

**BRINE SHRIMP PROVIDES A RICH-HIGH ENERGY FOOD FOR
MIGRATING BIRDS: A CASE STUDY OF AN ARTIFICIAL POND IN BASRAH,
IRAQ**

**Malik Hassan Ali, Hanaa Hussein Mohammed, Dawood Salman Abdulla and
Huda Kadhim Ahmed**

Department of Marine Biology, Marine Science Centre, University of Basrah, Basrah, Iraq (MHA); Dept. of Biological Development in Shatt Al-Arab & N W Arabian Gulf, Marine Science Centre, University of Basrah, Basrah, Iraq (HHM); Dept. of Marine Biology, Marine Science Centre, University of Basrah, Basrah, Iraq (DSA); Dept. of Marine Biology, Marine Science Centre, University of Basrah, Basrah, Iraq (HKA).

email: malik54ha@yahoo.com, malikh.ali1954@gmail.com

Phone number: +964 7706414401

ABSTRACT: A case study focusing on the attraction of migrating birds by brine shrimp (*Artemia franciscana*) into an artificial pond in Basrah, Iraq. A dump area had constructed at the intertidal mudflat's zone of Khor Al-Zubair Channel, Basrah, Iraq. Basra Gas Company implemented a dredging operation to increase the channel depth in 2019 to use the dump area as a disposal place for the company's benthic sediments, which are usually mixed with seawater, converting the dump area to a large hypersaline artificial pond. Unexpectedly, the pond became a habitat for many shorebird species a few months later. The pond has been surveyed five times between March 2019 and January 2020. For each survey, frequent environmental and biological events were observed. Due to high temperature during most summer months (30-50°C), the water level decreased dramatically to (< 0.5 m), which ultimately led to increase levels of salinity in the pond (80 psu). Moreover, growth of blue-green algae was observed and appearance of brine shrimp *A. franciscana*. During autumn and winter surveys, an abundance of live *A. franciscana* and their cysts was observed. Birds appeared to forage primarily on *A. franciscana* in the pond. The abundance of brine shrimp attracts migrating birds to exploit this prey. 11 species of migrating birds were detected in the pond. These species were flamingo *Phoenicopterus ruber*, flocks of avocet *Ricurvirostra avosetta* and Shelduck *Tadorna tadorna*. Therefore, this site with abundant food resources could provide a rich-high energy food for migrating birds and staging area for a long flight.

KEYWORDS: *Artemia franciscana*, artificial pond, energy, migrating birds, Basrah

INTRODUCTION

Brine shrimp is widely distributed in southern Iraq, particularly in Basrah region, it's usually growing in shallow saline temporary swamps. Since Gurney, (1921) it was put incorrectly under the name *Artemia salina* in some local waters. In 2010 the species was identify as *Artemia francescana* based on molecular data (Mohammed *et al.*, 2010).

Even that, valuable knowledge were got on their life cycle and it nutritional value in aquaculture (Abdullah, 2007; Mohammed *et al.*, 2010), there is limited data known about its role in natural ecosystems at Basrah region. In fact these crustaceans are an able to

growing in estuarine and sea habitats due to the presence of large number of predators such as fishes and other carnivorous invertebrates whereas, these predators can't live in hyper saline environment where *Artemia* usually growing in the high density.

Birds during their migration across the continents have to fly over thousands of kilometers, enduring the high energy cost of flying which is higher than any type of locomotion such as swimming and running, even that flying is more efficient (Alexander, 2013). These birds need to be supplied with enough bio-fuel quantity. Food is the type of fuel utilized by birds to get their energy requirements for such high energy demand travels. Therefore, an essential factor for the successfulness of such a long flight is the availability of high energy contents food in the ways of their travelling (Kommentare, 2017).

