LIMNOLOGY, FAUNA AND FLORA OF WADI EL-RAYAN LAKES AND ITS ADJACENT AREA, FAYUM, EGYPT

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Keywords: Wadi el-Rayan lakes, fauna and flora, wildlife, ecotourism

Contents

Summary

Wadi el-Rayan is a natural depression (703 km^2 between lat. 28º 15′ and 29º 17′ N), located at about 90 km southwest of Cairo in the western desert. It is part of the great Sahara biogeographical region holds two main lakes, at different elevations, connected by a swampy channel. Part of it was then declared a World Heritage Site in 2005. The lakes and springs play a critical role iFn the life cycles of a remarkable diversity of

species, including 38 wild plant species, 68 zooplankton species, 214 phytoplankton species, 25 macrobenthic species, 34 fish species, 163 bird species, 28 mammal species, and 19 reptile species. Wadi el-Rayan protectorated area is one of the most important habitats for certain bird species of national, regional and international importance. The area holds several threatened species of mammals, including the slender horned gazelle, *Gazella leptoceros*. The human activities, include agricultural land reclamation, digging and exploration for crude oil, fish farming, the building of cafeterias, and the creation of tourist visiting areas could be accelerate the water contamination of the lakes.

1. Introductions

Fayum is a representative example of the oases of the great North African Sahara desert in its form, origin, geologic formation, culture and ecosystem. The strategic location of Fayum as a separate oasis on the western boundaries of the Nile Valley set it to become the gateway to the North Africa desert oases regionextending from Egypt to Morocco. Wadi el-Rayan (wadi literally means "valley" in Arabic) is a depression (703 km^2 between lat. 28º 15′ and 29º 17′ N) in the desert to the southeast of Fayum Oasis about 90 km southwest of Cairo in the western desert (Zahran, 1973). It is part of the great Sahara biogeographical region. It was made a protected area in 1989. Part of it was then declared a World Heritage Site in 2005. Wadi el-Rayan contains a pair of new lakes, which were actually created by a mismanaged government drainage project in the 1970s (Figure 1). Though just a 30-minute drive from Fayum Oasis, the lakes are surrounded on all sides by golden sand dunes and new growth that houses both indigenous and migratory birds. Unlike most of the arid desert regions it is of high biological diversity. Wadi al Hitan, or "Valley of the Whales," is named for the ancient whale skeletons that were found on the surface of the desert. These spectacular, 40-million-year-old remains are reminders that the entire area was once covered by a giant inland sea. It was declared a World Heritage Site in an effort to protect the fossils. Two slightly brackish, man-made lakes were created in April, 1973 in the lower portion of the depression. About one year later, water started to settle and accumulate in the upper basin and overflow to the lower basin in 1978. The major habitat-type occurring in the depression are: sobkhas, sand flats, sand dunes, wetlands (man-made lakes), springs and desert area (Serag et al., 2003).

Sabkhas

Along the shoreline of the two lakes, sabkhas are formed due to the change of water level in the lakes. Wadi el-Rayan sabkhas are dominated by halophytic species such as *Alhagi graecorum*, associated with *Nitraria retusa*, *Tamarix nilotica*, *Calligonum polygonoides*, *Cressa cretica* and *Zygophyllum album*. Pure population of *Phragmites australis* were recorded in the salt lands around both lakes (ref?).

Sand Flats

Along the Wadi el-Rayan depression, sand flats are well represented around both the lake, in the spring area. Sand flats are dominated by *Alhagi graecorum*, *Desmostachya bipinnata*, Sporobolus spicatus, *Zygophyllum album*, *Salsola imbricate* and *Haloxylon salicorricum.*

