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BDI: A tool for management and conservation of Iran's biodiversity

Elahi, M.[1,2], Elahi, J.[3] and Aliabadian, M.[1,4],*

[1] *Department of Biology, Faculty of Science, Ferdowsi University of Mashhad, Mashhad, Iran.*
[2] *Department of Environmental Sciences & Engineering, Faculty of Agriculture & Natural Resources, Ardakan University, P.O. Box 184, Ardakan, Iran*
[3] *ENTEZAR software group, Iran*
[4] *Research Department of Zoological Innovations, Institute of Applied Zoology, Faculty of Science, Ferdowsi University of Mashhad, Mashhad, Iran*

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Abstract
Biodiversity is one of the key components of environmental sustainability and its conservation is very important. To conserve biodiversity, both its management and measurement management are necessary. Biodiversity measurement means some quantitative value that can be ascribed to the various measurements so these values can be compared. With its geographic and climatic variety, Iran has a valuable biodiversity, which includes about 1130, 25000, and 8000 species of vertebrates, invertebrates and flora, respectively. Due to the large amount of data (occurrence points) and complexity of calculations, utilizing computer programs is essential. We here present BDI v. 1.0.0 (BioDiversity of Iran), a user-friendly software utility which facilitates the biodiversity management and conservation by documenting the data and calculating the most commonly used biodiversity indices and then spatially visualizes the results on a map. While we acknowledge the other computer programs in this field, this software has a high spatial precision and resolution and is able to read and create both graphical and digital data formats. BDI is highly efficient in biodiversity evaluation and conservation priorities of protected areas.

Key words: *BDI, Software, Biodiversity indices, Iran.*

INTRODUCTION

Biodiversity is one of the key components of environmental sustainability, and achieving higher biodiversity can enhance the temporal stability of all ecosystem properties (Vackar *et al.* 2012; Wang & Loreau 2016). The term biodiversity (biological diversity) was first used by Lovejoy (1980) and describes the number of species. In fact, biodiversity represents the complexity of life on Earth, and has four dimensions: phenotypic, genotypic, taxonomic, and ecologic. Biodiversity can be measured within taxa (e.g., genetic diversity), across taxa (e.g., species diversity, which includes important conceptual components: richness, evenness, dominance, and rarity), or across ecosystems (e.g., landscape diversity) (Swingland 2001; Wilsey *et al.* 2005).

To conserve biodiversity, both its management and measurement management are necessary. Biodiversity measurement means some quantitative value that can be ascribed to the various measurements so these values can be compared (Swingland 2001). Three spatial scales for measuring biodiversity are alpha (diversity within a community or ecosystem), beta (diversity between communities or ecosystems), and gamma (overall diversity within a geographical area) (Whittaker 1972). To measure the different components of biodiversity, a great variety of indices were proposed (Morris *et al.* 2014). An efficient way to calculate biodiversity indices is using computer programs. In other words, to better

*Corresponding Author: aliabadi@um.ac.ir

identify and conserve biodiversity, utilizing modern and efficient tools such as computer programs is essential (Casanoves *et al.* 2011).

Iran, with a terrestrial surface area of 1,648,195 km^2 (equivalent to the combined surface areas of Spain, Germany, France, and the United Kingdom), is the seventeenth largest country in the world (Jowkar *et al.* 2016). Because of its geographic and climatic variety, Iran has valuable biodiversity and is one of the most important countries in the Middle East in biodiversity conservation. The ecosystems of Iran contain approximately 1130, 25000, and 8000 species of vertebrates, invertebrates and flora, respectively (Farashi & Shariati 2017; Department of Environment of Iran 2015).

Although there are several different computer programs such as Biodiverse (Laffan *et al.* 2010), EcoMeth (Kenny & Krebs 2001), WorldMap (Williams 2000), EstimateS (Colwell & Elsensohn 2014), and BIODIV (Baev & Penev 1995) in this field, the creation of a particular spatial visualization program with high precision and resolution and the ability to read and create both graphical and digital data formats were necessary. This has motivated the development of a rapid, convenient, and reliable computer program for management of Iran's biodiversity.

MATERIAL AND METHODS

The program: BDI v. 1.0.0 (BioDiversity of Iran)

Here introduced is BDI, a user-friendly software utility to facilitate two aims: 1) spatial visualization of taxa distribution with high precision and resolution and 2) facilitation of the calculation process and interpretation of the most commonly used biodiversity indices (alpha indices) by reading the data on the map based on the taxonomic relationships.

To achieve the above objectives, the provincial border map of Iran was first prepared and divided into 4,480 square units (quadrates) with dimensions of about 25 * 25 kilometers. These georeferenced square units are the basis of the geographic visualization of taxa distribution and indices calculation.