Iraq is one of the main inter-continental routes of the global migrant birds, and it was recognizing as an important site for migratory birds in the whole of western Eurasia (UNEP, 2001, Salim *et al.*, 2009). Moreover, the great Mesopotamian marshlands that covering an area of 12000- 15000 Km², supporting several millions of birds every year as stopover, feeding and breeding staging (Iraqi Ministry of Health Environment, 2010). It's well known that these marshlands are thrive aquatic ecosystem constituting high productive trophic levels communities of phytoplankton, zooplankton, benthos and fishes (Rubea *et al.*, 2009). Unfortunately, this ecosystem had subjected to vast environmental damages during the period between (1980-2003), in which a draining of the marshes carried out by the previous Saddam H. regime. As a result 90% of the marshlands had disappeared (Fawzi *et al.*, 2016). After 2003, there is a good recovery proportion of the marshes when many constructed dams were removed and the marshes were reflooded (Hopkin, 2005; Ali *et al.*, 2021a). However, these habitats were continuously subjected to degradation due to various environmental and anthropogenic factors such as the shortage of freshwater, change of water quality, mainly the salinity and pollution (Ali *et al.*, 2021a). Furthermore, land dryness and the utilization of more area for different projects establishment as well as other popular activities (Fawzi *et al.*, 2016).

The goal of this case study was to follows this exiting natural phenomena and concluded the lesson learned from it.

MATERIALS AND METHODS

Study area: The constructed pond (N 30° 155' 49", E 047° 92' 484") is located at the east side of Khor Al-Zubair (KAZ) channel South-west Basrah City, Iraq (Fig. 1), the pond area is nearly 4.5 km², surrounded by a dam of 2m high and 3m width, and was constructed in 2018. The site is a part of an important national Key biodiversity Area (KBA) consist of high productive intertidal mudflat habitat characterized by a high density of mixed population of mudskippers and crabs, all are benthic burrowing species (Ali and Mohammed, 2019; Ali *et al.*, 2021b).

Recently, Basrah Gas company (BGC) implemented a dredging operation in the Khor Al-Zubair channel aiming at deepening the part of the channel in the front of the gas export terminals (Ali and Mohammed, 2019). For this purpose, a dump area was constructed on the other site of the channel for depositing the dredging materials. At the

