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Plant Biodiversity on Coastal Rocky Ridges Habitats with Reference to Census Data in Ras El-Hekma and Omayed Area, Egypt

Omar Saad Sharashy

Department of Botany, Faculty of Science, Sebha University, Libya

A B S T R A C T

Biodiversity is a word recently introduced by experts in field of biology, and it is important for ecosystem health and productivity, biodiversity is one of the primary interests of ecologists, and the widely used diversity indices are Shannon's and Simpson's index. This study aims to characterize the plant communities and to identify and compare the plant species diversity in the Ras El-Hekma area   and Omayed protectorate. The results of the application of the indices of plant biodiversity in both the Ras El-Hekma area and the Omayed protectorate showed that the value of the Shannon index (H') 2.058 and 2. 322, the value of the Simpson index (D) 0.85 and 0.92, the value of the Evenness index (E) 0.89 and 0.96, the value of Effective Number of Species (ENSSh , ENSSi) 6.66, 7.83 and 12.5, 10.19 respectively. The results demonstrated the highest values were recorded in the community of Omayed protectorate compared with the Ras El-Hekma area. The results also revealed that (H') in the two communities $2 \geq H' < 3$. According to the criteria of diversity index, they were moderate diversity. As for the Evenness index (E), $0.75 > E \leq 1$. According to the categorized of the Evenness index, both are stable community. Through the results, diversity indices indicate that there is a more diverse community in the Omayed protectorate compared with the Ras El-Hekma area. The reason may be due to the individuals in Omayed was more evenly distributed among the species than the individuals in Ras El-Hekma. Based on the interpretation of the criteria and categories of Shannon, Simpson, Evenness and Effective Number of Species indices, this meant that the Omayed had high environmental wellness and biodiversity level. Both indices are more reflective in nature and can predict the ecosystem health. Therefore, it may be good to have one of these biodiversity indices to be used for plant communities to understand the ecosystem healthiness in the habitats.

التنوع الحيوي النباتي على موائل الحواف الصخرية الساحلية بالرجوع إلى بيانات التعداد في منطقة رأس الحكمة والعميد. مصر

عمر سعد شراشي

قسم علم النبات، كلية العلوم، جامعة سبها، ليبيا

الملخص

التنوع البيولوجي هو مصطلح قدمه مؤخرًا خبراء في مجال علم الأحياء، وهو مهم لصحة النظام البيئي وإنتاجيته، والتنوع البيولوجي هو أحد الاهتمامات الأساسية لعلماء البيئة، ومؤشرات التنوع المستخدمة على نطاق واسع هي مؤشر شانون وسيمبسون. تهدف هذه الدراسة إلى توصيف المجتمعات النباتية وتحديد ومقارنة تنوع الأنواع النباتية في منطقة رأس الحكمة ومحمية العميد. أوضحت نتائج التطبيق لمؤشرات التنوع البيولوجي النباتي في منطقة راس الحكمة و محمية العميد، ان قيمة مؤشر شانون 2.059 ('H)، 2.322. وان قيمة مؤشر سيمبسون 0.85 (D)، 0.92. وقيمة مؤشر التكافؤ 0.89 (E)، 0.96. أما قيمة العدد الفعال للأنواع (ENS Sh و ENS Si) 6.66 ، 7.83 و 12.5، 10.19 على التوالي. وكما بينت النتائج ان القيم الاعلى سجلت في مجتمع محمية العميد بالمقارنة مع منطقة رأس الحكمة. كما أظهرت النتائج ايضا ان ('H) في المجتمعين $2 \leq 3 > H'$. وفقا إلى معايير مؤشر التنوع كان التنوع معتدلاً. أما مؤشر التكافؤ (E) وبحسب النتائج فإن $0.75 \leq 1 > E$. وفقا لتصنيف مؤشر التكافؤ، كلاهما مجتمع مستقر. ومن خلال النتائج، تشير