BDI is written in C# and is available to download from http://appliedzoology.um.ac.ir free of charge. It can run under 32-bit or 64-bit MS Windows, with Microsoft Net Framework v. 4 or later, which is pre-installed in MS Windows 8 and higher. The program has been successfully tested in MS Windows 7, 8, and 10. To execute this program, the BDI zip file needs only to be decompressed and readily installed in the proper path.

Environment

The BDI software has a friendly environment. It is customizable for display in both the Persian and English languages. By logging into the application, the first window, "Biodiversity of Iran", contains four options: "File", "Help", and "Language". In the "File" menu, by selecting "New project", "Open", or "Samples", a window entitled "BDI" will be displayed (Fig. 1). This window includes two main parts: On the left side, there will be Iran's map as well as three menus and on the right side, a panel with several tabs.

Importing data

The principle category for all calculations in the program is "species", and the taxonomic status of taxa will be considered. Whenever some species are selected by the user to calculate an index, the software will automatically select all species within that category. Hence, before inputting the taxa abundance and occurrence point data, the taxonomic status of each taxon must be defined (located on tree) for the software in the path: "File" > "Taxa management" (Fig. 2).

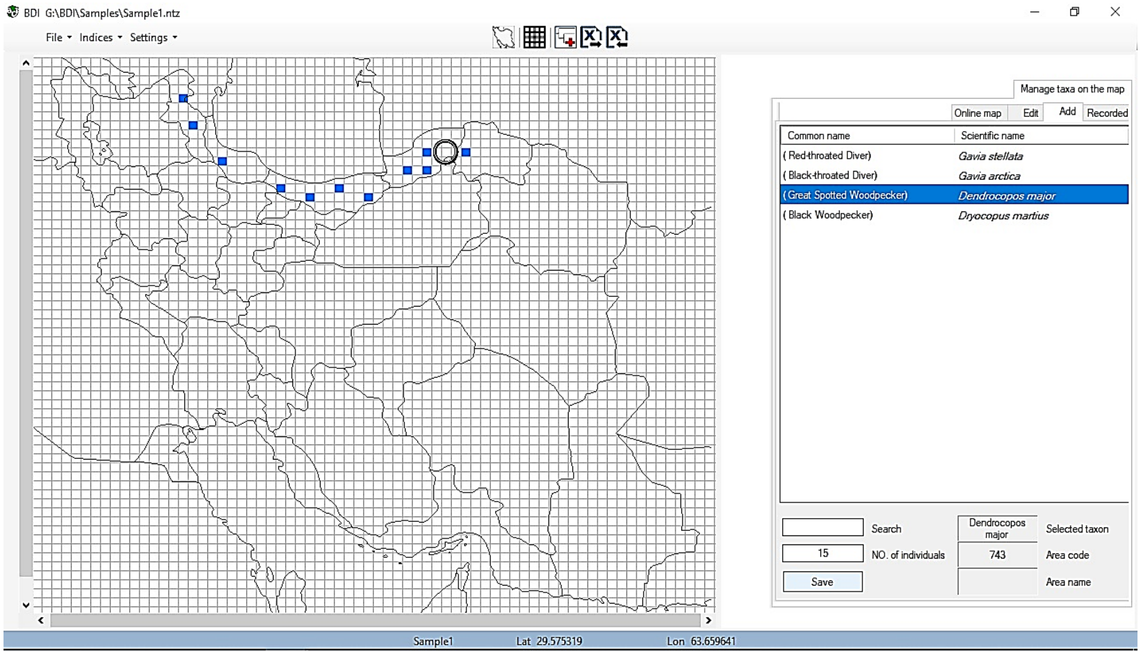

FIGURE 1. "BDI" window, the most usable window in the program.