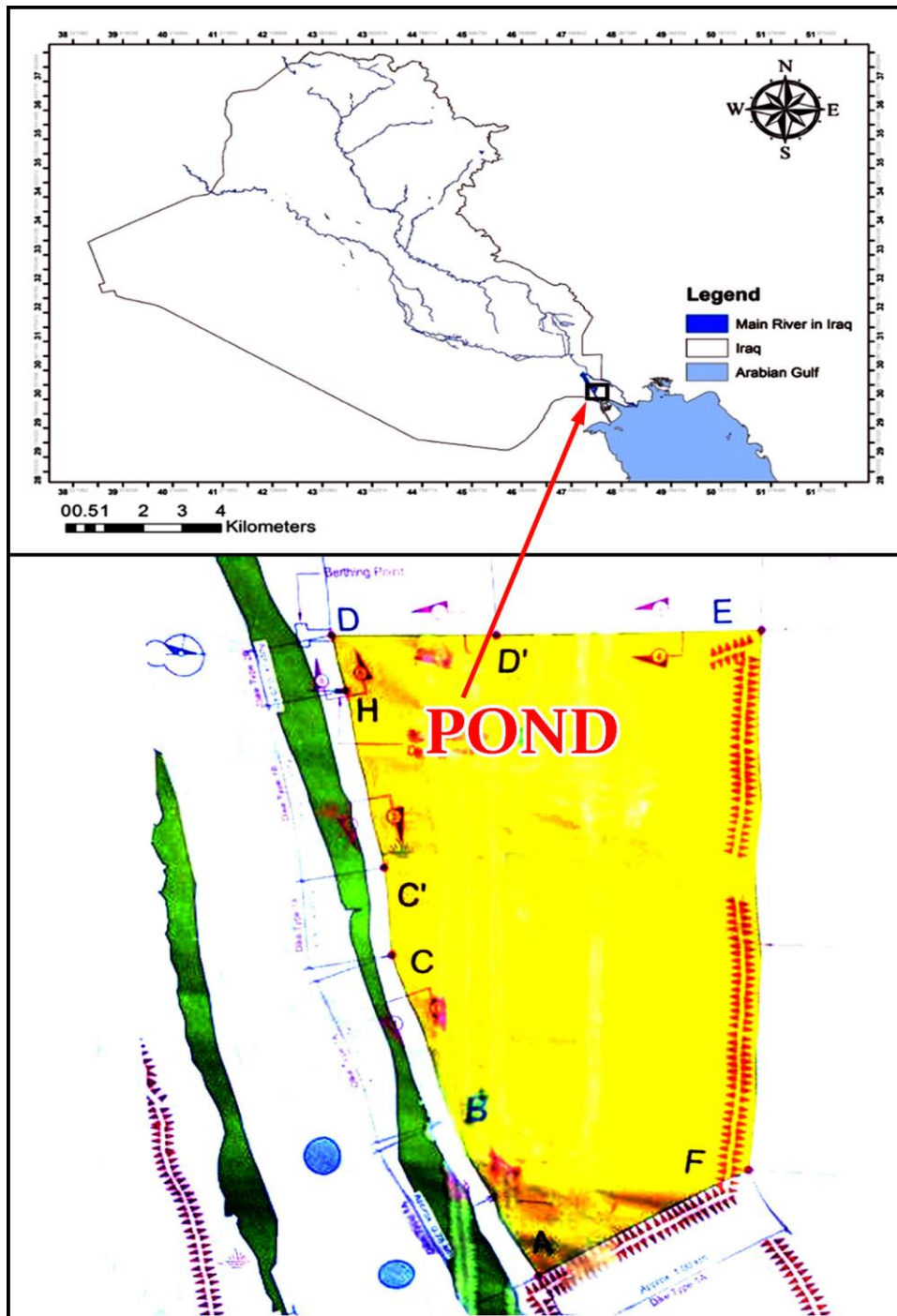


Fig. 1. the Map of the study area.

beginning of the construction, the dump area was totally dry. After few months later, when a dredging material mixed with seawater were discharged into the pond, unexpectedly, many birds flocks, remarkably the big flamingo became observed in the pond accompanied with a brine shrimp bloom.

Data collection: Data of this study were collected from five surveys conducted in the years 2019 and 2020: March 7th 2019, September 18th 2019, December 8th 2019, December 24th 2019 and January 29th 2020. Each survey was lasted between five to seven hours and the team used a vehicle in addition to walk- over. In the first visit, February 21st 2019, the GPS coordinates of the pond and other information were taken before the dredging operation started and including seawater deposing into the pond. The pond area was measured using a map provided by the dump area constructor team of the Basrah Ports Company. Salinity of pond water was measured in the field via a hand held portable salinity refractometer (type EXTECHRF 20) and samples of water were taken manually. Adults *Artemia* were collected by hand net and *Artemia*'s cysts were sieved through 0.1 mesh sieves. Morphological identification was done using dissecting microscope.

RESULTS AND DISCUSSION

Brief description of surveys

1st visit, March 7th 2019

The pond was totally dry and absence of any benthic fauna. No dredging operation was observed in the channel, no birds were observed.



Fig. 2. Large amount of *A. franciscana* cysts at the edge of the pond in Khor Al- Zubair (KAZ). © Hanaa H. M.

2nd visit, September 18th 2019

The dump area was filled with water, and an artificial pond was formed. This water was accompanied with the dredging material and seawater. The salinity of the pond was high (80 psu) due to high evaporation rates as temperature increases at this time of the year. A large amount of brine shrimp was observed in all parts of the pond. Different life stages of *A. franciscana* were collected including live and dead adults. Big quantities of *A. franciscana* aggregated cysts were found at the edge of the pond (Fig. 2). Approximately, 200 individual birds were counted in the pond belonging to 4 species, namely: *Calidris alpina*, *Calidris minuta*, *Charadrius alexandrinus* and *Charadrius hiaticula*, all are small size bird species (Table 1).

Table1. Bird species observed in the artificial pond, khor Al-Zubair, Basrah, Iraq (September 2019-January 2020).