*Corresponding author:
E-mail addresses: osharash@yahoo.co.uk

مؤشرات التنوع إلى وجود مجتمع أكثر تنوعًا في محمية العميد مقارنة بمنطقة رأس الحكمة. قد يكون السبب هو أن الأفراد في العميد كانت موزعة بالتساوي بين الأنواع أكثر من الأفراد في رأس الحكمة. بناءً على تفسير المعايير وتصنيف مؤشرات شانون وسيمبسون والتكافؤ والعدد الفعال للأنواع ، فإن هذا يعني أن العميد يتمتع بمستوى عال من العافية البيئية والتنوع البيولوجي. كلا المؤشرين أكثر انعكاسًا في الطبيعة ويمكنهما التنبؤ بصحة النظام البيئي. لذلك، قد يكون من الجيد استخدام أحد مؤشرات التنوع البيولوجي هذه لمجتمعات النباتات لفهم صحة النظام البيئي في الموائل.

Introduction:

Diversity is a concept central to ecology, and its measurement is essential for any study of ecosystem health [1]. Biodiversity is important for ecosystem health and productivity, as will as high biodiversity makes ecosystems more flexible with increasing threats to species from global climate change or natural disasters, more species can mean a greater potential that some organisms will have the necessary features to survive [2].

Habitat diversity is one of the attractive concepts in ecology that reflects the wellbeing ecological systems [3]. In previous decades, biodiversity prospect largely in terms of species richness, and the ecosystems supporting these species were seen as static and predictable [4]. The composition of plants, animals, and microbes within an area affects structure of ecosystem and function and, therefore, the services of ecosystem (e.g., disease resistance, pollination, and production) upon which humans depend [5],[6].

Egypt and Libya except El-Gebel Al-Aghder are the only two countries in North Africa where desert climate extends to Mediterranean coast, consequently preventing the development of any Mediterranean arboreal vegetation [7]. The Egyptian coastal and inland deserts cover more than 96% of its total area.

Due to the very scanty rainfall, most vegetation of Egypt is concentrated primarily in Wadis and depressions (contracted distribution pattern). Although most of the greater part of Egypt is desert vegetation, the proportion of desert plants is relatively small as compared to other phytogeographical regions [7]. The deserts in Egypt are characterized by the growth of a permanent structure of xerophytic and halophytic vegetation types in seven different habitats, namely, mangrove swamps, reed swamps, salt marshes, sand dunes, rocky ridges, desert wadis and mountains. The major communities forming these vegetation types are described with regard to their dominance, floristic composition and geographical distribution in Egypt [8].

By the middle of the 20th century, ecologists began to process the problem of describing and comparing community characteristics such as diversity, especially with increase in human threats to ecosystems. One of the most important indices used to assess the sustainability of plant communities is species diversity. In ecology, this index is used to quantify the biodiversity of a habitat. Diversity can be used to evaluating of any population in which each member belongs to a unique species [9].

In ecology, diversity index is important parameter intended to measurement of biodiversity within an ecosystem. Two basic statistical tools ecologists use to quantify diversity of species, Shannon's and Simpson's diversity indices, Shannon-Wiener diversity index has been used extensively in environmental studies to estimate the species richness and ecosystems abundance. The index works using very well under comparative situations; where one is comparing two or more environments simultaneously [10].

Aim of study.

The study aims to describe the status of plant communities and comparing the species diversity on the habitats of rocky ridges between Ras El-Hekma area and Omayed protectorate.

Material and Methods

Location and general description

The western Mediterranean coastal strip of Egypt extends from Sollum to Abo Qir, the most noticeable feature of the Mediterranean coast west of Alexandria is the spread of ridges of soft Oolitic limestone, the coast land that extends from Alexandria to Sollum is distinguish a southern plateau more arid and less calcareous and a northern coastal plain less arid more calcareous with four habitats, coastal ridges, coastal ridges overlain by dunes, saline depressions,

non-saline depression, and inland ridges [11]. This study has been conducted to survey the plants diversity in Ras El-Hekma and Omayed protectorate on the western coastal area of Egypt.

Ras El-Hekma is a little village, 5 km long located in western Mediterranean coast of Egypt, it is lying about 230 km west of Alexandria (31° 13' 51.7" N and 27° 51' 21.9" E) altitude 20 m. Ras El-Hekma is characterized by alternating elevations and depressions. The climate is moderate temperature, high relative humidities and high wind velocity [12]. The habitats at Ras El-Hekma constitute of rocky calcareous ridges and sandy depressions.