Sand dunes

Sand dunes in the depression are classified into simple compound or complex dunes according to their relationship to formative wind and the number of slip faces (McKee, 1979). There are only longitudinal dunes and vegetated linear dunes in the Wadi el-Rayan depression, mainly southwest of the lakes. According to Saleh et al. (1988), this ecosystem lies within the hyper-arid warm Saharan region where the main source of water is superficial groundwater. Plant cover in the desert plains is poor and there are sometimes large areas with no vegetation at all. Unlike many other desert regions in Egypt, no ephemeral growth has been observed in these plains, obviously due to the scarcity of rainfall. On vegetated sand dune bases and interdune areas the dominant species are *Alhagi graecorum, Desmostachya bipinnata*, *Tamarix nilotica, Nitraria retusa*, *Calligonum polygonoides*, *Cressa cretica* and *Zygophyllum album.*

Wetlands

Two slightly brackish, man-made lakes were created in April, 1973 in the lower portion of the depression. About one year later, water started to settle and accumulate in the upper basin and overflow to the lower basin in 1978 via a connecting channel and waterfalls. The two lakes were created to channel out excess agriculture drainage water in order to slow-down the increase in the water-table in the Fayum main depression and in Lake Qarun. These habitats are dominated by *Phragmites australis* associated with *Typha domingensis, Cynanchum acutum, Tamarix nilotica, Cyerus laevigatus, Juncus acutus, Zygophylium album, Z. coccineum* and *Imperata cylindrical.*

Springs

The water of the three natural el-Rayan springs, located below Minqar el-Rayan in a site known as the Oyun el-Rayan or springs area, is believed to come from the remotely charged Nubian sandstone strata (Ball, 1927). The output has been measured as 1.6, 4.8 and 14.4 litres per minute for the northern, western and southern springs, respectively (Zahran, 1973). A new spring was dug out by Coptic monks between the western and the southern springs in 1999. All the springs provide drinking water for wildlife. The physical and chemical properties of the lakes and the springs, including seasonal variations, were studied in 1988 and 2000 (Saleh et al., 1988; Saleh et al., 2000).

2. Etymology

Wadi el-Rayan is one of the most important natural reserves located in Egypt after Ra's Mohammad and St. Catherine. Wadi el-Rayan is named in after the king of claim Rayyan ibn al-Walid, who lived in the area with his army. the watering of water from natural springs in the region have agreed Bedouin on these label found to be assets of an old Egyptian was also found in the Papyrus

3. Wadi El-Rayan as a Flood Water Reservoir

In the late 19th century, there was a debate as to whether to use Wadi el-Rayan as a reservoir for the Nile’s floodwaters or to build a dam across the river in its upper

reaches. A scheme was designed, encompassing an inlet canal from the Nile to the depression and an outlet canal to direct the stored water back to the Nile. Work started in the early 1950s. In the 1960s, however, the Aswan High Dam scheme replaced all earlier storage schemes, and the Rayan flood-water storage project was abandoned. The project had several advantages. Accordingly, Fox (1951) stated that as Egypt is the gift of the Nile, Wadi El-Rayan is the gift of the desert. He summarized these advantages as: 1) protecting Egypt against disastrous flood, 2) providing stored water to augment the volume of Nile water, 3) creating a new province in the area, 4) raising the water supply for the surrounding provinces and 5) allowing for cultivation of new areas in Giza province.

4. Wadi El-Rayan as A Drainage Water Reservoir

For the needs of reclaiming new lands and developing the present productive areas of El-Fayoum, there was an increase in the total income of the irrigating water. While Lake Qarun received the drainage water, it did not meet the increase in drainage water. It flooded over the adjacent cultivated areas and villageson several occasions. A series of suggestions and studies have carried out since the 1960s to solve these problems. The suggestions included the construction of an embankment around Qarun or mixing the drainage water with irrigation water to re-use it. Besides, this problem revived the idea of utilizing Wadi El-Rayan as a reservoir of drainage water. The idea was to connect El-Wadi drain with the depression through digging a long a channel that would be partly open (7 kilometres) and partly in a tunnel (7.7 kilometres). This drainage water created the upper lake during the 1970s and then in the early 1980s spilled over to create a waterfall, that is now a special attraction of the area, and formed the lower lake. These two man-made brackish lakes added a significant feature to the Rayan landscape and provided a wetland habitat for a variety of resident and transient wildlife. They also allowed various new land uses (farming, fisheries and recreation), while an abandoned monastery was renovated and reoccupied. These changes brought inhabitants to the area and at the same time made it hard to manage nature conservation.