Birds Species	Total no./4 visits	IUCN
<i>Phoenicopterus ruber</i> Greater Flamingo	157	LC
<i>Ricurvirostra avosetta</i> Avocet	765	LC
<i>Larus genei</i> Slender Billed Gull	592	LC
<i>Tadorna tadorna</i> Common Shelduck	62	LC
<i>Anas clypeata</i> Sheveler	150	LC
<i>Limosa limosa</i> Black-tailed Godwit	32	NT
<i>Himantopus himantopus</i> Black-wing Stilt	79	LC
<i>Calidris alpina</i> Dulina	22	LC
<i>Calidris minuta</i> Little Stint	30	LC
<i>Charadrius alexandrinus</i> Kentish Plover	21	LC
<i>Charadriu shiaticula</i> Ringed Plover	18	LC
Total No.	1888	

3rd Visit, December 8th 2019

High number of large size bird species were observed in the pond. Hundreds of *P. ruber*, *R. avosetta*, *T. tadorna*, *A. clypeata* as well as the other small bird species were either flying over the pond or descended in the water. A Flamingo *P. ruber* flock is a remarkable species among them consist of 53 individuals (Fig.3). The hyper-saline water > 80 PSU consist large mass of *A. franciscana* and their cysts.

4th Visit, December 24th 2019

No visible change was observed from last site visit. Mixed flocks of bird species *P. ruber*, *R. avosetta*, *T. tadorna* and *A. clypeata* were forage in the pond which consist high density of *A. franciscana* and their cysts. Due to winter season the pond was supplied with freshwater during the raining days, but however, the water was hyper-saline (50 PSU). As hatching large amounts of Artemia cysts which caused accumulated in the pond. In fact the freshwater can be inducing agent of Artemia cysts hatching.

5th Visit, 29th January 2020

During this visit, *A. franciscana* was abundant in the pond. Flocks of the large birds and the other recorded species were either foraging in the pond or flying above it. The total number of counted birds during all visits is given in table (1). A total of 1888 birds individuals were counted during all surveys, representing 11 species were utilized the artificial pond as a stopover place in their way of migration. We have recognized two species, the *A. clypeata* and *L. limosa* were near-threaten species (NT) in the International Union for Conservation of Nature (IUCN list. A previous study indicated that the flamingo *P. ruber*, the common shelduck *T. tadorna* and the shoveler *A. clypeata* were never seen in the mudflat area near the studied pond (Ali and Mohammed, 2019). Also, we had recorded over 95 bird species in the area most of them were migrant species using the mudflat as stopover and feeding ground (Ali *et al.*, 2022).



Fig. 3. Large numbers of birds species in the pond of Khor Al- Zubair (KAZ). © Hanaa H. M.

It seems reasonable to suggest that the existing of these birds in the pond does not only limit to resting purposes, but also seems to be a habitat for birds feeding. Therefore, we suggest here that the bloom of brine shrimp in the pond plays an important role to attract migrating birds as food source. However, the current investigation wasn't extended to examine the stomach contents of the birds which is a direct method to determine the consumed diets (Siqueira *et al.*, 2015). Previous studies on bird's food behaviors in similar areas could support our suggestion. For instance, previous studies found that flamingos are well adapted to feeding in highly saline water using their two rows of comb-like brislen to filter out the food which comprise small crustacean, insects, worm, brine shrimp, blue- green algae and algae (Bildstein *et al.*, 1993; Kurnssa and Bekele, 2014; Seaworld Park and Entertainment, 2021). Moreover, the avocet *R. avosetta*

with its long up- curved beak usually found forage (Scything and pecking) in saline shallow habitats including salt ponds and saltwater wetlands. Their diet consists of brine flies, brine shrimp, small crustacean and insects (Moreira, 2008; BirdFact, 2021).

Furthermore, the shelduck *T. tadorna* also reported in the sandflats and mudflats coastal areas, salt marshes, salt lakes, ponds as well as in estuarine and marsh habitats (Viaina *et al.*, 2011). This bird scything and sieving small organisms, mollusca, amphipods, worm and algae (Thompson, 1981). The shoveler *A. clypeata* with their large spoon- shaped bill, are able to filter out tiny crustacean, marine worm and other aquatic invertebrates, they also reported forage in the salt marshes, estuaries, lakes, wetlands, agricultural, ponds and waste water (Boreal Songbird Initiative, 2015). The black- tailed godwit *L. limosa* is a mid-size, NT (conservation status) bird, also it was reported they forage in the muddy and sandy intertidal zone as well as in inland saline and freshwater marshes, eating small invertebrates and aquatic plant (Van Gils *et al.*, 2020). Similar habitat uses and food type was recorded for the black- winged still *H. himantopus*. However, this species using variety feeding habits depending on the food density (Pierce, 1985). Other small bird species such as the dunlin *C. alpina*, the small wader *C. minuta*, the Kentish plover *C. alexandrius* and the common ringed plover *C. hiaticula* were reported in many previous studies, which indicated that most of them were forage in saline, brackish and tidal habitats as well as in other shallow freshwater shallow water bodies; and they feed on small invertebrates such as insects, crustacean and worms. The finding of an important study on the avian diets in the largest Salt Lake in North American, Utah could support or suggestions. This study indicated that most of the bird species, many of them are similar to those of current study, are consumed large amount of brine shrimp and brine fly. It was mentioned also that diet of eared grebes (*Podiceps nigricolis*) was consist of mainly brine shrimp (Caudell and Conover, 2006). Therefore, these studies could support our suggestion that brine shrimp attract migrating birds.