Omayed protectorate is located 80 km west of Alexandria (30° 44' 45.2" N, and 29° 09' 57.2" E). It extends about 30 km along the Mediterranean coast from west El-Hammam to El-Alamin with a width of 23.5 km to the south.. The coastal plain is characterized by alternating ridges and depressions running parallel to the coast in E-W direction. This physiographic variation leads to the differentiate of six types of habitats in the following series arranged from the north to the south. Coastal ridge, Saline depressions, Non-saline depressions, Inland ridges, Inland plateau, Inland siliceous deposits [13]. (Fig. 1).
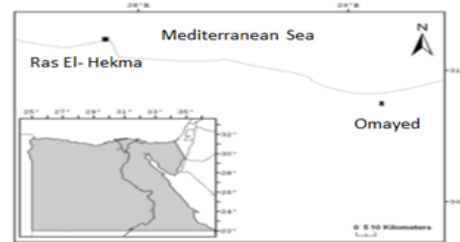

Fig. 1. Map of Egypt showing the study sites at the western Mediterranean coast.

Collection sampling

Samples were collected using the randomly quadrats method at a scale of 5 m x5 m. The number of plant species within each quadrat, as well the number of individuals of each species noted. The plant identification were carried out by the following references: [14], [15-18].

To measurement the plant diversity (biodiversity) on the rocky ridges of Ras El- Hekma and Omayed protectorate, the Shannon-Weiner index (H') and Simpson's diversity index (D) and Evenness index (E) were used the equations is as the follows:

Shannon-Weiner index (H'):

$$H' = - \sum_{i=1}^{s} pi \ln pi \quad [19],[20].$$

Where H' = Shannon-Weiner index, $Pi = \frac{ni}{N}$ ni = Number of individuals of a species,

N = Total individuals of all species, ln is the natural log, Σ is the sum of the calculations, and s is the number of species.

The diversity index based on criteria are as follows [20]:

H' ≤ 1 = Low diversity

1 < H' ≤ 3 = Moderate diversity

H' ≥ 3 = high diversity [20].

(The higher H is the higher is the diversity).

Simpson's diversity index (D):

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)} \quad [21].$$

Where n = number of individuals of a particular species.
N = total number of individuals of all species.
(D) is usually between 0 and 1. The closer D is to 1, the higher is diversity).
Evenness index (E):

$$E = \frac{H'}{Hmax}$$ [20].

Where E = Evenness index, H' = is the Shannon diversity index, Hmax = ln S, S = Number of species found.
The evenness index value ranges from 0 - 1. Furthermore, the evenness index based on categorized as follows [22]:
0 < E ≤ 0.5 = Depressed community.
0.5 < E ≤ 0.75 = Unstable community.
0.75 < E ≤ 1 = Stable community.
(E is usually between 0 and 1. The closer E to 1, then more Species in the sample are equally common, diversity is higher).
Effective Number of Species (ENS) is measure of true diversity with Species number as its unit. It is the number of Species in a community with equal abundances that would give the observed value of a diversity index, D or H. This is excellent for comparing the diversities of different samples. This corrects the non-linearity of D and H.
(The higher the ESN the diverse is a community)

Results and Discussion
The present study results highlighted on the biodiversity and were represent two major habitat of Ras El-Hekma and Omayed area,

each with unique indicator of ecological conditions. Diversity index is a quantitative measure that reflects how many different types such as species that are in a dataset, and simultaneously takes into account how evenly the basic entities such as individuals are distributed among these types. Diversity index value increases both when the number of types increases and when evenness increases [23]. Shannon-Wiener Index (H) is like the Simpson's Index and also measures the richness and abundances of the species. From the Shannon-Wiener Index Evenness can be calculated [24].
The results in Table (1,3) exhibited that the values of Shannon-Weiner index (H′) in the Ras El-Hekma and Omayed areas were 2.058 and 2.322 respectively, the Omayed protectorate reveals slightly more diverse compared with Ras El-Hekma area. Shannon-Wiener diversity index ranges from 0 to 5 where zero indicates that the environment is under severe stress and 5 represents a healthy environment [25]. Based on diversity index criteria [20], 1 < H' ≤ 3 moderate diversity. Both Ras El-Hekma and

