

A window to the future: effects of climate change on the distribution patterns of Iranian Zygaenidae and their host plants

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Supplementary material I

I. Selection of environmental variables

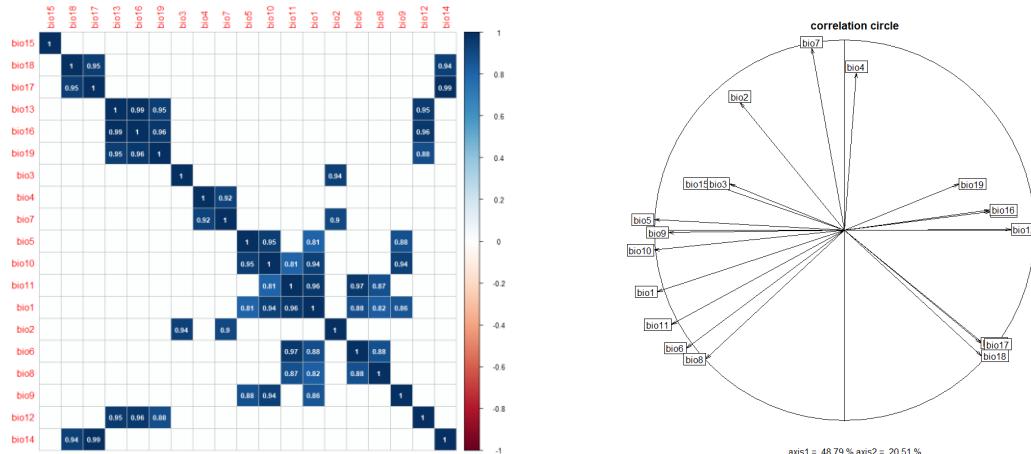


Figure S1. a) results of pairwise Pearson's correlation coefficient (> 0.75) and b) The Correlation circle of variables resulted from Principal Component Analysis (PCA) to select the most independent climate variables for the studied species (for more details see CHELSA, <https://chelsa-climate.org>).

II. Results of habitat suitability for zygaenid moths and their host plants

The following plots depict the results of our SDM and ESMs for the whole extent of the zygaenid moth species and their host plants. The occurrences of the moth species shown as transparent back dots only on the map for current habitat suitability of the species. The rest of the plots show habitat suitability of the species under three climate-scenarios for future (Spp126, Spp370, and Spp585). The Multivariate environmental similarity surfaces (MESS) layer added to each plot as a transparent gray layer. MESS helps to have a better interpretation of resulting habitat suitability for the species. Here we only plot the negative values of MESS, which implies unreliable prediction of habitat suitability.

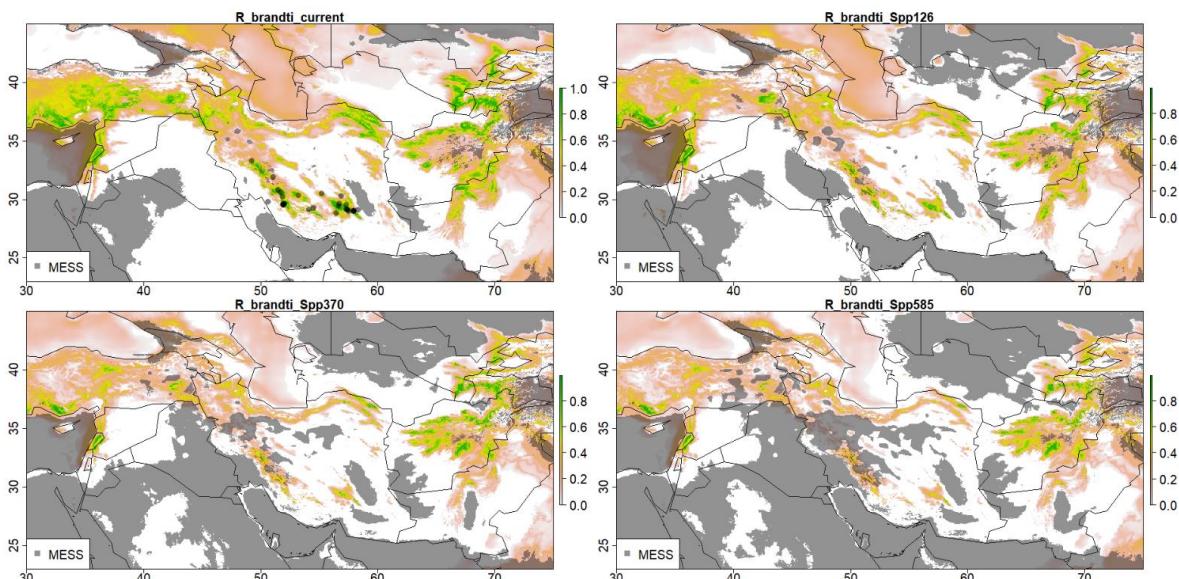


Figure S2. Habitat suitability of *Rhagades brandti*. Intensity of the green color depict higher probability for presence of the species in the study area.

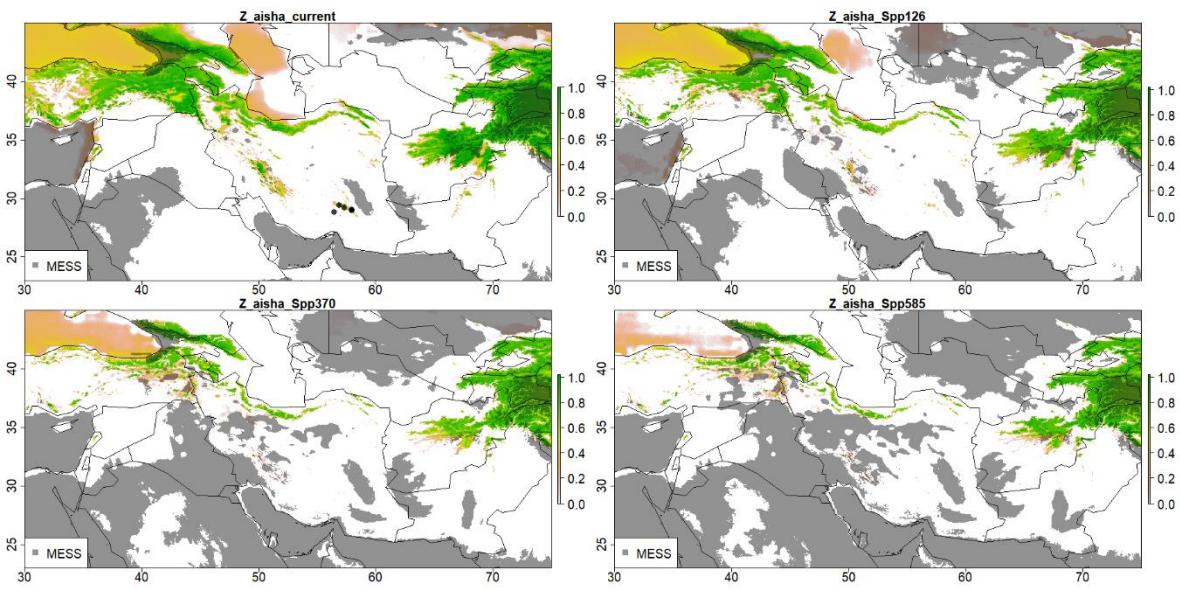


Figure S3. Habitat suitability of *Zygaena aisha*. Intensity of the green color depict higher probability for presence of the species in the study area.

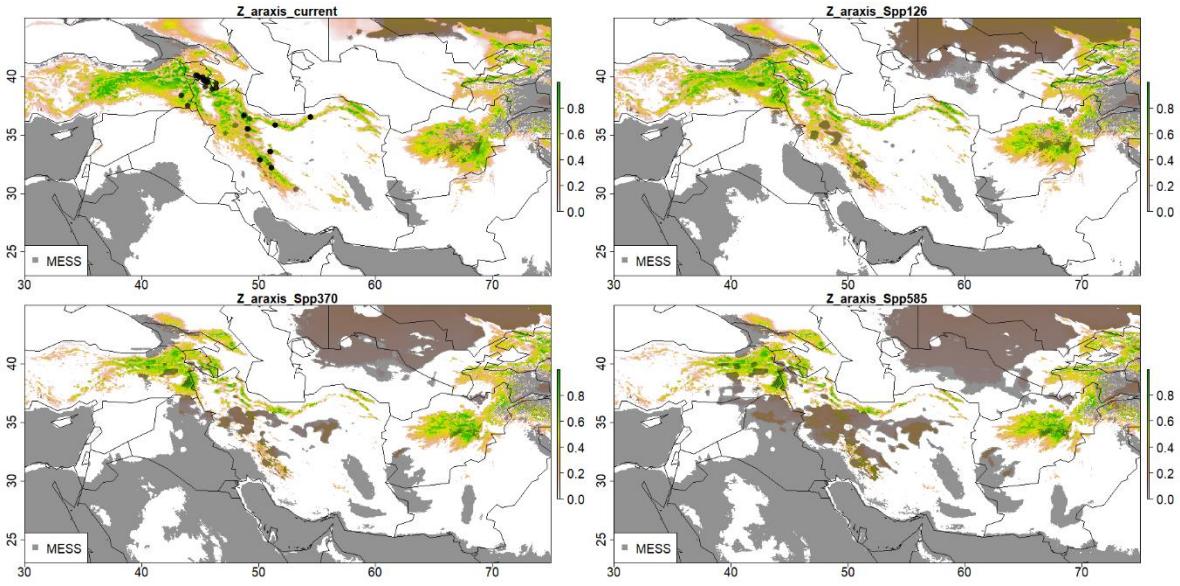


Figure S4. Habitat suitability of *Zygaena araxis*. Intensity of the green color depict higher probability for presence of the species in the study area.