Brine shrimp (*Artemia franciscana*)

The morphological characteristic of the samples collected from the pond indicated that this shrimp belong to the species *A. franciscana*. The species name was confirmed in a previous study using a morphological and molecular data (Mohammed *et al.*, 2010), *A. franciscana* is widespread globally (Salman *et al.*, 2012)

Fresh aggregated cysts *A. franciscana* usually found in the corner of the pond due to wind action, the process highly facilitated the method of cysts collection. A total area at which the aggregated cysts measured is 23.5m². The height of pond's water was 0.5m, and therefore the cysts were distributed in 11.75m³ of the pond. A sample of 0.101m³ was collected during September 2019, sieved and collected in a zooplankton nets for a period of one week to dry in outdoor at temperature rang 30-35°C. The obtained dry weight of the cyst sample was 30Kg/ 0.101m³. The estimated total dry weight of the cyst in the pond was 3490 kg. The abundant of *A. franciscana* adults Artemia were varying in the pond water. The counted density were ranged from 150-1920 ind/L, mean number was 524 ind/L (524,000 ind/m³). *A. franciscana* and other brine shrimp species can supply the migratory birds with high energy value fuel, the energy content of 1g = 18.8KJ- 23.9KJ (Abdulla, 1995; Caudell and Conover, 2006). However, cysts of Artemia consist higher energy value but had low digestible energy and birds rarely feed on them. Of course, same amounts of cysts can be interring the digestive system of the birds in the course of

their feeding on adult *Artemia* and by this process the undigested cysts can transfer to other areas by birds (Green *et al.*, 2005; Brochet *et al.*, 2010).

Information obtained from this study and others example: Karakas (2017); Bai *et al.* (2018) and Giosa *et al.* (2018) revealed that such created artificial ponds and similar artificial water bodies such as aquaculture ponds and sewage treatment basins, would be a support habitat for shorebirds, water birds and others. Although the conservation values are not as high as the natural wetlands, the artificial ponds and wetlands can be acting as a complimentary role for birds' biodiversity by mitigated and protected their communities from various adverse environmental impacts.

CONCLUSION

The results of this study provide strong evidence that many migrated bird species have utilized the artificial pond as stopover and feeding stages benefited from the high density and a high energy content of *A. franciscana* which bloomed naturally.

- A creation of such artificial ponds with less efforts and simple management works can be a good conservation action for protection of avian biodiversity at a conditions were the natural habitats showing continuous degradation, it also provides a safe place away from the abusers and overhunting

ACKNOWLEDGMENTS

We would like to thank the crew of local station of Iraq ports company at dump area of KAZ for their helps during our visits. We are also thankful to Dr. Master, A. Ali from Basra Oil Company for logistic assistance. We also like to thank Dr. Amjed Albresm, University of South Carolina for providing helpful comments on this manuscript.

