

Notes on the Hydrobiology of Azraq Oasis Jordan

by

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with 2 figures

Azraq Oasis lies in the Jordanian desert (lat. 31°50' N and long. 36°50') 85 km east of Amman in the northern part of the great Arabian desert region. It is situated at the junction of the basalt region to the north and the limestone-flint region to the south. The oasis is the only area of permanent water in this region and the water is supplied by two powerful springs and, lying in a depression, forms during the rainy season the catchment area for about 31 thousand sq km. The total area of the oasis is about 26 sq km.

The only substantial *precipitation* occurs in December-January; the mean annual rainfall (1937—1955) is averagely below 100 mm per year. Summer temperatures may reach 41°C, average is 29°C, but in winter temperatures may fall below freezing point. There is a very high rate of evaporation and water is continually drawn up by capillarity together with the dissolved salts. Heavy salt incrustations are formed and there is commercial though primitive exploitation of salt from artificial salt pans. We have therefore an arid and saline series of habitats.

The oasis is roughly kidney shaped and is surrounded by scrub of *Artemisia*, *Phlomis* and *Chenopods*; *Linaria palestina*, *Stipa* and *Aristida* species occur in places of blown sand. Two permanent villages lie in the oasis, Azraq Shishan and Azraq Druz, separated by several kilometres; during certain seasons nomadic Bedawin gather at the oasis.

Azraq oasis is of great potential interest as the centre for a large scale conservation and national park project under the aegis of the Jordanian government and the International Biological Programme.

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In preparation for this enterprise several teams have worked in the area; in 1965 a limited amount of hydrobiological material was gathered here and was given to the author for working out and presentation.

In its vegetation the oasis belongs to the Mediterranean and Irano-Turanian region as part of the Saharo-Sindian province (GUEST 1966). As to animal life only the birds of the oasis have been studied in the recent past. Over 200 species have been recorded, of which at present 60 have been found resident with a number of aquatic fowl (MOUNTFORT 1965). Geographically, many birds are migrants from East Africa and Southern Arabia to their other homes in Western Asia, Eastern Europe and Asia minor. Ecologically there is a peculiar mixture of wetland, aquatic and desert types.

Water basins of the oasis and their limnological character.

The two powerful springs and seasonal rainfall contribute to the origin of a network of waters with a great variety of chemical composition and permanence (table).

On emerging from underground the two springs form sizable pools with clear water of about 1.5 m depth. The two groups of pools are separated by several kilometres (sites 1,4,7, and site 3) and show differences in chemical composition due to the different origin of the two springs; but they keep within the limits of fresh waters.

These pools overflow into rivulets, meandering and forming swamps with stands of *Phragmites*, *Scirpus* and *Tamarix*, covering several hundred hectares. Isolated freshwater pools (sites 6 and 9) show a partly conventional fauna and persist for a long time. Wells occur also in the area and are of special interest (site 2).

Towards the margin of the swamps rivulets and rain combine and create extensive, very shallow inundations of temporary character. Waterlogged mud-flats (site 5a and b) occupy several thousands of hectares, interspersed with drier ridges. These are saline and framed by a vegetation of *Nitraria*, *Tamarix*, *Scirpus maritimus*, species of *Juncus*, *Artemisia* and *Seidlitzia*.

The most conspicuous temporary water body was a large saline 'lake' (Qa el Azraq)* within the oasis, lying in a depression not much more than 1 m deep, but covering a large and changing area (site 8).

The oasis offers therefore a series of waters of graded salinity and permanence of great interest to arid zone limnology. As the table of analyses shows general conductivity figures range from 650 to 25 000 micro-ohms (10^{-6} mho); sodium ions from 3.26—278.0 milli-equivalents per litre, to mention only two items. These factors are in part

* Qa, special word in Arabic for large inundations.

subjected to quick changes by the effect of evaporation on the marginal waters. Consequently the Azraq waters offer excellent opportunities for more prolonged studies of the physiology and ecology of some organisms living in these conditions.



Azraq Oasis (part) from the air.

The view is from west to east; the village Azraq Shishan surrounded by trees lies at the edge of the extensive network of water basins which are visible as spring pools near the village, meander out as streamlets into a swamp area (dark) and at the lower horizon is visible a vast inundation of temporary nature, the Qa el Azraq.

Photo (Copy-right) E. Hosking, London.