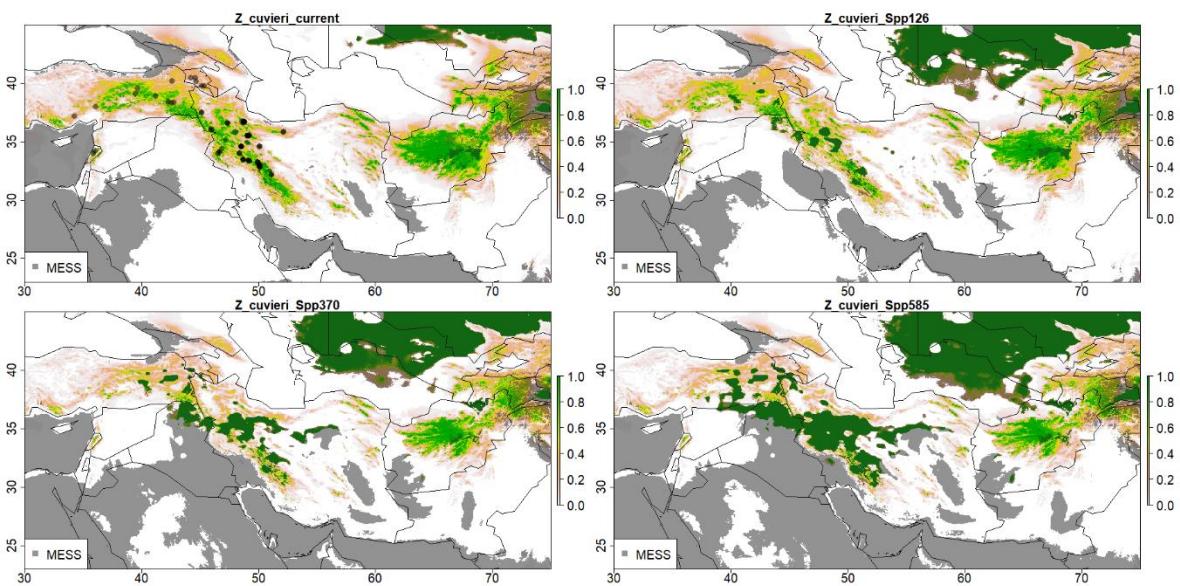


Figure S5. Habitat suitability of *Zygaena cuvieri*. Intensity of the green color depict higher probability for presence of the species in the study area.

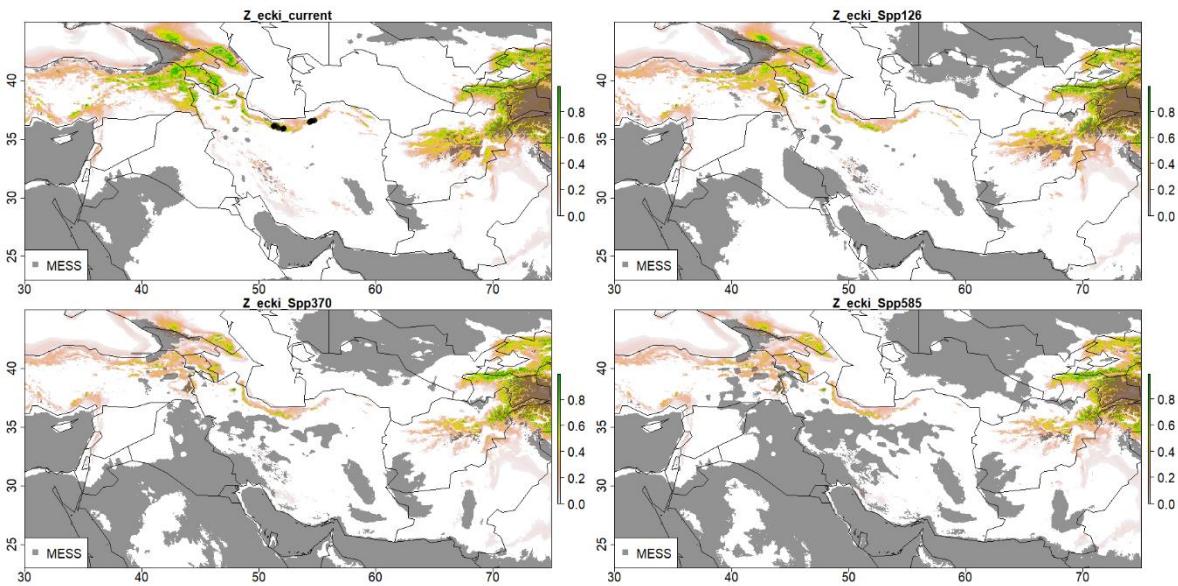


Figure S6. Habitat suitability of *Zygaena ecki*. Intensity of the green color depict higher probability for presence of the species in the study area.

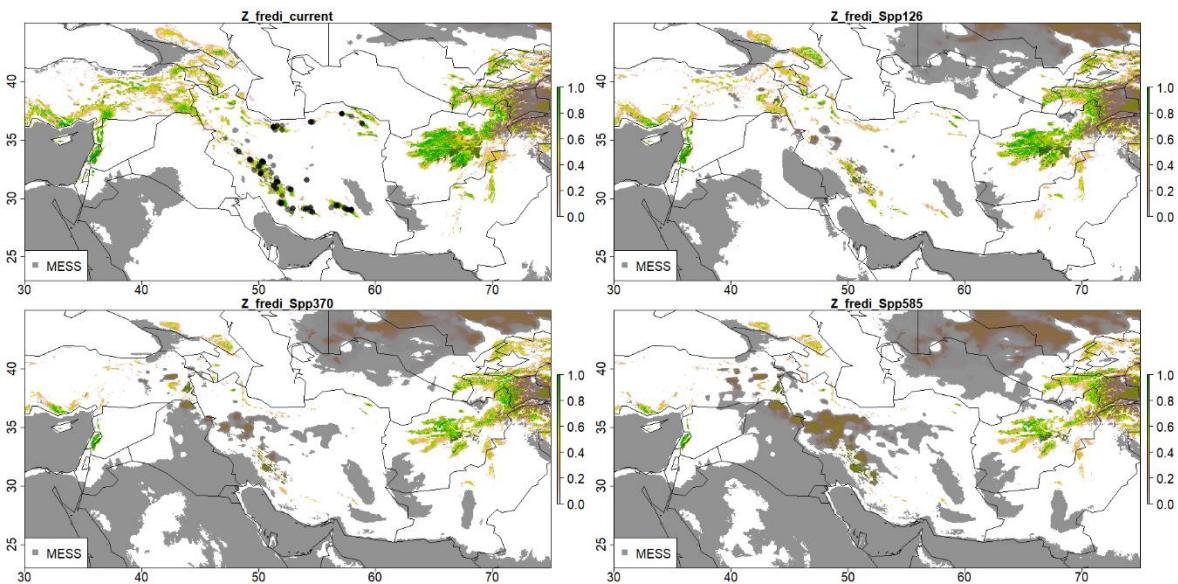


Figure S7. Habitat suitability of *Zygaena fredi*. Intensity of the green color depict higher probability for presence of the species in the study area.

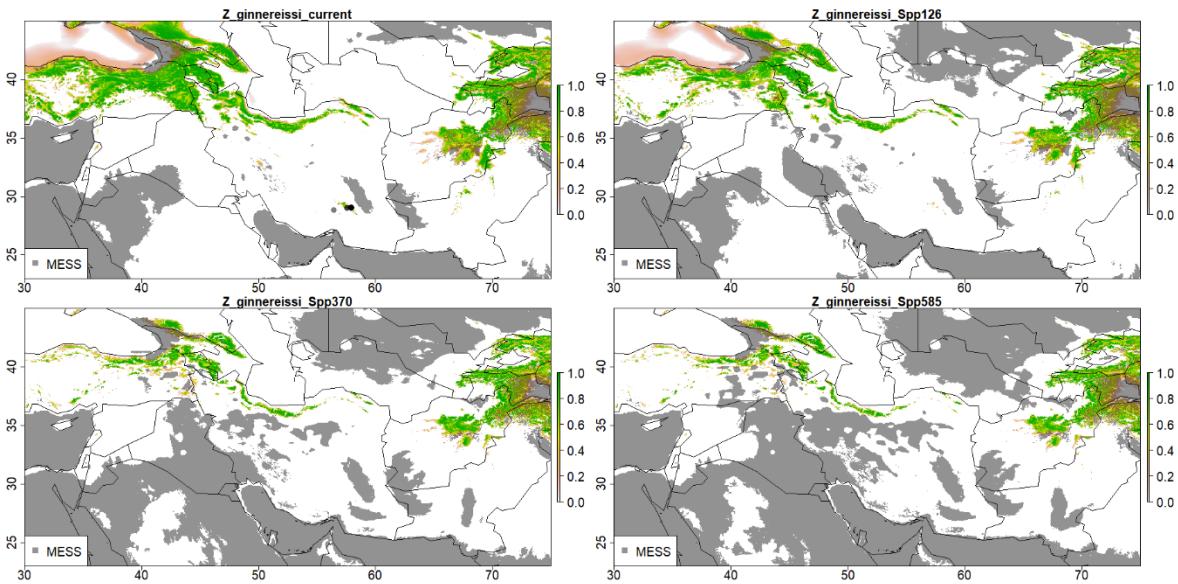


Figure S8. Habitat suitability of *Zygaena ginnereissi*. Intensity of the green color depict higher probability for presence of the species in the study area.