REFERENCES

- Abdullah, D.S.M. 2007. Selection of optimum conditions for the best production of the brine shrimp *Artemia franciscana* (Kellogg) in Basrah. *Ph. D. Thesis, College of Science, Univ. Basrah*, 166 pp.
- Alexander, R.M., 2013. Principles of *Artemia* Locomotion. Course Book ed. Princeton University press. Project MUSE, www.muse.jhu.edu/book/41646: PP 384.
- Ali, M.H. and H.H. Mohammed and M.A. Salim, 2022. Survey of Khor Al-Zubair and Umm Qasr Mudflat Birds: Effect of Tidal Cycle and Seasonal Variations on Their Assemblages and Abundance, Basrah, Iraq. IOP Conf. Series: Earth Environ. Sci., Volume 1029, Second International Virtual Conference on Environment & Natural Resources, 19-20 January 2022, Coll. Sci. Univ. Al-Qadisiyah, Iraq. 1029 012037, 1-12. (doi: 10.1088/1755-1315/1029/1/012037).
- Ali, M.H. and H.H. Mohammed, 2019. Birds biodiversity survey at the intertidal zone of Umm Qasr, BGC Marine Terminal and the proposed disposal sites. Study report for Marine Consulting Bureau, Marine Science Centre, University of Basrah, Iraq. 15 pp.

- Ali, M.H., D.S. Salman, N.A. Salman, H.K. Ahmed and H.H. Mohammed, 2021a. Biodiversity of the inland waters of Basrah following the 2003. marshlands restoration project (An overview). 1st Edition. Published by Dar Al-Fikr, Basrah, Iraq. Pp 192.
- Ali, M.H., N.A.M. Fawzi, H.H. Mohammed, B. Helmuth and Dwyer, A.M. 2021b. Winners and losers: Post conflict biodiversity in the stressed ecosystem of Khor Al-Zubair, Iraq. *Pak. J. Mar. Sci.* 30(2): 76-95.
- Bai, M-L, W.C. Chih, Y.C. Lai, P.F. Lee and Y.Y. Lien, 2018. Aquaculture ponds as important high tide habitats for waterbirds along the west coast of Taiwan. *Orinthol. Sci.* 17(1): 55-67. (doi:10.2326/osj.17.55).
- Bildstein, K.L., C.B. Golden, B.J. McCraith, B.W. Bohmke and R.E. Seibels, 1993. Feeding Behavior, Aggression, and the Conservation Biology of Flamingos: Integrating Studies of Captive and Free-ranging Birds. *Amer. Zool.* 33(2): 113-125. (<https://doi.org/10.1093/icb/33.2.117>).
- Bird Fact, 2021. Avocet *Recurvirostra avosetta*. (<https://birdfact.com/birds/avocet>).
- Boreal Songbird Initiative, 2015. Northern Shoveler *Anas clypeata*. (<https://www.borealbirds.org/boreal-bird-field-list>)
- Brochet, A.L., M. Gauthier-Clerc, M. Guillemain, H. Fritz, A. Waterkeyn, A.J. Green, 2010. Field evidence branchiopoda, Ostracods and Bryzoans by teal (*Anas crecca*) in the Camargue (Southern France). *Hydrobiologia*, 637(1): 255-261. (doi:10.1007/s10750-009-9975-6).
- Caudell, J.N. and M.R. Conover, 2006. Energy content and digestibility of brine shrimp (*Artemia franciscana*) and other prey items of eared grebes (*Podiceps nigricollis*) on the Great Salt Lake, Utah. *Biol. Conserve.* 130(2): 251-254. (doi:10.1016/j.biocon.2005.12.018).
- Fawzi, N.A., K.P. Goodwin, B.A. Mahdi and S.M.L. Stevens, 2016. Effects of Mesopotamian Marsh (Iraq) desiccation on the cultural knowledge and livelihood of Marsh Arab Women. *Ecosyst. Health Sustainabil.* (2)3: e011207. (doi:10.1002/ehs2.1207).
- Gurney, R., 1921. Fresh-water crustacean collected by Dr. P. A. Buxton in Mesopotamia and (Persia). *J. Bombay Natural History Society*, 27(4): 835-844.
- Giosa, E., C. Mammides and S. Zotos, 2018. The importance of artificial wetlands for birds: A case study from Cyprus. *PLOS ONE* 13(5): e0197286. (<https://doi.org/10.1371/journal.pone.0197286>)
- Green, A.J., M.I. Sánchez, F. Amat and J. Fignerola, 2005. Dispersal of invasive and native brine shrimps *Artemia* (Anostraca) via waterbirds. *Limnol. Oceanogr.* 50: 737-742.
- Hopkin, M., 2005. Reflooding bodies well for Iraqi marshes. (<https://doi.org/10.1038/news05221-1>).
- Iraqi Ministry of Health and Environment (IMoHE), 2010. National report on biodiversity in Iraq. Fourth national report to the convention on Biological diversity (CBD), July 2010, 1-53. (www.cbd.int/doc/wold/iq/iq-nr-04-en.doc).
- Karakas, P., 2017. Ornithological importance of artificial pond: a case study Kabakli pond, South eastern Anatolia, Turkey. *AGRIS.* 15(4): 919-930.
- Kommentare, K., 2017. Energy demand and adaptations of migrating birds. BIOGIONIK 07. Dez.blogionik.org