Outside the oasis, but worthy of mentioning, was the incidental observation of molluscs, amphipods and a crab in the very short rivulet emerging from a spring in the Qumran area on the Dead Sea. From its emergence at the foot of the Qumran escarpment this streamlet ran only for about 200—300 m before it entered the Dead Sea in a swampy small delta; in Roman times part of this streamlet was cleared and circum walled, forming a basin with a mosaic at its bottom.

All these sites were visited and collections made from the 14 to 18 April 1965.

Some notes on the aquatic fauna.

The power of the common aquatic fauna to colonise any waters even remote, is well known. Ubiquist species of a large ecological valence

are therefore found also in Azraq. Some freshwater organisms are selective and will appear only under specific conditions.

Only fishes, molluscs and some crustaceans are recorded here from the Azraq waters from this first examination.

Fishes: *Tilapia zillii* (GERVAIS) and *Clarias lazerae* (VALENCIENNES) occur in the spring pools and may have been introduced. – In the shallow inundations and mud-flats *Aphanius dispar* (RÜPPELL) appeared, especially in ditches which had a more prolonged degree of permanence. This species is indigenous and splits into a complex of 'varieties' all over Asia Minor. The material is in the hands of a specialist for incorporation into a larger series of finds.

Molluscs: Nine species have been recorded from the collected material, some of these not completely identified.

Melanoides tuberculatus (MÜLLER) was found in the spring pools (sites 1 and 3). This is found in brackish waters of estuaries on some coasts of the Indian Ocean; it occurs also south of the Sahara and is widely distributed in East Africa.

Melanopsis praemorsa (LINN.) in the spring pools and in the streamlet at Qumran.

Theodoxus macrii (RECLUZ) was found in the spring pools. Both *Melanopsis* and *Theodoxus* species are found in North African waters, bordering the Mediterranean and in the Near East. *Theodoxus* extends further south than *Melanopsis* and has been found in Lake Tana, Ethiopia. A further species of *Theodoxus* was found as single large shell in one of the spring pools and has not been identified so far.

Planorbis planorbis philippii (DE MONTERASATO) was found alive only in site 9, which was an isolated pool with a low Cl content; but shells were present also elsewhere; this species is normally restricted to fresh water.

Hydrobia species were represented by three forms, as could be expected; similar species have been found on both European and African shores of the Mediterranean. One of these forms is similar to *Hydrobia ventrosa* and this species has only recently been found in an inland water habitat in Europe. – Two more forms of the genus were found at site 3, still unidentified.

Hydrobia species normally occur in brackish waters.

Limnea auricularia (LINN.), a freshwater species, occurs in isolated pools which have little salinity in comparison with other waters in this region (site 9).

Crustacea

Potamon potamios (OLIVIER) – *Decapoda* – was quite numerous in the spring pools and at Qumran. This species is known from Palestine; the Azraq specimens probably belong to a subspecies or variant

TABLE I

Total amino acids of *Ulva*, *Dictyota* and *Pterocladia* after treatment with urea, ammonium salt, nitrate and vitamin B₆. (mg/g dry weight of each alga).