5. Wadi el-Rayan Lakes

The upper lake (maximum depth of 25 m) has an area of about 48 km^2 and the lower of about 45.9 km^2. They lie between 30^o 20´- 30^o 25´ E and 29^o05´- 29^o20´ N. The connecting area between the two lakes is characterized by permanent shallow water that provides conditions for continuous cover by emerged aquatic macrophytes; thus leading to swamp formation. The Upper Lake is completely filled with water and is surrounded by dense vegetation (Saleh, 1984). The Lower Lake is changing all the time. The maximum water depth recorded in the Lower Lake is 23 m. The Upper Lake is less saline (1.52-1.94 g/l) than the lower one (14.3-17.33 g/l). In the lower lake, salinity increases from north to south. Nutrients are higher in the upper Lake than in the lower one (Aboul-ela and Khalil, 1988; Saleh, et al., 1988; Anon, 1998; Konsowa and Abd Ellah, 2002a&b). Many changes have occurred in the Wadi el-Rayan area since the lakes were formed in 1973. The human activities with the most impact include agricultural land reclamation, digging and exploration for crude oil, fish farming, the building of cafeterias, and the creation of tourist visiting areas.

Figure 1. Wadi el-Rayan lakes

5.1. Climate

The climate of Wadi el-Rayan is typically Saharan, hot and dry with scanty winter rain (<?mm) and bright sunshine throughout the year (Smith, 1984). According to bioclimatic regions of Egypt defined by Ayyad and Ghabbour (1986) the area is hyper-arid with mild winter and hot summer.

5.2. Potential Rate of evaporation

The minimum rate of evaporation (3.18 cm) is detected in autumn, while the maximum value (25.67 cm) occurrs in summer.

5.3. Solar Radiation

The incident light shows a visible maximum during spring (649.5 wat.m^{-2}) and decrease gradually until minimum value of 241.21 wat. m^{-2} in late autumn.

5.4. Wind Speed and Direction

The wind directions play an important role in the changing of weather condition and water movement. The Lake is characterized by a prevalence of N, NNE and NNW in most of the year. The minimum wind speed of 2.11 m/s was recorded in December, while the maximum value (5.4 m/s) was occurred in June, with a mean amount of 4.32 m/s

5.5. Water Budget

The total inflow of the El-Wadi drain to the upper lake is 221 10^6 m^3 y^{-1}, while annual discharge to the lower lake is 127 10^6 m^3 y^{-1}. The net water budget for the upper lake used to have a positive value of 13 10^6 m^3 y^{-1}, and 39 10^6 m^3 y^{-1} for the lower lake. These values have recently become negative (Abd Ellah, 1999).

5.6. Physical and Chemical Properties of Water

Water temperature varies between 14.18 in December to 28.83 ^oC in August. The water of the lower lake is more transparent than the first one, the entrance of the both lakes sustains the lowest transparency values. The pH values are always in the alkaline side with small local differences without significant seasonal variations. It varies from 8.12 to 8.55 in the upper and from 7.98 to 8.42 in the lower lake. (El-Sayed and Abdel-Satar, 2009). There is an observed increase in EC in the lower lake (6.50-17.60 mS cm^{-1}) in comparison with the upper one (2.20-3.04 mS cm^{-1}). The long term change in salinity at the both Wadi el-Rayan lakes are shown in Table 1. Dissolved oxygen value varies from 4.4 to 13.4 mg $l^{-1}O_2$. The minimum values were recorded in the bottom samples of the deepest stations of the two lakes (El-sayed and Abdel-Sataar, 2009). The COD and BOD shows high values in the upper lake compared with the lower one. The dominant anions within the water column of Wadi el-Rayan Lakes are chlorides and sulphates. The lower lake shows higher chloride ion concentration (1.11-4.54 g l^{-1}) than the upper (0.449-0.886 g l^{-1}). The concentration of cations is generally higher in the lower lake than the upper and governed mainly by the intrusion of drainage water through the El-Wadi drain. Sodium is the dominant cation contributing 71 & 57% for the upper and lower lakes, respectively, followed by Mg^{2+} (16 & 28 %) and Ca^{2+} (9 & 10%), while K^+ represents the lowest percentage (4 & 5% ionic composition. The average concentrations of ortho-P, nitrite, nitrate and ammonia in the 1st lake sites are slightly lower compared with the 2second lake (El-sayed and Abdel-Sataar, 2009).