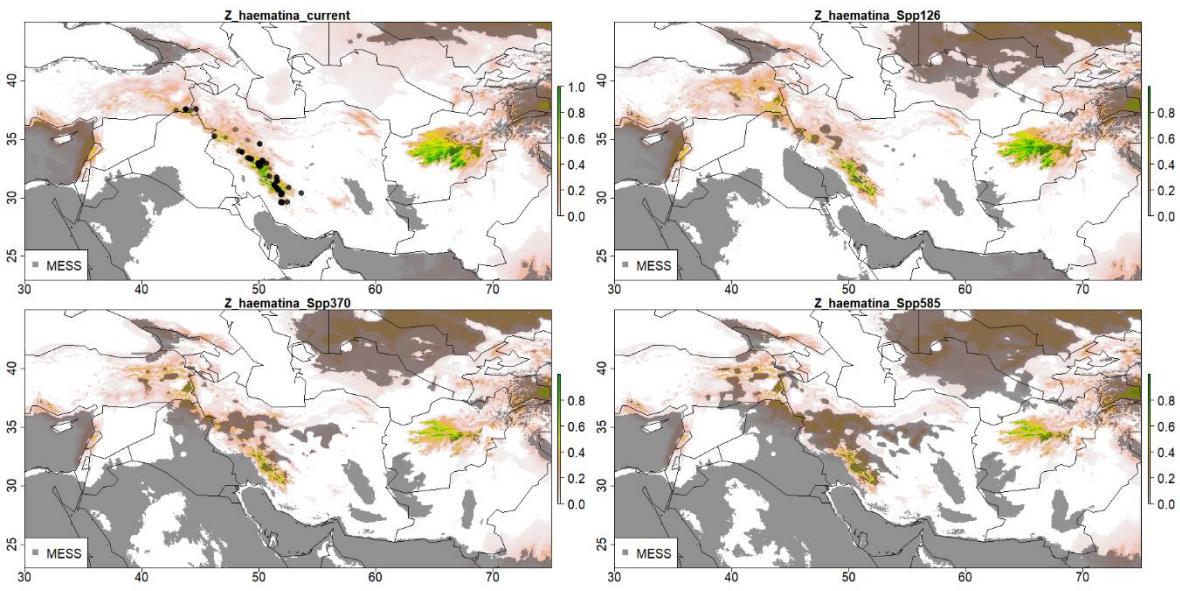


Figure S9. Habitat suitability of *Zygaena Zygaena haematina*. Intensity of the green color depict higher probability for presence of the species in the study area.

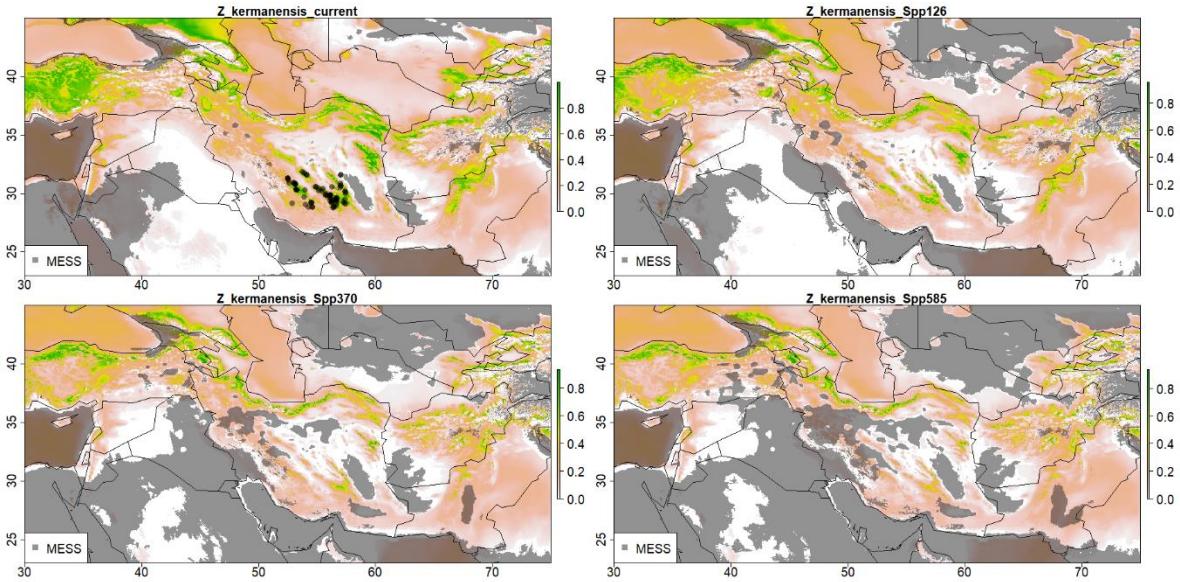


Figure S10. Habitat suitability of *Zygaena Zygaena kermanensis*. Intensity of the green color depict higher probability for presence of the species in the study area.

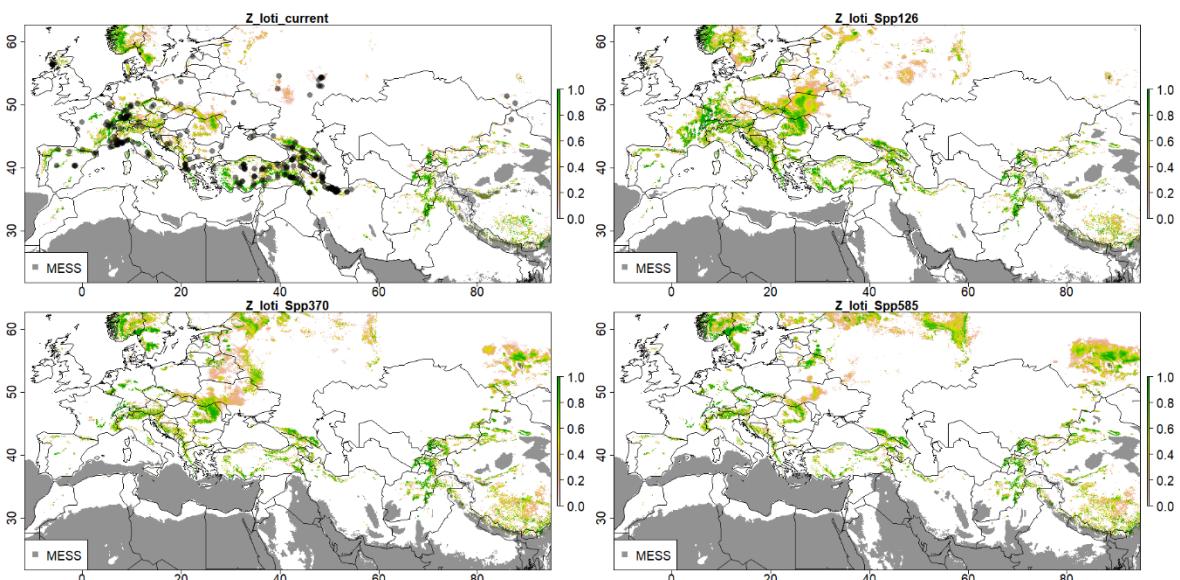


Figure S11. Habitatsuitability of *Zygaena loti*. Intensity of the green color depict higher probability for presence of the species in the study area.

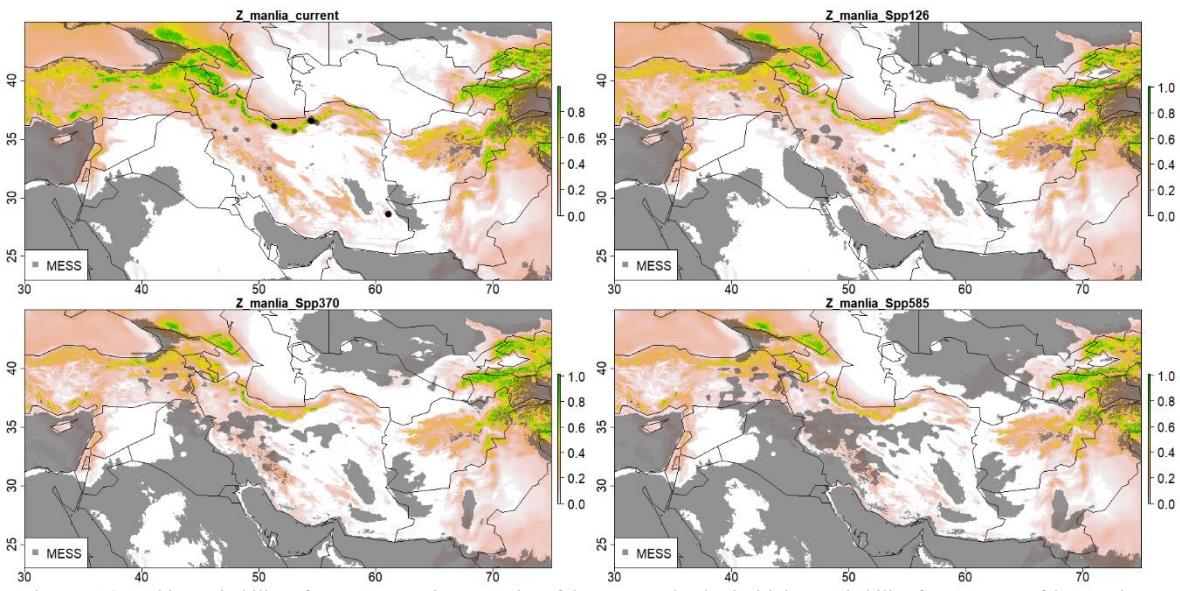


Figure S12. Habitat suitability of *Zygaena manlia*. Intensity of the green color depict higher probability for presence of the species in the study area.

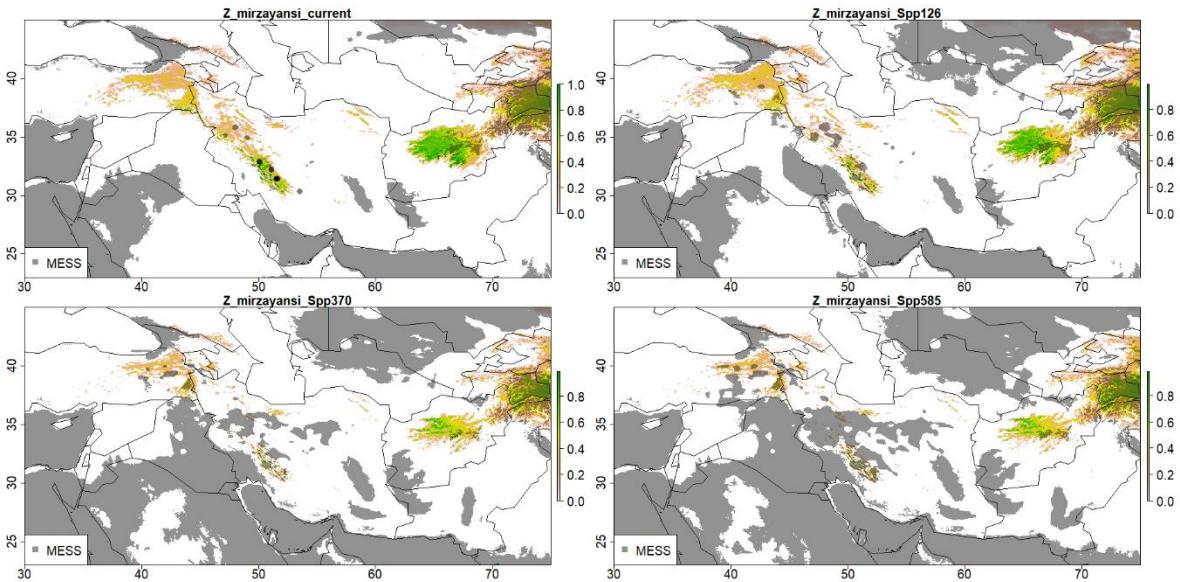


Figure S13. Habitat suitability of *Zygaena mirzayansi*. Intensity of the green color depict higher probability for presence of the species in the study area.