- Kurnssa, T. and A. Bekele, 2014. Feeding Ecology of Lesser Flamingo (*Phoeniconaias minor*) in Aijata-Shalla Lakes National Park (ASLNP) with special Reference to Lakes Abijata and Chitu, *Ethiopia-Asian J. Biol. Sci.* 7(2): 57- 65.
- Mohammed, D. S., S.D. Salman, and M.H. Ali, 2010. Morphological and molecular study on *Artemia franciscana* (Branchiopoda: Anostraca) from Basrah, Iraq. *Crustaceana*, 83(8): 941-956.
- Moreira, F., 2008. The winter-feeding ecology of Avocets *Recurvirostra avosetta* on intertidal areas. 1. Feeding strategies. *Ibis*. 137(1): 92-98. (doi:10.1111/j.1474-919X.1995.tb03224.x).
- Pierce, R.J., 1985. Feeding methods of stilts (*Himantopus* spp.). *N.Z. J. Zool.*, 12(4): 467-472. (<https://doi.org/10.1080/03014223.1985.10428298>).
- Roberts, A.J., 2013. Avian diet in a saline ecosystem: Great Salt Lake, Utah, USA. *Hum. Wildl. Interact.* 7(1): 158-168.
- Rubee, C., A. Alwash and A. Bachmann, 2009. The key biodiversity Areas Project: Objectives and Scope 2004- 2008. In: Krupp F. Masselman L.J., Kotb M.M.A., Weidig I. (Eds.). Environment, Biodiversity and Conservation in Middle East. Proceeding of the First Middle Eastern Biodiversity Congress, Aqaba, Jordan, 20-23 October 2008.
- Salim, M., P. Porter and C. Rubec, 2009. A summary of birds recorded in the Marshes of Southern Iraq, 2005-2008. *BIORISK?* Biodiversity Ecosyst. Risk Assess. 3: 205-219. (doi: 10.3897/biorisk.3.14).
- Salman, D.S., D.S. Mohammed and M.H. Ali, 2012. Review of the biogeography of *Artemia* Leach, 1819 (Crustacea: Anostraca) in Iraq. *Int. J. Artemia Biol.* 2(1): 62-73.
- Seaworld Park and Entertainment, 2021. All about Flamingos Diet and Eating Habits. (<https://Seaworld.org>).
- Siqueira, P.R., M.F. de Vasconcelos, R.M. Goncalves and L.O. Leite, 2015. Assessment of stomach contents of some Amazonian Birds. *Ornitol. Neotrop.* 26: 79-88.
- Thompson, D.B.A., 1981. Feeding behavior of wintering Shelduck on the Clyde Estuary. *Wildfowl.* 32: 88-98.
- UNEP, Partow, H., 2001. The Mesopotamian Marshlands: Demise of an Ecosystem. Early warning and Assessment. Technical Report. UNEP/DEWA/ TR-01-3 Rev.1
- Van Gils, J., P. Wiersma, D.A. Christie, E.F.J. Garcia and P.F.D. Boesman, 2020. Black-tailed Godwit (*Limosa limosa*), Vetsion. O. In birds of the world (J. delHoyo, A. Elliott, J. Sargatal, D.A. Cristie, and E. de Juana, Eds.). The Cornell Lab of ornithology, Ithaca, NY, USA. (<https://doi-org/10.2173/bow-bktgod.oi>).
- Viaina, A., F. Corre, P. Dolaporte, E. joyeu and P. Bocher, 2011. Number, diet and feeding methods of common shelduck *Tadorna tadorna* wintering in the estuarian bays of Aiguillon and Marennes-Oleron, western France. *Wildfowl.* 61: 121-141.