Omayed
areas 2 ≥ H' < 3, thus their considered moderate diversity. In accordance with Odum's statement(1993),the diversity index 1 < H' < 3 was in the moderate category, meaning that the ecosystem is still in a stable condition [20]. The value of H'
appears in the Omayed protectorate is higher than that in the Ras El-Hekma, and therefore is considered more diverse.

Table (1). Shows Shannon-Wiener diversity index calculation of the Ras El-Hekma and Omayed areas.

Species	Ras El-Hekma area				Omayed protectorate area			
	# of individuals (n)	Pi	ln Pi	Pi* ln Pi	Shannon's - Pi (ln Pi)	# of individuals (n)	Pi	ln Pi	Pi* ln Pi	Shannon's - Pi (ln Pi)
Ebenus armitagei	40	0.202	- 1.599	- 0.323	0.323	4	0.097	- 2.333	- 0.226	0.226
Ononis vaginalis	6	0.030	- 3.506	- 0.105	0.105	-	-	-	-	-
Phlomis floccosa	-	-	-	-	-	4	0.097	- 2.333	- 0.226	0.226
Crucianella maritima	38	0.191	- 1.655	- 0.316	0.316	-	-	-	-	-
Artemisia monosperma	-	-	-	-	-	4	0.097	- 2.333	- 0.226	0.226
Deverra tortuosa	20	0.101	- 2.292	- 0.231	0.231	7	0.170	- 1.771	- 0.300	0.300
Zygophyllum album	18	0.090	- 2.407	- 0.216	0.216	-	-	-	-	-
Seriphidium herba-album	-	-	-	-	-	3	0.073	- 2.617	- 0.191	0.191
Centaurea pallescens	-	-	-	-	-	3	0.073	- 2.617	- 0.191	0.191
Salvia lanigera	7	0.035	- 3.352	- 0.117	0.117	-	-	-	-	-
Echiochilon fruticosum	40	0.202	- 1.599	- 0.323	0.323	-	-	-	-	-
Fumana thymifolia	-	-	-	-	-	4	0.097	- 2.333	- 0.226	0.226
Crucianella aegyptiaca	-	-	-	-	-	3	0.073	- 2.617	- 0.191	0.191
Helianthemum stipulatum	5	0.025	- 3.688	- 0.092	0.092	-	-	-	-	-
Anabasis articulata	-	-	-	-	-	5	0.121	- 2.111	- 0.255	0.255
Thymelaea hirsuta	-	-	-	-	-	2	0.048	- 3.036	- 0.145	0.145
Gymnocarpos decandrus	14	0.070	- 2.659	- 0.186	0.186	-	-	-	-	-
Lygeum spartum	10	0.050	- 2.995	- 0.149	0.149	-	-	-	-	-
Echinops spinosus	-	-	-	-	-	2	0.048	- 3.036	- 0.145	0.145
Total (N)	198				2.058	41				2.322

The results in Table (2,3) showed that the values of Simpson's diversity index (D) for Ras El-Hekma was 0.85 while for Omayed protectorate was 0.92. D is usually between 0 and 1. The closer D is to 1, the higher is diversity. In the Omayed protectorate has D 0.92 more closer to 1 than the Ras El-Hekma area was 0.85. Therefore, the

Omayed protectorate is considered more diverse than Ras El-Hekma, and this agree with [26], higher D, the more diverse the community. Increasing diversity tends to suggest more stable ecosystems with more connection within them.

Table (2). Shows Simpson's diversity index calculation of the Ras El-Hekma and Omayed areas.