	ULVA					DICTYOTA					PTEROCLADIA				
	Control	Urea	NH ₄ Cl	KNO ₃	VitB ₆	Control	Urea	NH ₄ Cl	KNO ₃	VitB ₆	Control	Urea	NH ₄ Cl	KNO ₃	VitB ₆
Glycine	1.9	1.6	2.08	2.88	2.76	3.6	15.2	7.2	5.2	14.2	2.6	6.36	5.2	5.2	3.01
α -Alanine	3.7	1.6	4.12	4.10	3.23	7.2	8.52	10.8	t	t	3.6	8.63	5.2	5.2	5.72
β -Alanine	1.4	26.88	0.24	1.17	10.3	t	t	t	3.6	4.8	t	1.33	3.6	2.6	1.50
α -Aminobutyric	0.4	4.7	0.6	0.4	9.9	t	t	t	7.2	1.3	t	t	10.8	5.2	1.38
γ -Aminobutyric	4.2	t	t	0.42	t	t	3.9	t	t	t	2.6	18.96	7.2	3.6	6.24
Valine	3.4	6.3	3.59	2.76	18.76	5.2	5.1	7.2	7.2	8.1	7.2	20.46	14.4	10.8	12.1
Leucine(s)	6.26	6.1	9.67	9.48	16.96	8.8	8.6	12.4	10.8	15.4	10.8	25.03	18.0	14.4	17.7
Serine	t	1.88	t	t	0.22	t	0.1	t	t	t	3.6	32.5	t	3.6	5.14
Threonine	1.9	0.90	2.08	1.8	3.99	3.6	3.5	3.6	5.2	4.0	3.6	8.1	12.4	5.2	3.9
Aspartic	1.9	0.90	2.82	2.64	3.89	3.6	6.5	5.2	5.2	4.02	2.6	6.0	8.8	7.2	3.9
Asparagine	0.5	6.05	0.24	0.24	t	t	1.84	t	t	4.25	t	t	t	t	t
Glutamic	2.52	1.4	3.22	3.90	7.03	5.2	7.0	8.8	8.8	6.64	5.2	10.55	14.4	12.4	7.18
Glutamine	t	t	t	t	0.62	t	t	t	t	4.88	t	t	1.6	1.6	0.3
Cysteine	t	t	0.52	t	1.84	t	t	t	t	t	t	t	t	t	t
Cystine	0.42	t	1.29	0.51	3.60	t	t	0.64	t	0.88	1.6	5.4	3.6	2.6	2.3
Methionine	t	t	t	0.84	1.3	t	0.75	1.6	t	3.76	t	t	1.6	2.6	1.38
Phenylalanine	4.75	2.3	7.98	7.42	9.5	5.2	7.6	8.8	7.2	8.17	7.2	45.51	12.4	10.8	39.8
Tyrosine	1.04	3.8	2.70	3.90	10.43	1.6	1.25	3.6	3.6	1.9	3.6	10.4	14.4	5.2	10.99
Ornithine	0.49	2.9	1.41	1.08	3.42	t	1.7	1.2	2.4	0.1	t	1.2	2.6	1.6	0.75
Lysine	0.37	2.22	t	0.24	4.62	0.64	t	1.6	2.4	2.39	0.48	0.66	1.6	2.6	0.65
Arginine	0.37	0.32	0.88	0.12	0.02	t	1.7	1.6	1.6	1.8	t	3.1	t	t	1.88
Proline	1.10	4.6	1.41	2.64	8.2	1.6	2.7	3.6	1.6	6.95	5.2	10.4	10.8	8.8	6.4
Hydroxyproline	t	0.8	t	0.12	t	t	t	t	t	0.55	t	0.33	t	t	0.33
Histidine	0.37	0.3	1.77	1.92	0.6	1.6	4.33	0.8	0.8	6.69	0.48	0.80	3.6	3.6	0.75

t = Trace amounts.

TABLE III

Total amino acids of Ulva, Dictyota and Pterocladia after treatment with acetate, pyruvate and glucose (mg/g dry weight of each alga).

	<i>ULVA</i>				<i>DICTYOTA</i>				<i>PTEROCLADIA</i>			
	Cont.	Acet.	Pyr.	Gluc.	Cont.	Acet.	Pyr.	Gluc.	Cont.	Acet.	Pyr.	Gluc.
Glycine	1.9	1.4	5.2	10.8	3.6	7.47	5.2	t	2.6	7.2	1.6	5.2
α -Alanine	3.66	2.99	7.2	10.8	7.2	4.3	5.2	7.2	3.6	7.3	3.6	3.6
β -Alanine	1.4	22.8	8.8	t	t	2.4	5.2	2.6	t	2.0	5.2	3.6
α -Aminobutyric	0.4	6.4	10.8	t	t	t	t	t	t	1.3	t	8.8
γ -Aminobutyric	4.15	1.8	5.2	t	t	3.6	8.8	10.8	2.6	18.0	8.8	t
Valine	3.35	13.4	8.8	5.2	5.2	2.4	5.2	5.2	7.2	21.6	7.2	8.8
Leucine(s)	6.25	10.6	14.4	14.4	8.8	8.7	12.4	12.4	10.8	30.8	16.1	16.1
Serine	t	t	1.6	t	t	t	t	t	3.6	1.9	t	t
Threonine	1.9	2.1	7.2	5.2	3.6	3.4	5.2	5.2	3.6	10.6	5.2	7.2
Aspartic	1.9	2.5	3.6	8.8	3.6	5.4	5.2	5.2	2.6	6.4	5.2	5.2
Asparagine	0.5	0.42	t	t	t	t	t	t	t	t	t	t
Glutamic	2.52	4.5	8.8	7.2	5.2	6.4	10.8	7.2	5.2	11.9	14.4	8.8
Glutamine	t	t	4.24	t	t	t	t	t	t	t	t	t
Cysteine	t	1.8	t	t	t	0.48	t	t	1.6	2.6	1.6	1.6
Cystine	0.42	t	t	t	t	t	t	1.6	1.6	10.2	1.6	1.6
Methionine	t	t	t	0.64	t	t	3.6	t	t	t	t	1.6
Phenylalanine	4.75	5.1	10.8	10.8	5.2	5.2	10.8	10.8	7.2	37.03	12.4	10.8
Tyrosine	1.04	6.8	5.8	3.6	1.6	1.1	5.2	5.2	3.6	5.8	7.2	5.2
Ornithine	0.49	0.96	t	1.6	t	1.1	3.2	2.6	t	t	2.6	1.6
Lysine	0.37	1.53	0.64	1.6	0.64	2.56	0.64	1.6	0.48	t	2.5	0.6
Arginine	0.37	0.11	1.6	0.64	t	1.2	1.6	0.64	t	6.1	t	t
Proline	1.1	6.6	3.6	1.6	1.6	3.8	1.6	1.6	5.2	15.6	8.8	5.2
Hydroxyproline	t	t	t	t	t	t	t	t	t	t	t	t
Histidine	0.37	0.21	0.64	0.64	1.6	9.6	1.6	1.6	0.48	10.9	2.6	1.6

