography (Cop.)* **2008**, *31*, 161–175. [CrossRef]
44. Fielding, A.H.; Bell, J.F. A Review of Methods for the Assessment of Prediction Errors in Conservation Presence/Absence Models. *Environ. Conserv.* **1997**, *24*, 38–49. [CrossRef]
45. Smith, R.V.; Jordan, C.; Annett, J.A. A Phosphorus Budget for Northern Ireland: Inputs to Inland and Coastal Waters. *J. Hydrol.* **2005**, *304*, 193–202. [CrossRef]
46. Łaszewski, M.; Fedorczyk, M.; Stępniewski, K. The Impact of Land Cover on Selected Water Quality Parameters in Polish Lowland Streams during the Non-Vegetative Period. *Water* **2022**, *14*, 3295. [CrossRef]
47. Manjarres-López, D.P.; Andrades, M.S.; Sánchez-González, S.; Rodríguez-Cruz, M.S.; Sánchez-Martín, M.J.; Herrero-Hernández, E. Assessment of Pesticide Residues in Waters and Soils of a Vineyard Region and Its Temporal Evolution. *Environ. Pollut.* **2021**, *284*, 117463. [CrossRef]
48. Dixon, J.; Garrity, D. Chapter 23. Perennial Crops and Trees Targeting the Opportunities within a Farming Systems Context. In *Perennial Crops for Food Security, Proceedings of the FAO Expert Workshop, Rome, Italy, 28–30 August 2013*; Batello, C., Wade, L., Cox, S., Pogna, N., Bozzini, A., Choptiany, J., Eds.; Food and Agriculture Organization of the United Nations: Rome, Italy, 2014; pp. 307–324.
49. Merow, C.; Smith, M.J.; Silander Jr, J.A. A Practical Guide to MaxEnt for Modeling Species' Distributions: What It Does, and Why Inputs and Settings Matter. *Ecography (Cop.)* **2013**, *36*, 1058–1069. [CrossRef]
50. Ryszkowski, L.; Bartoszewicz, A.; Kędziora, A. Management of Matter Fluxes by Biogeochemical Barriers at the Agricultural Landscape Level. *Landsc. Ecol.* **1999**, *14*, 479–492. [CrossRef]
51. Życzyńska-Bałoniak, I.; Szajdak, L.; Jaskulska, R. Impact of Biogeochemical Barriers on the Migration of Chemical Compounds with the Water of Agricultural Landscape. *Polish J. Environ. Stud.* **2005**, *14*, 671–676.

52. Ryden, J.C.; Ball, P.R.; Garwood, E.A. Nitrate Leaching from Grassland. *Nature* **1984**, *311*, 50–53. [CrossRef]
53. Jaguś, A. The Impact of Extensive Grazing on the Fertility of Mountain Streams on the Example of the Biała Woda Valley in the Pieniny Range (Polish Carpathians). *J. Ecol. Eng.* **2020**, *21*, 112–119. [CrossRef]
54. Schmidt-Kloiber, A.; Hering, D. Www.Freshwaterecology.Info—An Online Tool That Unifies, Standardises and Codifies More than 20,000 European Freshwater Organisms and Their Ecological Preferences. *Ecol. Indic.* **2015**, *53*, 271–282. [CrossRef]
55. Coulianos, C.-C.; Okland, J.; Okland, K.A. Norwegian Aquatic Bugs. Distribution and Ecology (Hemiptera-Heteroptera: Gerromorpha and Nepomorpha). *Nor. J. Entomol.* **2008**, *55*, 179–222.
56. Nosek, J.N.; Vásárhelyi, T.; Bakoyi, G.; Oertel, N. Spatial pattern of water bugs (Nepomorpha, Gerromorpha) at different scales in the Szigetköz (Hungary). *Biol. Bratislava* **2007**, *62*, 345–350. [CrossRef]
57. Ilie, D.M.; Olosutean, H. Structure and Seasonal Dynamics of Water Bugs Communities (Heteroptera: Nepomorpha) in Anthropic and Natural Ponds from South-Eastern Transylvania: The Role of Vegetation and Water Supply. In *Advances in Environment, Ecosystems and Sustainable Tourism*; Marascu-Klein, V., Panaitescu, F.V., Panaitescu, M., Eds.; WSEAS Press: Brasov, Romania, 2013; p. 213À218.
58. Gligorovic, B.; Savic, A.; Protic, L.; Pešic, V. Oceanological and Hydrobiological Studies Ecological Patterns of Water Bug (Hemiptera: Heteroptera) Assemblages in Karst Springs: A Case Study from Central Montenegro. *Oceanol. Hydrobiol. Stud.* **2016**, *45*, 554–563. [CrossRef]
59. EU-STAR EU-STAR. Standardization of River Classifications. Protocols. Energy, Environment and Sustainable Development Programme. 2005. Available online: http://www.eu-star.at/pdf/LatvianMacroinvertebrateSamplingProtocol.pdf (accessed on 26 January 2023).
60. Cheshmedjiev, S.; Varadinova, E. Chapter 5. Demersal Macroinvertabrates. In *Biological Analysis and Ecological Status Assessment of Bulgarian Surface Water Ecosystems*; Belkinova, D., Gecheva, G., Cheshmedzhiev, S., Dimitrova-Dyulgerova, I., Mladenov, R., Marinov, M., Teneva, I., Stoyanov, P., Ivanov, P., Mihov, S., et al., Eds.; Plovdiv University Press: Plovdiv, Bulgaria, 2013; pp. 147–162.