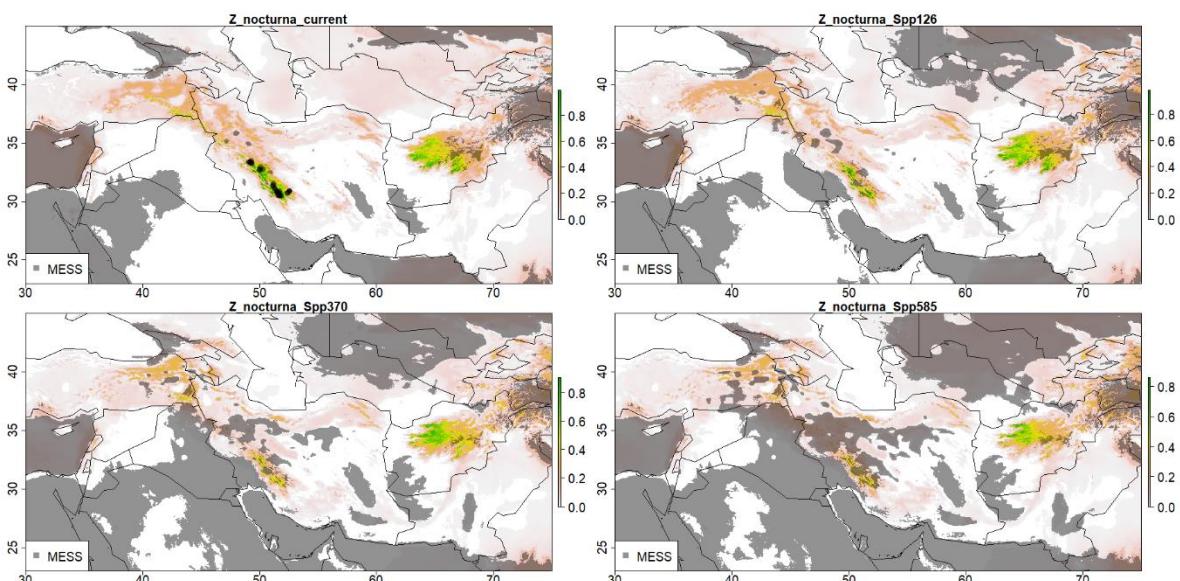


Figure S14. Habitat suitability of *Zygaena nocturna*. Intensity of the green color depict higher probability for presence of the species in the study area.

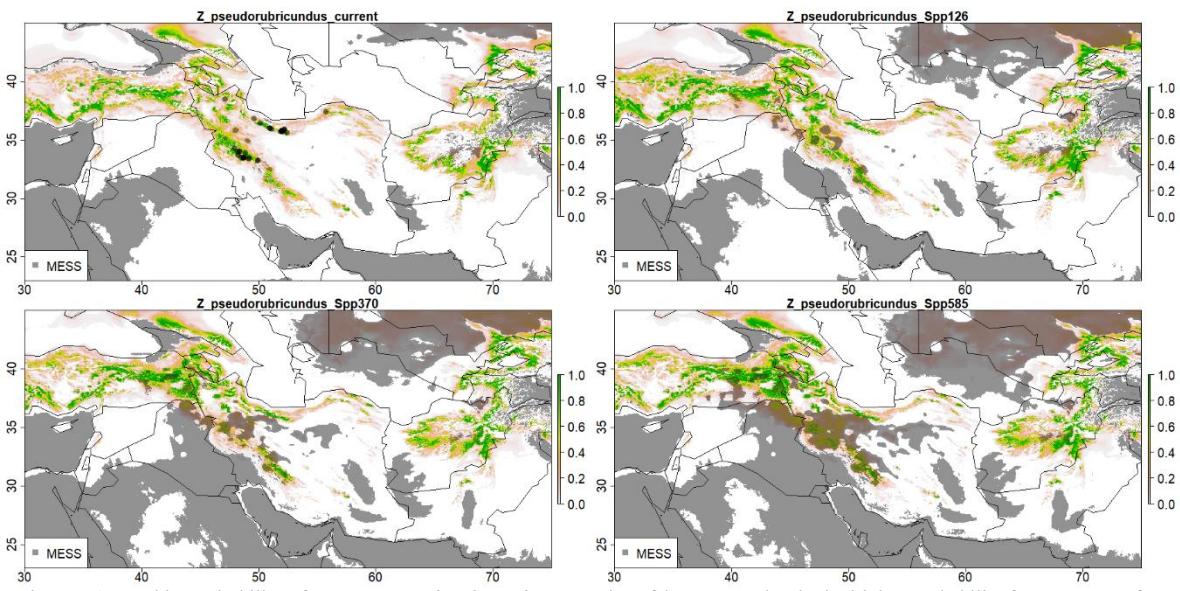


Figure S15. Habitat suitability of *Zygaena pseudorubicundus*. Intensity of the green color depict higher probability for presence of the species in the study area.

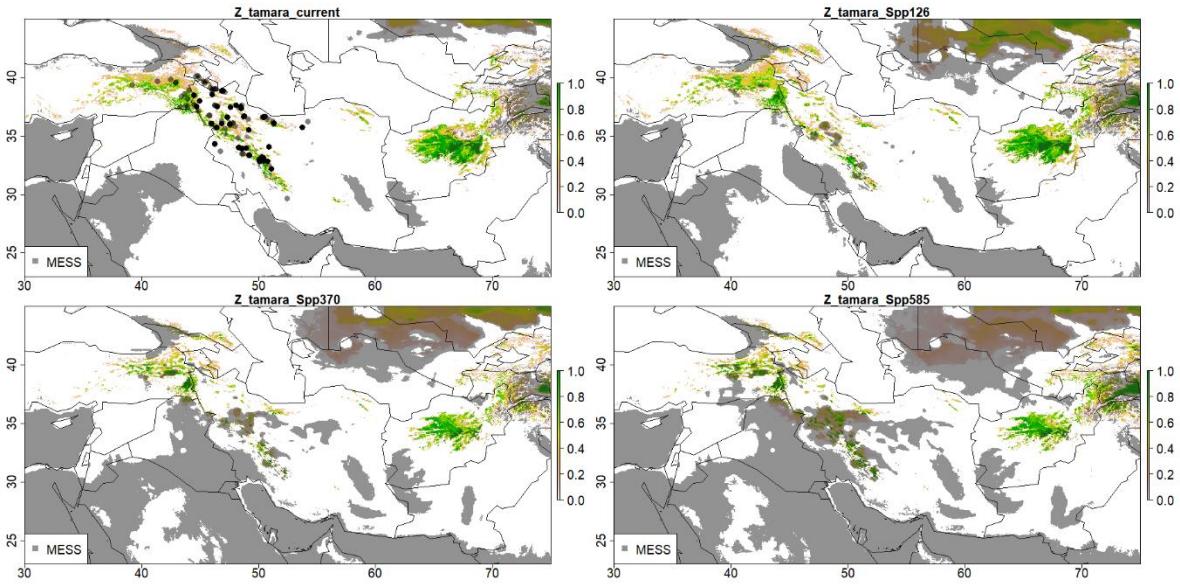


Figure S16. Habitat suitability of *Zygaena tamara*. Intensity of the green color depict higher probability for presence of the species in the study area.

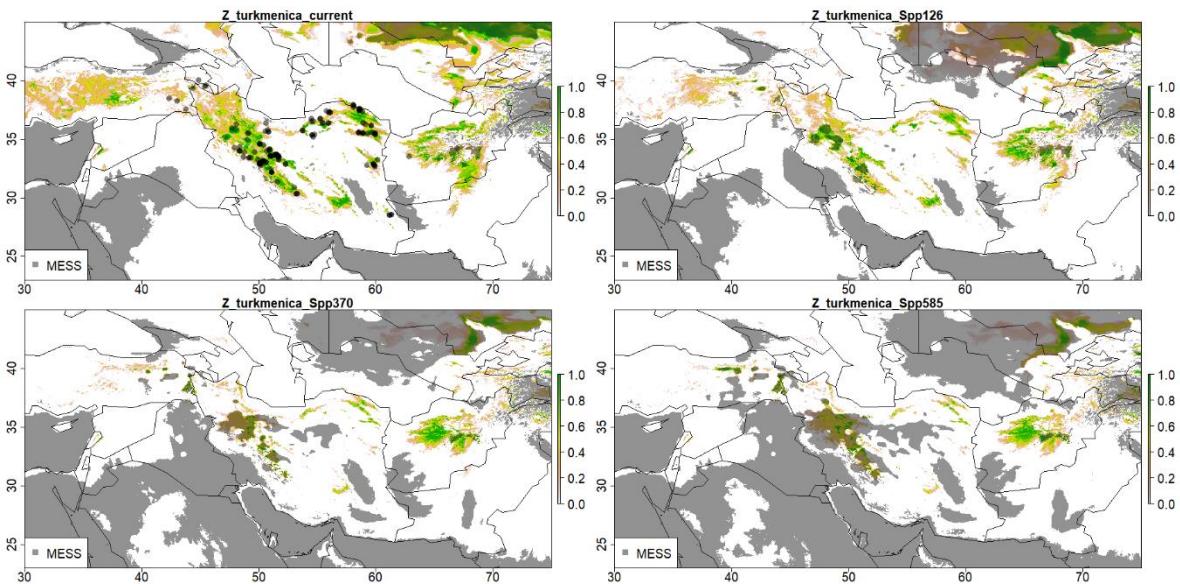


Figure S17. Habitat suitability of *Zygaena turkmenica*. Intensity of the green color depict higher probability for presence of the species in the study area.