Species	Ras El-Hekma area			Omayed protectorate area		
	# of individuals (n)	n - 1	n* (n - 1)	# of individuals (n)	n - 1	n* (n - 1)
Ebenus armitagei	40	39	1560	4	3	12
Ononis vaginalis	6	5	30	-	-	-
Phlomis floccosa	-	-	-	4	3	12
Crucianella maritima	38	37	1406	-	-	-
Artemisia monosperma	-	-	-	4	3	12
Deverra tortuosa	20	19	380	7	6	42
Zygophyllum album	18	17	306	-	-	-
Seriphidium herba-album	-	-	-	3	2	6
Centaurea pallescens	-	-	-	3	2	6
Salvia lanigera	7	6	42	-	-	-
Echiochilon fruticosum	40	39	1560	-	-	-
Fumana thymifolia	-	-	-	4	3	12
Crucianella aegyptiaca	-	-	-	3	2	6
Helianthemum stipulatum	5	4	20	-	-	-
Anabasis articulata	-	-	-	5	4	20
Thymelaea hirsuta	-	-	-	2	1	2

Gymnocarpos decandrus	14	13	182	-	-	-
Lygeum spartum	10	9	90	-	-	-
Echinops spinosus	-	-	-	2	1	2
Total number of individuals (N)	198	197		41	40	
		$\sum$	5576		$\sum$	132

The results in Table (3) indicated that the evenness index values (E) the Ras El-Hekma area was 0.89 while for Omayed protectorate was 0.96. The evenness index value ranges from 0 - 1. The closer E is to1, then more species in the sample are equally common, the diversity is higher. Omayed protectorate has (E) 0.96, higher evenness compared to Ras El-Hekma. In accordance with evenness index, E value closer to 1. Therefore, community more diverse. Evenness of species is the degree of equitability in distribution of individuals among species. Greater evenness signifies less difference in the numbers of individuals of each species. Maximum evenness happens when the number of individuals among all species is the same [2]. The results showed that the (E) values in both Ras El-

Hekma and Omayed areas were $0.75 > E \leq 1$. Accordance with evenness index based on [22], categorized, $0.75 < E \leq 1$, Stable community. The evenness index describes the individuals number between species in the community. The more evenly distributed individuals between species, the more balanced the ecosystem will be [20]. Evenness is a measure of the relative abundance of the different species forming the richness of the area [27]. Evenness complements species richness in that it gives a picture of the relative abundances of the different species represented on the areas.

Table (3). Calculation of values Shannon, Simpson, Evenness indices and Effective number of species for the Ras Al-Hekma and Omayed areas.

Index		Formula	Species Richness (S)			
			Ras El-Hekma (S) = 10		Omayed protectorate (S) = 11	
Shannon-Weiner (H')		$-\sum_{i=1}^{s} p_i \ln p_i$	- (- 2.058)	2.058	- (-2.322)	2.322
Simpson's (D)		$1 - \dfrac{\sum n(n-1)}{N(N-1)}$	$1 - \dfrac{5576}{198(198-197)}$	0.85	$1 - \dfrac{132}{41(41-40)}$	0.92
Evenness (E)		$\dfrac{H}{\ln(S)}$	$\dfrac{2.058}{\ln(10)}$	0.89	$\dfrac{2.322}{\ln(11)}$	0.96
Effective Number of Species (ENS)	Shannon-Weiner ENS_{Sh}	$\dfrac{1}{(1-D)}$	$\dfrac{1}{(1-0.85)}$	6.66	$\dfrac{1}{(1-0.92)}$	12.5
	Simpsons ENS_{si}	$\exp(H)$	$\exp(2.058)$	7.83	$\exp(2.322)$	10.19

The result in Table (3,4) revealed that the Effective Number of Species (ENS), values of ENS_{Sh} and ENS_{Si}, in the Ras El-Hekma were, 6.66 and 7.83 while for Omayed protectorate were 12.5 and 10.19. The results demonstrated the highest value of ENS was recorded in the Omayed protectorate. The larger differences in S, ENS_{Sh} and ENS_{Si} are the higher the degree of dominance [24]. We can say from the results that the degree of dominance is higher in Omayed protectorate than in Ras El-Hekma area, or some species in Omayed area are more dominant than some other species, consequently considered more diverse and this agrees with the higher the ESN the more diverse is a community.