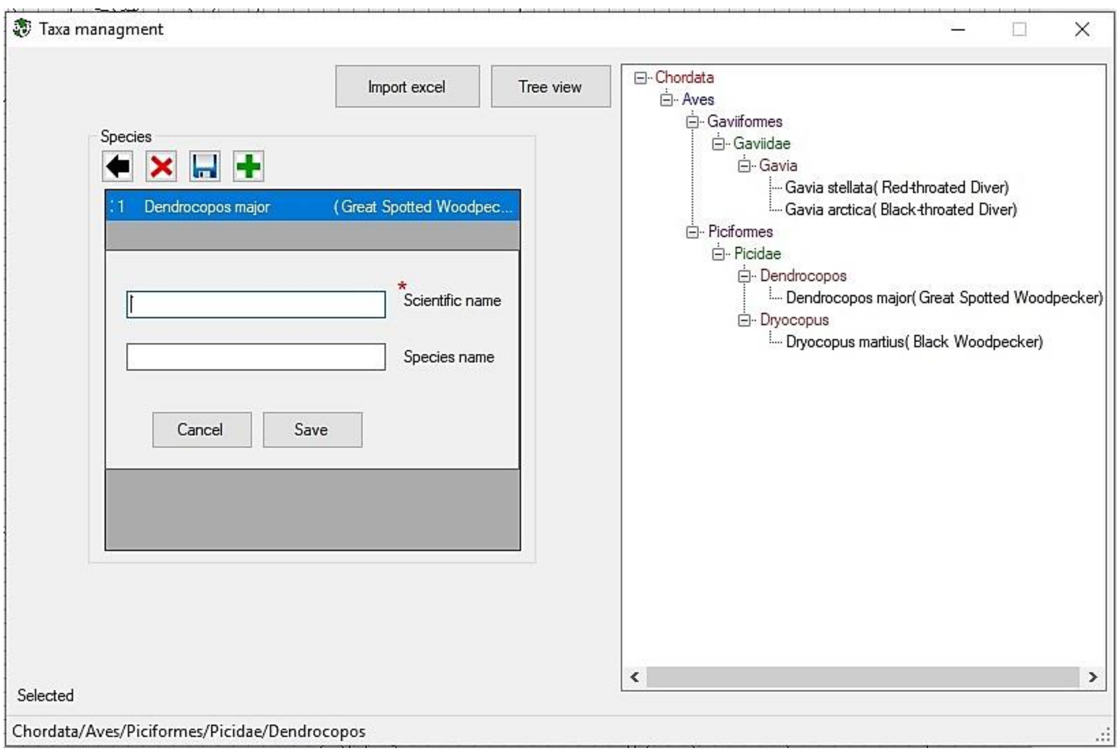

FIGURE 2. The "Taxa management" window contains two parts: taxa entry (on the left) and tree panel (on the right).

There are two ways to insert taxa on the map:

a) When occurrence point data are available in MS Excel format, it is possible to import data by clicking "File" > "Import Excel".

b) Whenever the data are not available in Excel format, manually select the species name from the "Add" panel and then add it to the quadrates on the left side (Fig. 1).
Data correction is available in the "Edit" panel whenever the saved taxa must be changed.

RESULTS

Calculating the biodiversity indices

The BDI software can calculate 16 biodiversity indices within three concepts of biodiversity, Species Richness, Heterogeneity, and Evenness (Table 1) (Krebs 1999). The user should select only the taxa names from the "Recorded" panel and then click on the relevant index accessible in the "Indices" menu. Only quadrates containing at least two species will be calculated. The results will be displayed in two formats: a) table (except Jackknife and Bootstrap) and b) map (except Jackknife, Rarefaction, and Bootstrap) (Fig. 3). An example input file which contains four bird species distributed in northern Iran is provided to calculate more indices in the software package in the path: "File" > "Samples" > "Sample 1".