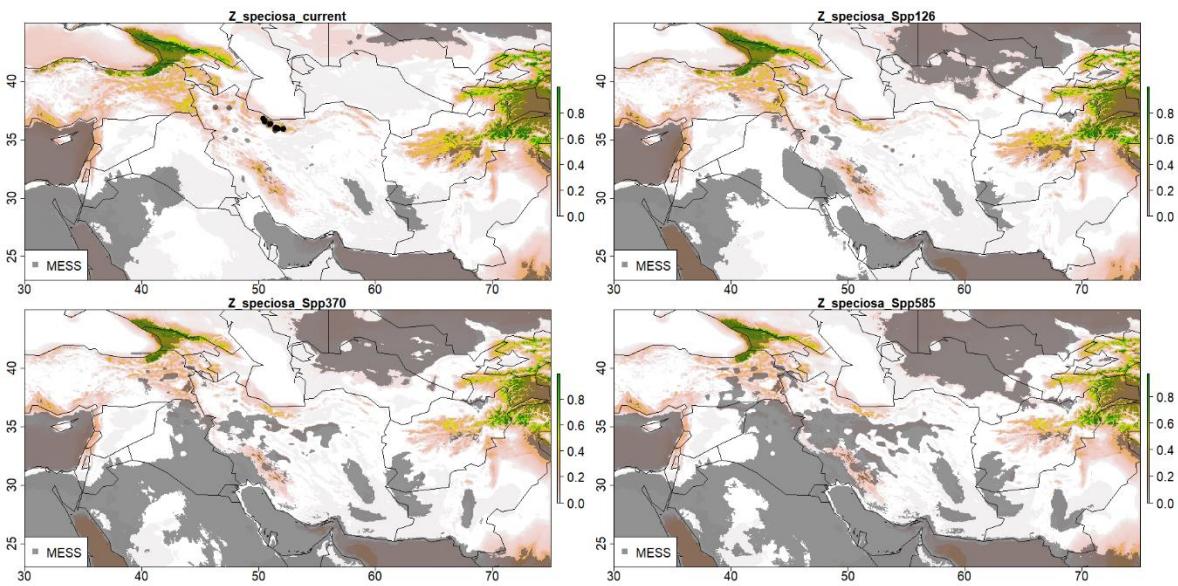


Figure S18. Habitat suitability of *Zygaena speciosa*. Intensity of the green color depict higher probability for presence of the species in the study area.

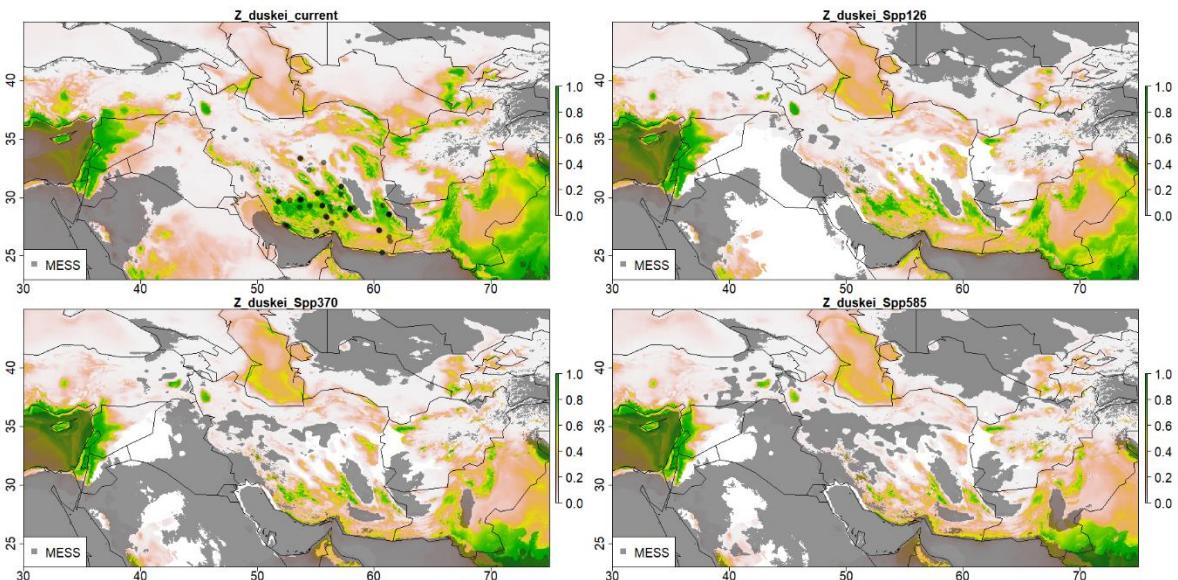


Figure S19. Habitat suitability of *Zygaenoprocis duskei*. Intensity of the green color depict higher probability for presence of the species in the study area.

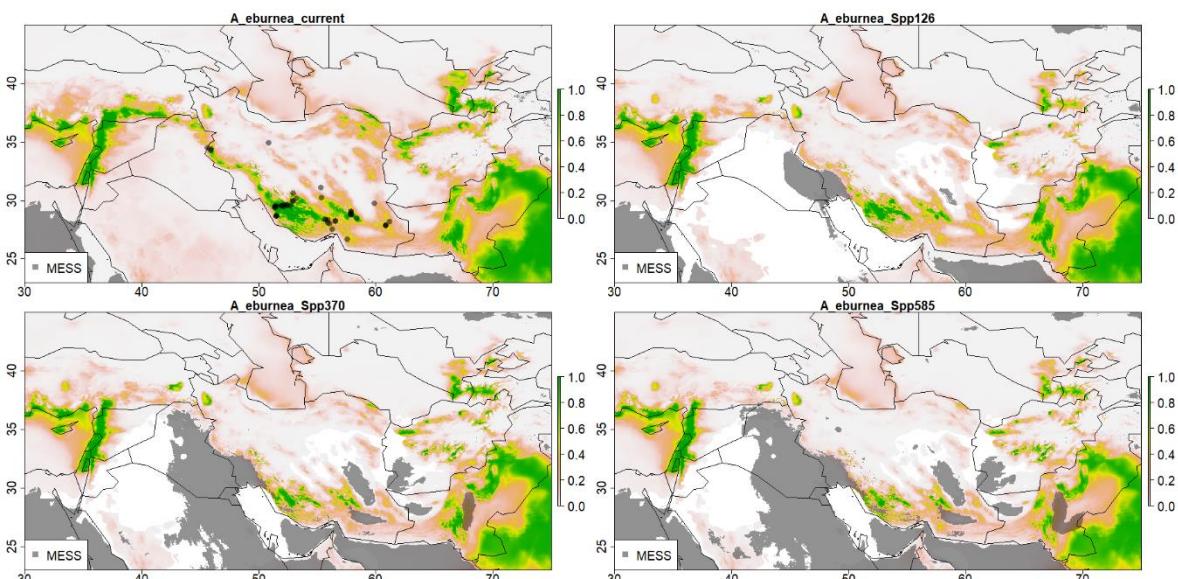


Figure S20. Habitat suitability of *Amygdalus eburnea*, host plant for *Rhagades brandti*. Intensity of the green color depict higher probability for presence of the species in the study area.

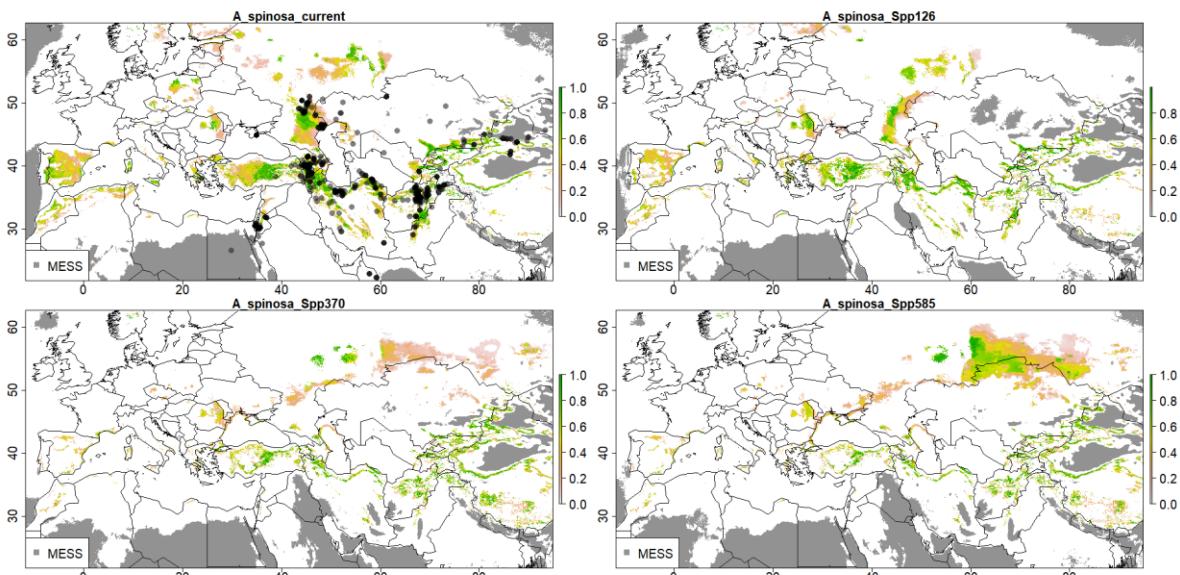


Figure S21. Habitat suitability of *Atraphaxis spinosa*, host plant for *Zygaenoprocis duskei*. Intensity of the green color depict higher probability for presence of the species in the study area