Cont., Control; Acet., Acetate; Pyr., Pyruvate; Gluc., Glucose; t = Trace amounts.

named *Potamon setiger* (RATHBUN) known only from the Aleppo region.

Echinogammarus pungens (MILNE-EDWARDS) – *Amphipoda* – appeared in all sites in numbers. This is a circum-mediterranean species or species complex with a considerable salt tolerance. It has only recently invaded freshwaters from the Mediterranean and is undergoing speciation.

Branchinella spinosa (MILNE-EDWARDS) – *Anostraca* – was found only in the large temporary 'lake', which had a very high concentration of salts. Described in 1840 from a locality near Odessa, it was later found there nearby and other records are from Bechuana-land and Spain. All these localities are in arid and saline regions. Sample records are kept in the British Museum of Natural History.

Cladocera and Copepoda

A number of these were found mainly of ubiquitous nature: *Ceriodaphnia reticulata* (JURINE), *Simocephalus expinosus* (KOCH), *Alona intermedia* (SARS); several representatives of the *Cyclops serrulatus* and *viridis* groups. Of interest amongst the Cyclopids is *Metacyclops minutus* (CLAUS) found in the temporary and saline basins. This species is well adapted to survive in temporary waters by forming cysts in a copepodite stage; it has been recorded from the most extreme temporary and shortlived rainpools in the Nubian desert (RZOSKA 1961).

The rediscovery of *Daphnia triquetra* (SARS).

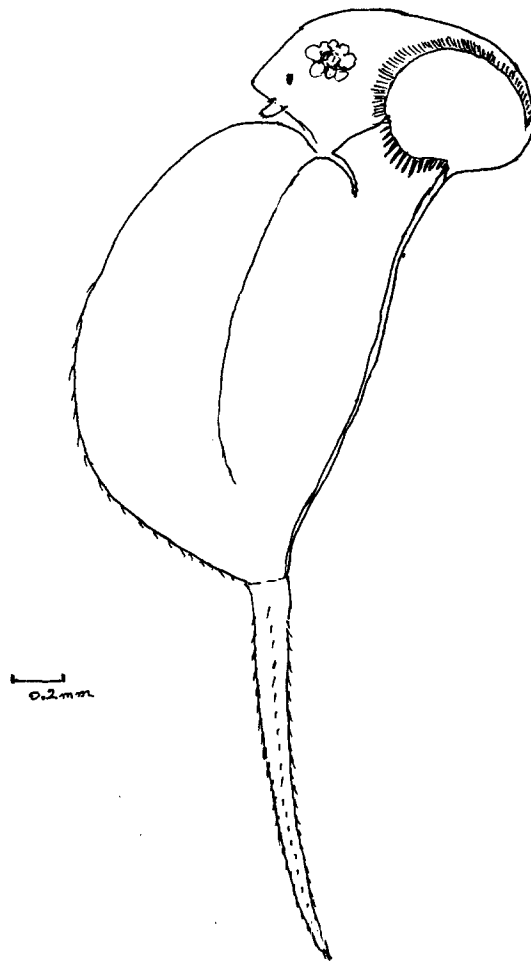
The rediscovery of this very peculiar species after many years is of considerable interest. It was found only in the highly mineralised and temporary waters of sites 5 and 8.