Species diversity, both the Shannon-Wiener (H') and Simpsons (D) Indices point to the community at Omayed protectorate more diverse as compared to Ras El-Hekma area (Table 4). The reason may be consequence the individuals in Omayed were more evenly distributed among the species than individuals in Ras El-Hekma. In

fact, the individuals *Ebenus armitagei* and *Echiochilon- fruticosum* in Ras El-Hekma occupy a greater proportion of the community than all other species (Table 1). According to the interpretation of the criteria and categorises of Shannon, Simpson, Evenness and Effective Number of Species indices, this meant that the Omayed had high environmental wellness and biodiversity level.

Simpson's index is more sensitive to evenness of species than richness of species. Shannon index in turn, does not provide information on rare species which are very important in biodiversity studies. Therefore it is advisable to use more than one indices when determining the biodiversity of ecosystem [28]. Habitat diversity research is interested in measuring the structural complexity of the environment or the number of communities present in a specific geographic area [29]. Habitat diversity measurement has become an important component of conservation ecology since the eighties [30],[31].

Table (4). Shows a summary of the values of Shannon, Simpson, Evenness indices andEffective Number of Species (ENS) in Ras Al-Hekma and Omayed areas.

Index		Ras El-Hekma	Omayed protectorate
Species Richness (S)		10	11
Shannon-Weiner (H')		2.058	2.322
Simpson's (D)		0.85	0.92
Evenness (E)		0.89	0.96
Effective Number of Species (ENS)	Shannon-Weiner ENS_{Sh}	6.66	12.5
	Simpsons ENS_{si}	7.83	10.19

References

[1]- Daly, A. J., Baetens, J. M. and De Baets, B. (2018). Ecological Diversity :Measuring the Unmeasurable. www.mdpi.com/journal/mathematics.

[2]- Duncan, S. I., Lenhart, S. and Sturner, K. K. (2014). Measuring Biodiversity with Probability. The National Council of Teachers of Mathematics, Inc. Vol. 107 (7): 547 – 549.

[3]- Elsaied, A. (2017). Habitat diversity and plant indicators of El-Harra Oasis,Western Desert, Egypt. Int. J. Adv. Res. Biol. Sci. Vol.4 (5): 25- 43.

[4]- Fiedler, P.L., White, P.S., Leidy, R.A. (1997). The paradigm shift in ecology and its implications for conservation. Pages 83-92 in Pickett STA, Ostfeld RS, Shachak M, Likens GE, eds. The Ecological Basis of Conservation: Heterogeneity, Ecosystems, and Biodiversity. New York: Chapman & Hall.

[5]- Isbell, F. (2011). High plant diversity is needed to maintain ecosystem services. Nature (477): 199 -202.

[6]- Le, P. T., L. M. Hartley, J. H. Doherty, C. B. Harris, and J. C. Moore. (2018). Is being familiar with biodiversity related to reasoning about ecology? Ecosphere. Vol. 9 (12): e 02532. 10.1002/ecs2.2532.

[7]- Hegazi, A. M., Afifi, M. Y., EL Shorbagy, A. M., Elwan, A. A., El- Demerdashe, S. (2005). Egyptian National Action Program To Combat Desertification. ARAB REPUBLIC OF EGYPT Ministry of Agriculture and Land Reclamation. Desert Research Center (DRC).

[8]- Zahran, M. A , El-Amier, Y. A. and Shawky, R. A. (2016). Natural Vegetation of the Egyptian Deserts: Ecology and Economic Potentialities. *Journal of Environmental Sciences,* Vol. 45, (3-4): 269-282.

[9]- Verma, V., Mishra, A. K., Dhawan, A. and Nath, D. C. (2020). Diversity in substance use behaviour among street children of Delhi under Bayesian paradigm. *BMC Medical Research Methodology.* 1- 9.

[10]- Omayio, D. and Mzungu, E. (2019). Modification of Shannon-Wiener Diversity Index towards Quantitative Estimation of Environmental Wellness and Biodiversity Levels under a Non-comparative Scenario. *Journal of Environment and Earth Science.* Vol. 9, (9): 46-57.