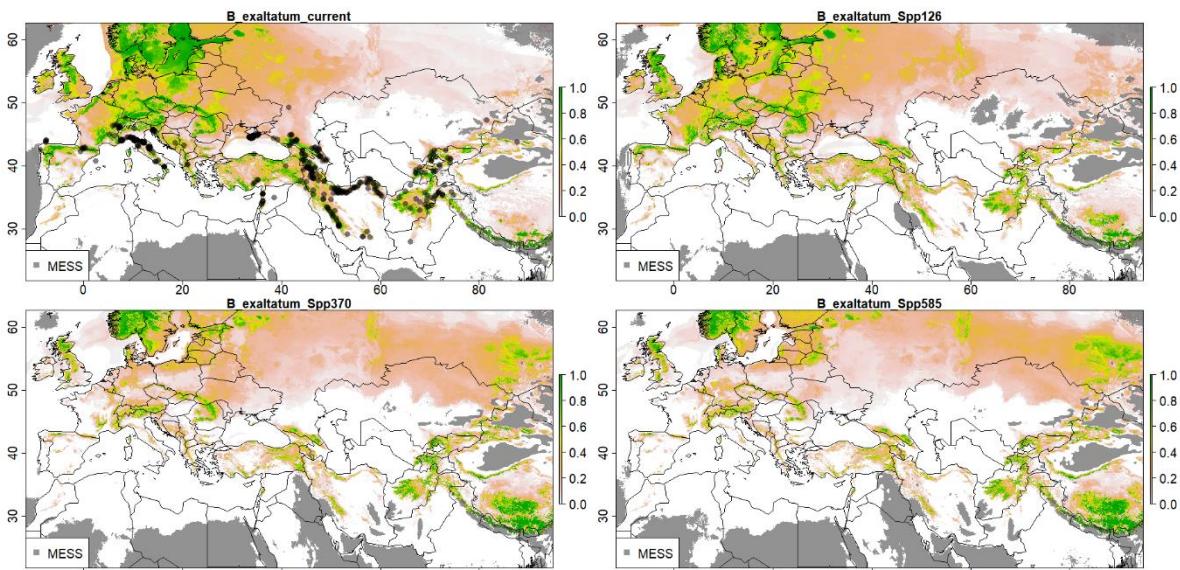


Figure S22. Habitat suitability of *Bupleurum exaltatum*, host plant for *Zygaena araxis*, *Z. fredi* and *Z. manlia*. Intensity of the green color depict higher probability for presence of the species in the study area.

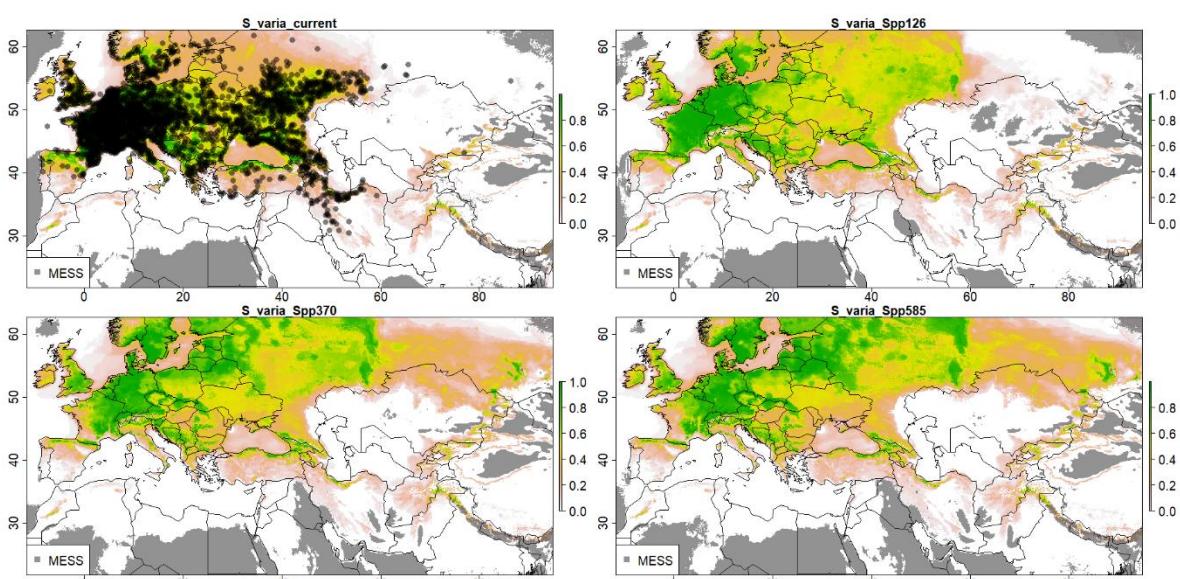


Figure S23. Habitat suitability of *Securigera varia*, host plant for *Zygaena loti*. Intensity of the green color depict higher probability for presence of the species in the study area.

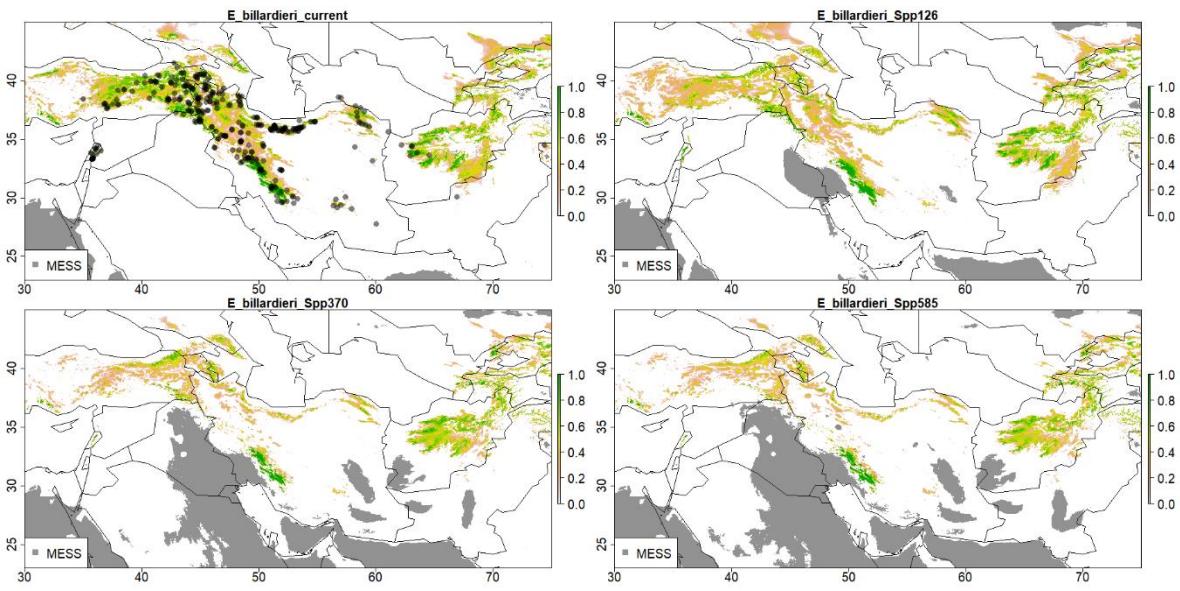


Figure S24. Habitat suitability of *Eryngium billardieri*, host plant for *Zygaena cuvieri*, *Z. ginnereissi*, *Z. kermanensis*, *Z. mirzayansi*, *Z. nocturna*, *Z. tamara* and *Z. turkmenica*. Intensity of the green color depict higher probability for presence of the species in the study area.

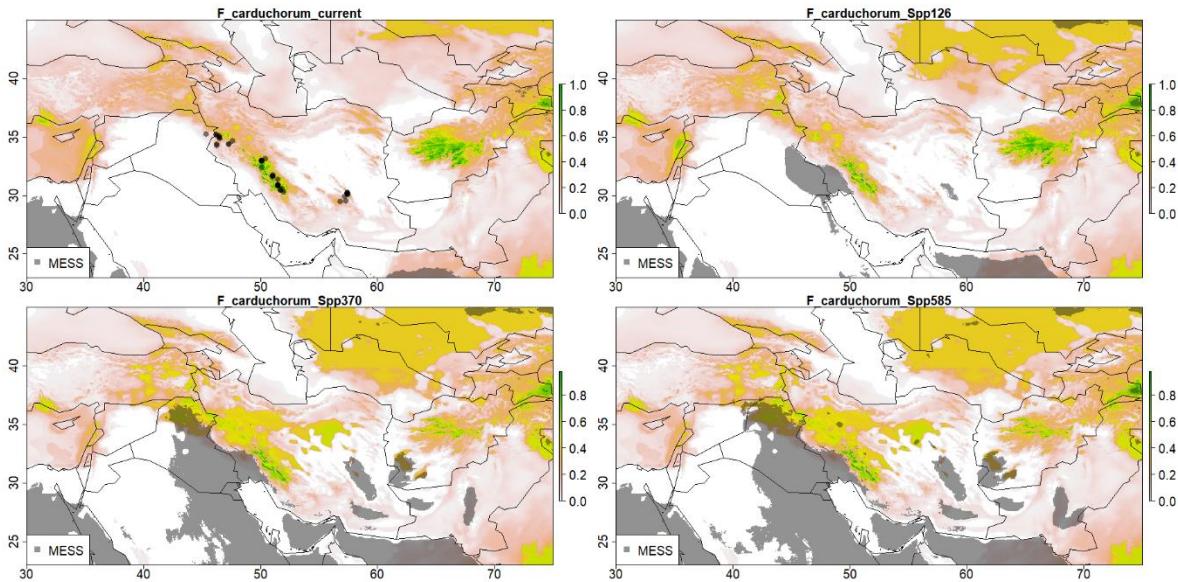


Figure S25. Habitat suitability of *Ferulago carduchorum*, host plant for *Zygaena haematina*. Intensity of the green color depict higher probability for presence of the species in the study area.