Year	Water salinity ‰		References
	upper lake	lower lake	
1975-1976	1.52	1.52	Boraey (1976)
1984-1985	0.96	2.41 ‰	Saleh et al (1988)
1989	1.52	2.5	El-Shabrawy (1993)
1996	1.48	4.63	Abd Ellah (1999)
1999	1.49	5.18	Anon (2000)
2001	1.43	5.68	Konsowa and Abd-Ellah (2002a,b)
2006	1.53-1.94	5.58-11.69	Sayed and Abed-Satar (2009)
2010-2011	1.3-1.9	14.3-17.9	Goher (per. comm)

Table 1. Long term Changing in salinity of Wadi el-Rayan lakes

5.7. Vegetation

Thirty eight wild plant species had been reorded in Wadi el-Rayan's various habitats (Table 2). The vegetation cover of the desert ecosystem around the lakes wis dominated by *Alhagi graecorum, Calligonum comosum, Desmostachya bipinnata, Nitraria retusa* and *Zygophyllum album*. *Zygophyllum coccineum* with low plant cover (< 5%), and two associate species *(Kochia indica* and *Fagonia Arabica*) occur close to the lake shore. Two vegetation types are distinguished along the lakes: aquatic and swampy. The aquatic vegetation is dominated by *Myriophyllum spicatum* and *Potamogeton crispus*, while *Najas marina, Potamogeton pectinatus* and *Zannichellia pallustris* were infrequently occurred. The swampy habitat had been dominated by *Phragmites australis* and *Typha domingensis*, besides *Cyperus laevigatus, Tamarix nilotica, Alhagi graecorum, Calligonum comosum, Desmostachya bipinnata, Zygophyllum album, Z. coccineum, Pluchea dioscordis, Salicornia fruticosa, Cynanchum acutum, Phoenix dactylifera, Imperata cylindrical* and *Eichhornia crassipes* which seem as a rare. The plant communities of the spring ecosystem are dominated by *Alhagi graecorum Tamarix nilotica, Phragmites australis, Nitraria retusa* and *Cressa cretica*.

1	*Adiantum capillus – veneris*	**20**	*Phragmites australis*
2	*Alhagi graecorum*	**21**	*Phoenix dactylifera*
3	*Arthrocnemum macrostachyum*	**22**	*Pluchea dioscoridis*
4	*Calligomum polygonoides*	**23**	*Polypogon monospliensis*
5	*Ceratophyllum demersum*	**24**	*Potamogeton pectinatus*
6	*Cormulaca monocantha*	**25**	*Ranunculus sceleratus*
7	*Cressa cretica*	**26**	*Rumex dentatus*
8	*Cynanchum acutum*	**27**	*Halaxylon salicornicum*
9	*Cynodon dactylon*	**28**	*Salsola imbricata*
10	*Cyperus laevigatus*	**29**	*Scirpus maritimus*
11	*Desmostachya bipinnata*	**30**	*Sonchus maritmus*
12	*Imberata cylindrica*	**31**	*Spergularia marina*
13	*Juncu rigidus*	**32**	*Sporopolus spicatus*
14	*Juncu acutus*	**33**	*Stipagrostis ciliate*
15	*Launaea nudicaulis*	**34**	*Tamarix nilotica*
16	*Melilotus indicus*	**35**	*Typha domingensis*
17	*Myriophyllum spicatum*	**36**	*Zygophyllum album*
18	*Najas armata = (Najas marina(L.))*	**37**	*Zygophyllum coccineum*
19	*Nitraria retusa*	**38**	*Hyocyamus muticus*

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Table 2. A list of macrophytes species recorded at Wadi el-Rayan (IUCN, 2001).

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