SARS described this species in 1903 from specimens collected from two saline lakes and a connecting stream near Akhmalinsk in Russian Asia. According to recent private informations, kindly supplied by N. N. SMIRNOV (1966, in litteris) no further finds have been recorded from Soviet territories. In 1931 KEISER described three similar but not identical forms from the Kara-Kum desert between the Caspian and the river Amu-Daria; the nearest of these to the *triquetra* is *Daphnia atkinsoni* var. *triquetriformis* KEISER. A record of *Daphnia triquetra* has been published by SPANDL (1925) in material of the Vienna Museum collections; no data exist of time or locality besides 'Sarawak-Borneo'.

Daphnia triquetra belongs according to BROOKS (1957) to the *atkinsoni* group of Daphniae. This group has been recorded under various names from widely separated localities of the palaeartic region (Spain, Sweden, Bohemia, Asia Minor, and Asia) Morphologically the *atkinsoni* group is very varied and was based initially on

imperfect descriptions of *Daphnia atkinsoni* by BAIRD in 1859 from Jerusalem. Illustrations published by LILLJEBORG (1900), WAGLER (1936) and SARS (1903) differ considerably. The *atkinsoni* group has, however, one outstanding feature in common, that is the expansion of the dorsal carapace ridge into the head region of various extent. Besides great morphological differences, there seems to exist also ecological differentiation with forms similar to the *triquetra* apparently confined to arid and saline regions and waters of temporary nature. Morphologically *D. triquetra* is unique in having a very big carapace extension surrounded by an almost circular band of spines.

The Azraq specimens differed from SARS' description in shape;



Outlines of *Daphnia triquetra* Sars, ♀ from Azraq Oasis, Jordan.

the head bulges backwards in the neckplate region giving the animal almost a halfmoon shape. (illustration). The carapace spine is longer; the terminal claws of the post-abdomen show proximally stronger spinules of 'comb' like nature followed by very fine setae; a bundle of fine denticles is inserted on the post abdomen near the insertion of the end claws, as in LILLJEBORG'S and KEISER'S drawings of their species. Sizes varied from 2.2 to 2.4 mm for the body (head to spine insertion) and 1.05 to 1.65 mm for the spine.

In the temporary and saline waters of Azraq only few females and mostly ephyppial ones were found; but a great number of ephyppia found in the net-sweepings indicated a previous large population, dying out at the approach of the dry season. The life cycle of this remarkable *Daphnia* in the short lived waters of Azraq should be of great interest.

The whole *atkinsoni* group of *Daphniae* is worthy of a revision, taxonomic, morphological and ecological; its physiology showing adaptations to a great variety of salt concentration is of particular interest.

SUMMARY

Waters of the Azraq Oasis in Jordan are described against the background of the desert. Two powerful springs and a seasonal rainfall in winter contribute to the creation of a varied system of waters in the oasis. Distributed over an area of 26 sq km these waters, initially non saline, become highly mineralised, form swamps and – on the margins – extensive temporary inundations. Examined sites of this network of waters show a great variety of chemical constitution (Table). The aquatic fauna shows a transience from ubiquitous fresh-water forms to highly restricted species, adapted to saline and in some cases temporary conditions. The rediscovery of *Daphnia triquetra* SARS, many years after its description in 1903 is so far the most remarkable event.

RÉSUMÉ

L'oasis d'Azraq dans le désert de Jordanie possède un réseau d'eaux douces et saumâtres, provenant de deux puissantes sources et d'une saison pluviale limitée en général à Décembre et Janvier. Ces eaux se distribuent sur une surface d'oasis de 26 km carrés et sont sujets à une puissante évaporation. C'est pourquoi elles montrent une grande variété de composition chimique, donc salinité. (table).

La faune aquatique montre une transition entre espèces ubiquistes d'eaux douces d'un part et d'autre part formes adaptées aux conditions de vie en eaux temporaires et très salines. La re-découverte de *Daphnia triquetra* SARS décrite en 1903 d'Asie est particulièrement intéressante. (illustration).

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