61. Papáček, M. On the benthic water bug Aphelocheirus aestivalis (Fabricius, 1794) (Heteroptera, Aphelocheiridae): Minireview. *Entomol. Austriaca* **2012**, *19*, 9–19.
62. Manko, P. Interesujące stwierdzenia trzech rzadkich i zagrozonych merolimnicznych gatunków owadów na Słowacji. *Forum Faunistyczne* **2011**, *1*, 56–62.
63. Popham, E.J. On the respiration of aquatic Hemiptera Heteroptera with special reference to the Corixidae. *Proc. Zool. Soc. Lond.* **1960**, *135*, 209–242. [CrossRef]
64. Kaczmarczyk-Ziemba, A.; Krepski, T. First report on Wolbachia endosymbiosis in freshwater *Aphelocheirus aestivalis* (Heteroptera: Aphelocheiridae) and its potential impact on genetic diversity of host. *Entomol. Sci.* **2020**, *23*, 44–56. [CrossRef]
65. Kurzatkowska, A. Preference of Micronectidae (Heteroptera: Corixidae) for Low Trophism Lakes: Data from Mazurian Lake District(Northeastern Poland). *J. Entomol. Res. Soc.* **2003**, *5*, 1–12.
66. Günther, H.; Hoffmann, H.-J.; Melber, A.; Remane, R.; Simon, H.; Winkelmann, H. Rote Liste Der Wanzen (Heteroptera) (Bearbeitungsstand: 1997). In *Rote Liste gefährdeter Tiere Deutschlands. Bundesamt für Naturschutz*; Remane, R., Simon, H., Winkelmann, H., Eds.; Bundesamt für Naturschutz: Bonn-Bad Godesberg, Germany, 1998; pp. 235–242.
67. Płaska, W. Water Bugs (Heteroptera Aquatica) as an Indicator of Ecological State of Running Watres (Preliminary Studies). *Acta Agrophysica* **2003**, *1*, 493–499.
68. Whitney, R.J. The Thermal Resistance of Mayfly Nymphs from Ponds and Streams. *J. Exp. Biol.* **1939**, *16*, 374–385. [CrossRef]
69. Verberk, W.C.E.P.; Calosi, P. Oxygen Limits Heat Tolerance and Drives Heat Hardening in the Aquatic Nymphs of the Gill Breathing Damselfly *Calopteryx Virgo* (Linnaeus, 1758). *J. Therm. Biol.* **2012**, *37*, 224–229. [CrossRef]
70. Verberk, W.C.E.P.; Bilton, D.T. Respiratory Control in Aquatic Insects Dictates Their Vulnerability to Global Warming. *Biol. Lett.* **2013**, *9*, 20130473. [CrossRef]
71. Verberk, W.; Sommer, U.; Davidson, R.L.; Viant, M.R. Anaerobic Metabolism at Thermal Extremes: A Metabolomic Test of the Oxygen Limitation Hypothesis in an Aquatic Insect. *Integr. Comp. Biol.* **2013**, *53*, 609–619. [CrossRef]
72. Artfakta. Available online: https://artfakta.se/artbestamning (accessed on 26 January 2023).
73. Havemann, N.; Gossner, M.M.; Hendrich, L.; Morinière, J.; Niedringhaus, R.; Schäfer, P.; Raupach, M.J. From water striders to water bugs: The molecular diversity of aquatic Heteroptera (Gerromorpha, Nepomorpha) of Germany based on DNA barcodes. *PeerJ* **2018**, *6*, e4577. [CrossRef]
74. Linke, S.; Gifford, T.; Desjonquères, C.; Tonolla, D.; Aubin, T.; Barclay, L.; Karaconstantis, C.; Kennard, M.J.; Rybak, F.; Sueur, J. Freshwater ecoacoustics as a tool for continuous ecosystem monitoring. *Front. Ecol. Environ.* **2018**, *16*, 231–238. [CrossRef]
75. Aukema, B.; Cuppen, J.G.M.; Nieser, N.; Tempelman, D. *Verspreidingsatlas Nederlandse Wantsen (Hemiptera: Heteroptera). Deel I: Dipsocoromorpha, Nepomorpha, Gerromorpha & Leptopodomorpha. [Distributional atlas of Dutch true bugs (Hemiptera: Heteroptera). Vol. I: Dipsocoromorpha, Nepomorpha, Gerromorpha & Leptopodomorpha]*; European Invertebrate Survey: Leiden, The Netherlands, 2002.
76. Teyrovsky, V. Piispevek k Faunistice a Eko1ogii Klest'anek (Rod *Sigara* F.) Tekoucich Vo. *Acta Univ. Palacki. Oomucensis* **1960**, *5*, 89–165.
77. Huxley, T. *Provisional Atlas of the British Aquatic Bugs (Hemiptera, Heteroptera)*; Centre for Ecology and Hydrology Biological records Centre: Huntingdon, UK, 2003; ISBN 1870393678.

78. Kovac, D. Zur Uberwinterung Der Wasserwanze *Plea Minutissima* Leach (Heteroptera: Pleidae): Diapause Mit Hilfe Der Plastronatmung. *Nachr. Entomol. Ver. Apollo NF* **1982**, *3*, 59–76.
79. Papáček, M. Small aquatic bugs (Nepomorpha) with slight or underestimated economic importance. In *Heteroptera of Economic Importance*; Schaefer, C.W., Panizzi, A.R., Eds.; CRC Press: Boca Raton, FL, USA, 2000; pp. 591–600.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.