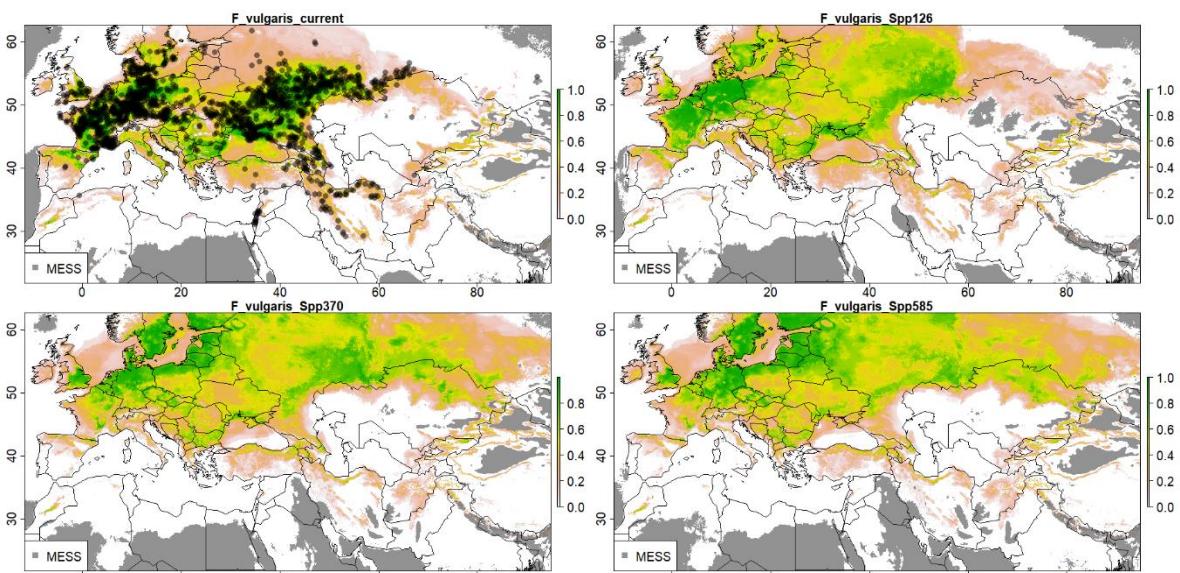


Figure S26. Habitat suitability of *Falcaria vulgaris*, host plant for *Zygaena pseudorubicundus*. Intensity of the green color depict higher probability for presence of the species in the study area.

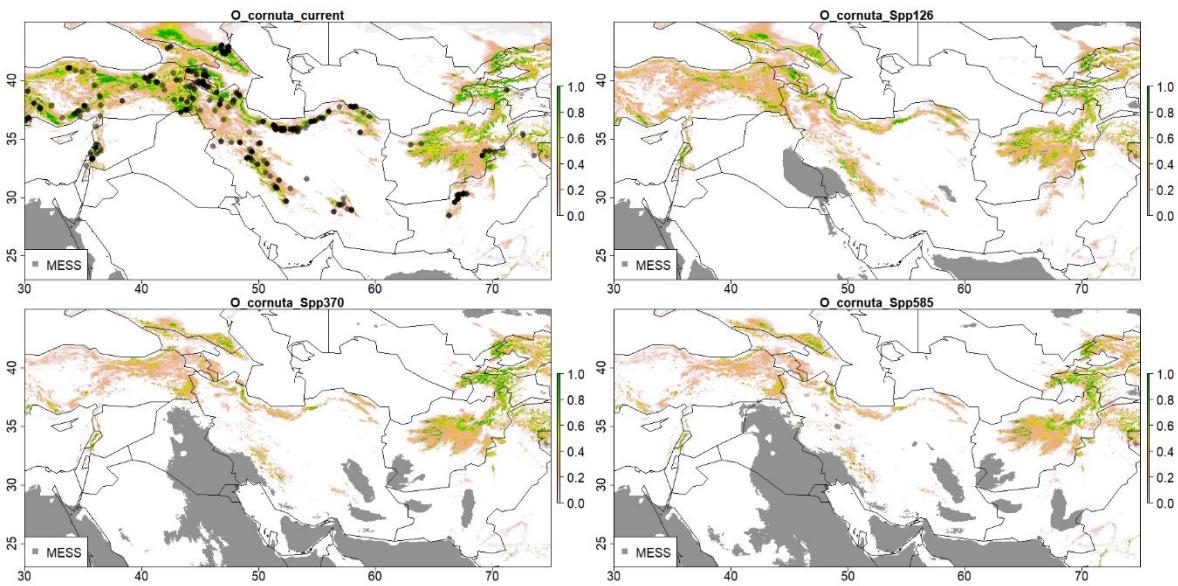


Figure S27. Habitat suitability of *Onobrychis cornuta*, host plant for *Zygaena ecki*. Intensity of the green color depict higher probability for presence of the species in the study area.

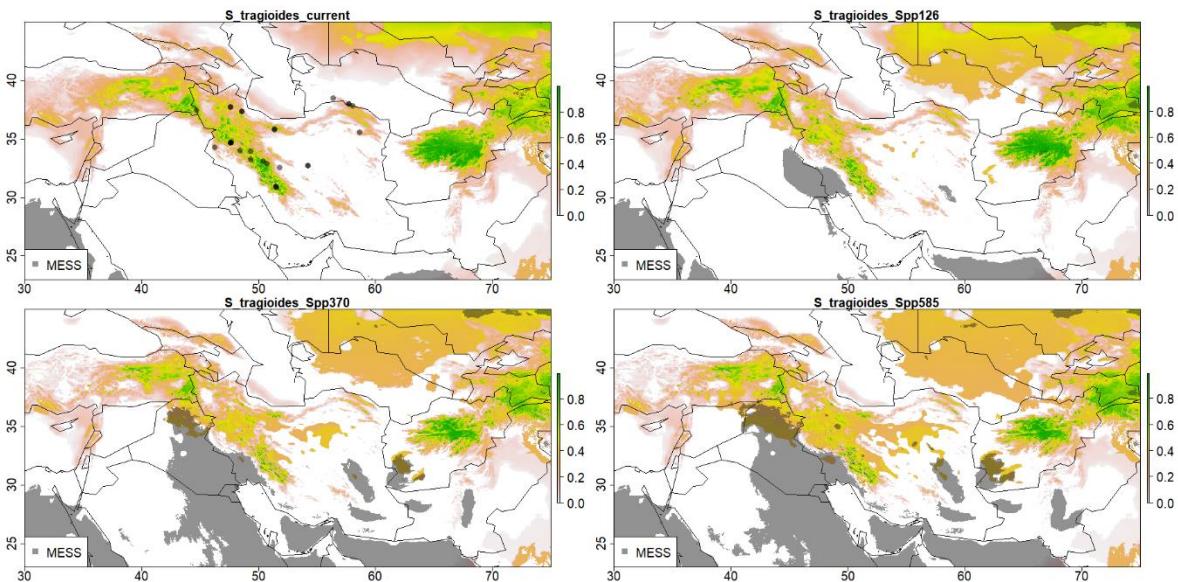


Figure S28. Habitat suitability of *Semenovia tragioides*, host plant for *Zygaena fredi* and *Zygaena speciosa*. Intensity of the green color depict higher probability for presence of the species in the study area.

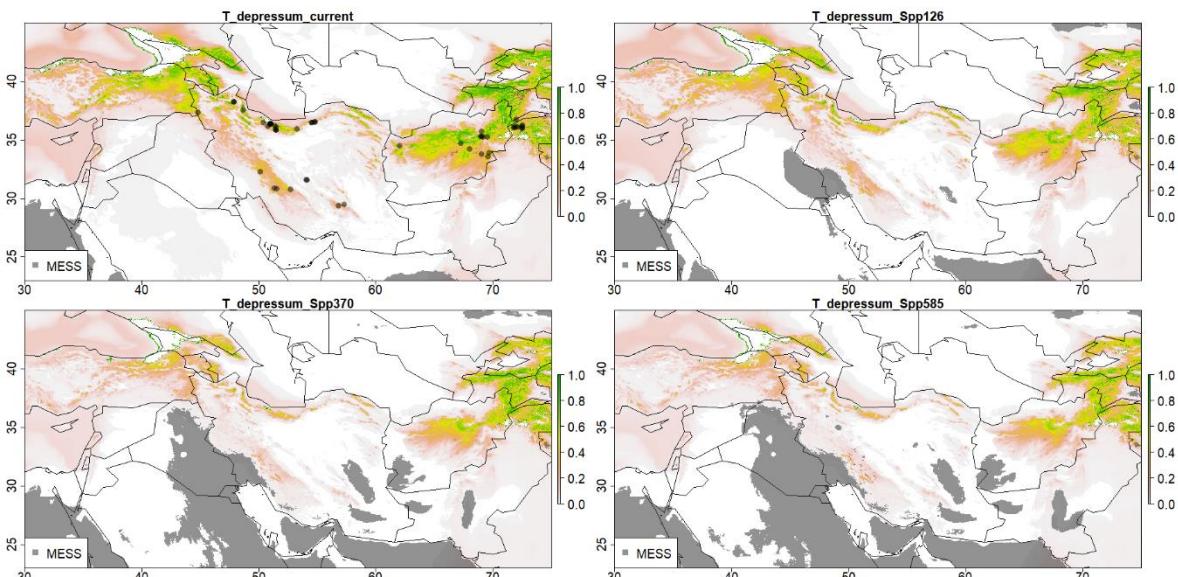


Figure S29. Habitat suitability of *Trachydium depressum*, host plant for *Zygaena speciosa*. Intensity of the green color depict higher probability for presence of the species in the study area.

III. References for GBIF datasets

The occurrence dataset for some of the hostplant species were downloaded from Global Biodiversity Information Facility; www.gbif.org. Table S1 depicts the references for each species dataset.

Table S1. References for downloaded occurrence data of hostplants from GBIF database.