[11]- Heneidy, S. Z. and Bidak, L. M. (1998). Diversity of the Wadi Vegetation in Matrouh region, Egypt. J. Union Arab Biol., Cairo, Vol. 6(B), Botany,   13 - 28.

[12]- Zahran, M. A. and Willis, A. J. (1992). The Vegetation of Egypt. Champan & Hall, London.

[13]- Shaltout, K. H. and Al-Sodany, Y. (2019). Plant Diversity of a Mediterranean Biosphere Reserve in Egypt: Omayed Biosphere Reserve LAP Lambert Academic Publishing. https://www.researchgate.net/publication/333396734

[14]- Täckholm, V. (1974). Students' flora of Egypt: (2nd ed.). Cairo University, Cairo.

[15]- Boulos, L. (1999). Flora of Egypt: volume one (Azollaceae - Oxlidaceae). Al-Hadara Publishing, Cairo. pp. 88, 125, 259, 340.

[16]- Boulos, L., (2000). Flora of Egypt: volume two (Geraniaceae - Boraginaceae). Al-Hadara Publishing, Cairo. pp. 22, 117, 123, 167, 239, 398.

[17]- Boulos, L., (2002). Flora of Egypt: volume three (Verbenaceae - Compositae). Al-Hadara Publishing, Cairo. pp. 17, 29, 145, 162, 259, 261.

[18]- Boulos, L. ,(2005). Flora of Egypt: volume four Monocotyledons (Alismataceae - Orchidaceae). Al-Hadara Publishing, Cairo. pp. 131.

[19]- Shannon, C. E. and Wiener, W. (1949). The Mathematical Theory of Communication. Urbana, IL: University of Illinois Press.

[20]- Ulfah, M., Fajri1, S. N., Nasir, M., Hamsah, K. and Purnawan , S. (2019). Diversity, evenness and dominance index reef fish in Krueng Raya Water, Aceh Besar. IOP Conf. Series: Earth and Environmental Science.

[21]- Simpson, E.H. (1949). Measurement of diversity. Nature, 163, 688.

[22]- Krebs, C. H. J. (1989). Ecological methodology *Univ. of British Columbia* Harper Collins Publisher. PP. 645.

[23]- Okpiliya, F. I. (2012). Ecological Diversity Indices: Any Hope for One Again?. Journal of Environment and Earth Science. Vol. 2, (10): 45-52.

[24]- http://www.marinespecies.org/introduced/wiki/Measurements_ of_biodiversity.

[25]- Rahgozar, M., Irani-Nejad, K. H., Zargaran, MR. and Saboori, A. (2019). Biodiversity and species richness of oribatid mites (Acari: Oribatida) in orchards of East Azerbaijan province, Iran. Persian J. Acarol Vol. 8, (2):   pp. 147-159.

[26]- Prinster, A. J., Hoskins, J. L. and Strode, P. K. (2019). Pitfall Traps & Diversity Indices: Using Quantitative Reasoning to Test Edge Effect Theory. The American biology teacher. Vol. 81, (4): pp. 234 - 241.

[27]- Supriatna, J. (2018). Biodiversity Indexes: Value and Evaluation Purposes. Institute for Sustainable Earth and Resources (I-SER) and Dept. of Biology, Faculty of Math and Sciences, Universitas Indonesia.

[28]- Shah, J.A. and Pandit, A.K. (2013). Application of diversity indices to crustacean community of Wular Lake, Kashmir Himalaya. *International Journal of Biodiversity and Conservation.*Vol. 5(6): PP.311-316.

[29]- Magurran, A. E. (1988). Why diversity?. In Ecological diversity and its measurement Springer Netherlands. pp. 1- 5.

[30]- Fuller, R.J. and Langslow, D.R. (1986). Ornithological evaluation for wildlife conservation. In Wildlife Conservation Evaluation (ed. M. B. Usher). Chapman and Hall, London, pp. 247- 69.

[31]- Usher, M. B. (1986). Wildlife conservation evaluation attributes, criteria and values. In Wildlife Conservation Evalution (ed. M. B. Usher), Chapman and Hall, London, pp. 3-44.