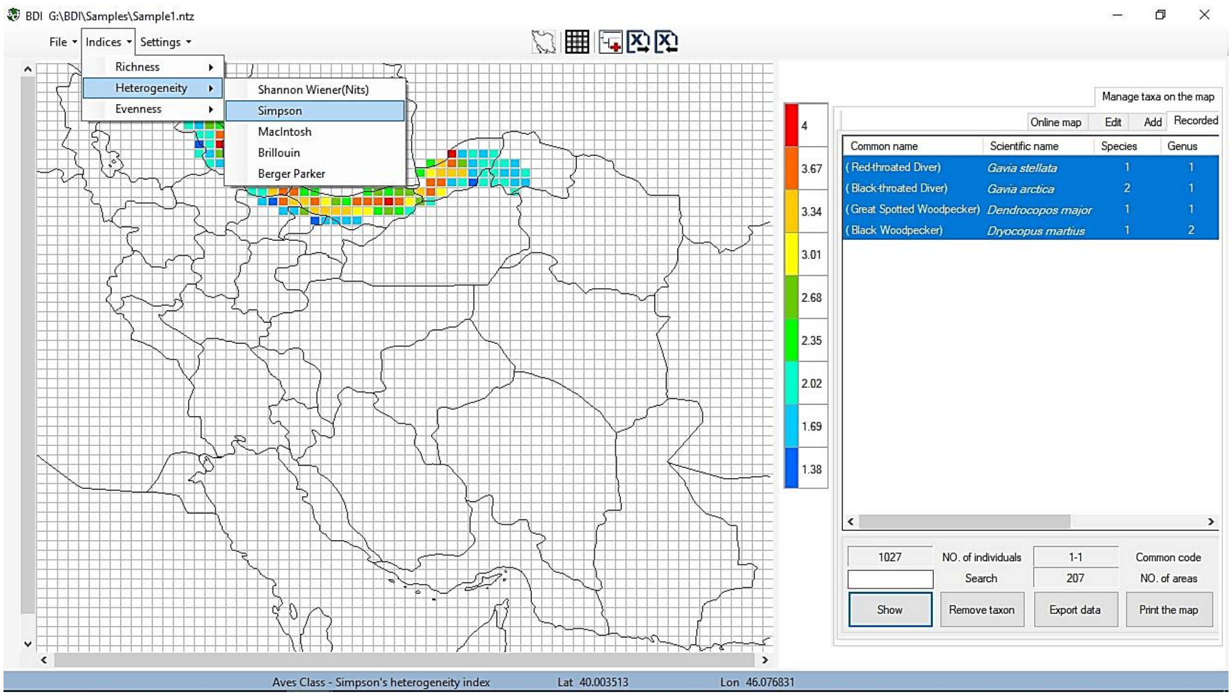

FIGURE 3. Final visualized result (Simpson's heterogeneity index).

DISSCUSSION

BDI is a software tool developed to document the georeferenced biological specimen and survey data, as well as to analyze the spatial patterns of a broad array of biodiversity indices (species richness, heterogeneity, evenness, and taxonomic range restriction) using a great database. Presenting an alternative approach to the other computer programs in this field, this software has a high spatial precision and resolution and is able to read and create both MS Excel and graphical formats. Although calculating biodiversity indices of the whole of Iran is theoretically feasible using BDI, much time is needed to gather input data (even for a genus). Consequently, as the first step, this software is very efficient in biodiversity evaluation and conservation priorities of the smaller ecosystems, like protected areas. As the next step, this software would be able to find the areas with high scores as the new protected area candidates.

Future plans

Since distribution of taxa is not restricted by artificial boundaries, many Iran's taxa (e.g., birds) shared their distribution with the adjacent countries. Hence, we intend to expand its geographic range to Iran and the neighboring countries, in addition to increasing the performance in indices calculation (e.g., beta indices) in the next versions. Moreover, designing a web-based version and creating a national database by biologists to share with other researchers would be the final goal and a strong motivational factor to use this software.

TABLE 1. The accessible indices in BDI.

Concept	Index	Formula	Reference
Species Richness	Menhinick	$D_{Mn} = \frac{S}{\sqrt{N}}$	Whittaker, 1977 Menhinick, 1964
	Margalef	$D_{Mg} = \frac{S-1}{\ln N}$	Clifford & Stephenson, 1975 Hawksworth, 1995
	Jackknife	$\hat{S} = s + \left(\frac{n-1}{n}\right)k$	Heltshe & Forrester, 1983
	Rarefaction	$E(\hat{S}_n) = \sum_{i=1}^{s}\left[1 - \frac{\binom{N-Ni}{n}}{\binom{N}{n}}\right]$	Simberloff, 1972
	Bootstrap	$B(\hat{S}) = S + \sum(1-P_i)^n$	Smith & van Belle, 1984
Heterogeneity	Shannon-Wiener	$\mathrm{H}' = -\sum_{i=1}^{s} P_i \ln P_i$	Shannon & Weaver, 1949 Magurran, 1988
	Simpson (Yule)	$\frac{1}{D} = \frac{1}{\sum_{i=1}^{s} {P_i}^2}$	Simpson, 1949 Hawksworth, 1995
	McIntosh	$D = \frac{N - \sqrt{\sum_{i=1}^{s} {n_i}^2}}{N - \sqrt{N}}$	McIntosh, 1967
	Brillouin	$H_B = \frac{\ln \mathrm{N}! - \sum \ln n_i\,!}{N}$	Margalef, 1958
	Berger-Parker	$\frac{1}{d} = \frac{1}{\frac{N_{max}}{N}}$	Berger & Parker, 1970
Evenness	Shannon	$E = \frac{H'}{\ln S}$	Shannon & Weaver, 1949 Magurran, 1988
	Simpson	$E_{\frac{1}{D}} = \frac{\frac{1}{D}}{S}$	Simpson, 1949 Hawksworth, 1995
	McIntosh	$E = \frac{N - \sqrt{\sum_{i=1}^{s} {n_i}^2}}{N - \frac{N}{\sqrt{S}}}$	Magurran, 1998
	Brillouin	$E = \frac{HB}{HB_{max}}$	Margalef, 1958
	Camargo	$E' = 1 - \left(\sum_{i=1}^{s} \sum_{j=i+1}^{s} \left[\frac{\lvert P_i - P_j \rvert}{S}\right]\right)$	Camargo, 1993
	Smith and Wilson	$E_{var} = 1 - \left(\frac{2}{\pi}\right)\left[\arctan\left\{\frac{\sum_{i=1}^{s}\left(\log(n_i) - \frac{\sum_{j=1}^{s}\log(n_j)}{S}\right)^2}{S}\right\}\right]$	Smith & Wilson, 1996

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