Species	Reference
<i>Amygdalus eburnea</i> Spach	GBIF.org (14 October 2022) GBIF Occurrence Download https://doi.org/10.15468/dl.xncv4p
<i>Atraphaxis spinosa</i> L.	GBIF.org (14 October 2022) GBIF Occurrence Download https://doi.org/10.15468/dl.n85dtk
<i>Bupleurum exaltatum</i> M.Bieb.	GBIF.org (14 October 2022) GBIF Occurrence Download https://doi.org/10.15468/dl.4pyhjd
<i>Eryngium billardieri</i> Delile	GBIF.org (14 October 2022) GBIF Occurrence Download https://doi.org/10.15468/dl.swr3u6
<i>Ferulago carduchorum</i> Boiss. & Hausskn.	GBIF.org (14 October 2022) GBIF Occurrence Download https://doi.org/10.15468/dl.a8snqd
<i>Falcaria vulgaris</i> Bernh.	GBIF.org (14 October 2022) GBIF Occurrence Download https://doi.org/10.15468/dl.bd8fkh
<i>Onobrychis cornuta</i> (L.) Desv.	GBIF.org (14 October 2022) GBIF Occurrence Download https://doi.org/10.15468/dl.f4hcyp
<i>Securigera varia</i> L.	GBIF.org (14 October 2022) GBIF Occurrence Download https://doi.org/10.15468/dl.fvs8c3
<i>Semenovia tragioides</i> (Boiss.) Manden.	GBIF.org (14 October 2022) GBIF Occurrence Download https://doi.org/10.15468/dl.4bnfhf
<i>Trachydium depressum</i> (Boiss.) Boiss.	GBIF.org (14 October 2022) GBIF Occurrence Download https://doi.org/10.15468/dl.jtwqcs

IV. Important environmental variables

The following graphs show the contribution of each environmental variable to the prediction model of zygeanid species and their host plant species distribution. We also imported the prediction of habitat suitability for host plants to anticipate species distribution of moths. We used different functions to extract the values of variable contribution from SDM and ESMs products, since then here we came up with different plots for each approach. For SDM we used `get_variables_importance`, which resulted in values for each variable per run. On the otherhand, in ESMs the function `ecospat.ESM.VarContrib` was used which returns a unique value for each variable. Here, we plot the results of both functions. Results of SDM are plotted using a boxplot with quantiles the values per run, while we presented the results of ESMs as bar plot, which values higher than 1 indicate the higher contribution of the variable in the model more than average.

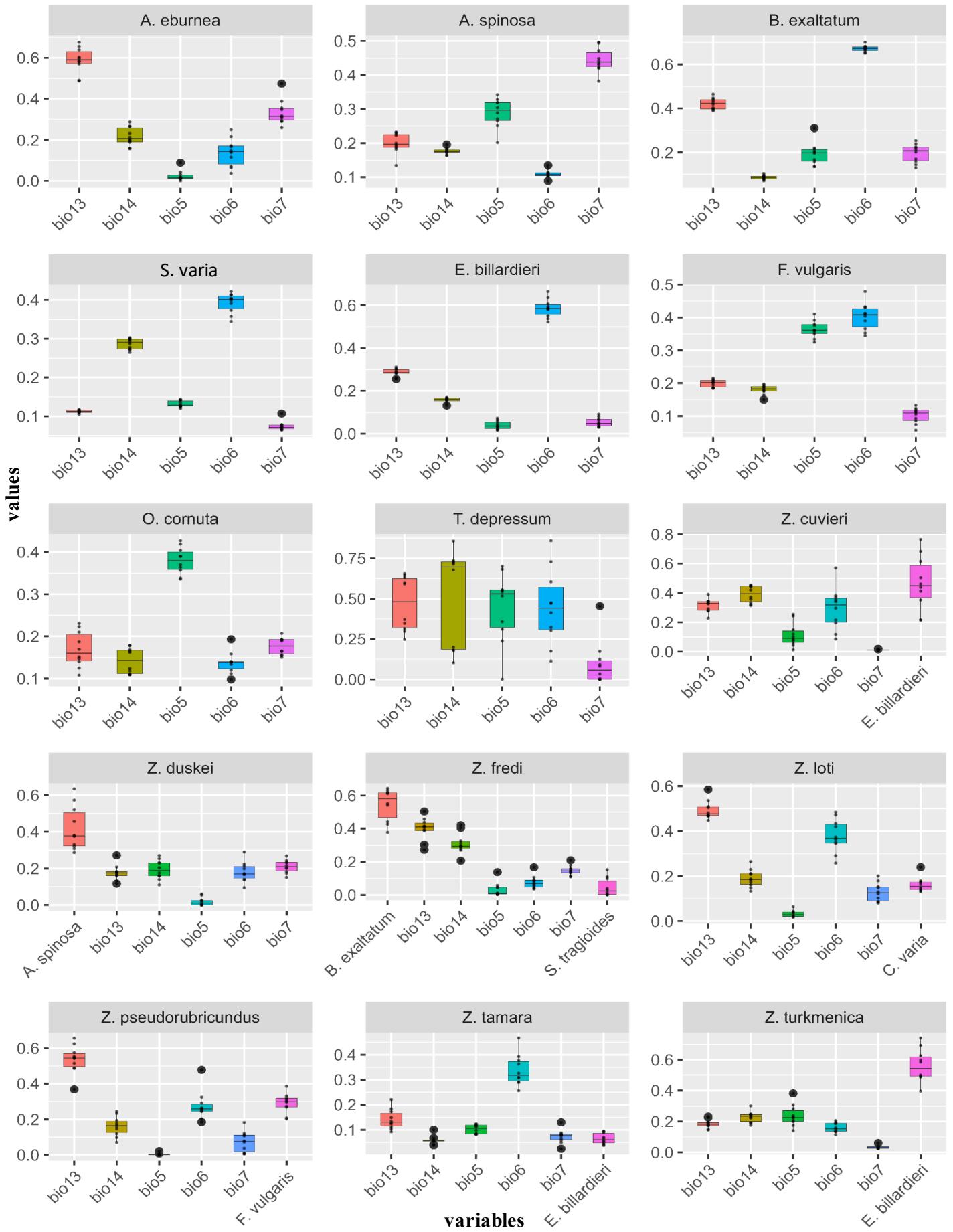


Figure S30. Contribution of each environmental variables and host plant for zygaenid moth and their host plants in species distribution modeling (SDM). Black dots represent the contribution of each variable in model per run. The box plots show median and interquartile (25%-75%) of contribution values.

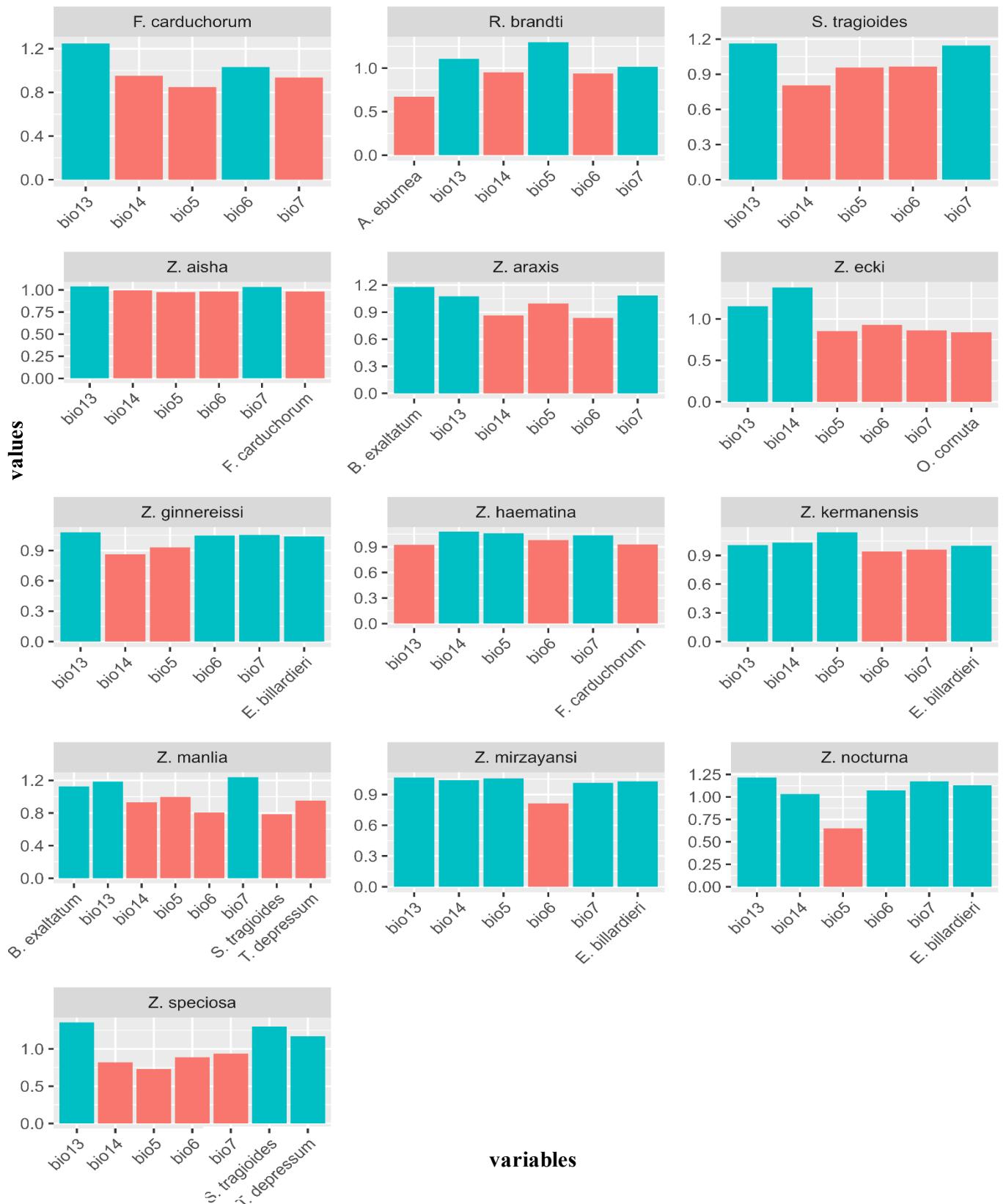


Figure S31. Variable Importance, contribution of environmental variables and host plant, in the Ensemble Small Models (ESMs) for zygaenid moths. Here model with higher values have the most significant impact of the ensemble prediction.