Articles

The Huleh and its Lost Aquatic Leaf Beetle

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Abstract

Much of the biological history and literature of the Huleh Lake and Swamps in the upper Jordan (Rift) Valley of Israel is reviewed. Prior to its drainage in 1951-1959, this unique aquatic habitat supported a considerably larger fauna and flora, especially tropical (Ethiopian) species. The transitions that this aquatic habitat went through before, during, and after its drainage are mentioned. A small section of the former lake and swamps was salvaged and established as a Nature Reserve in 1959.

Subsequent to early threats of drainage, several attempts were made to survey the flora and fauna of the Huleh; only the flora was significantly studied. Consequently, the opportunity to gather biological and ecological information about much of the Huleh fauna was lost after its drainage. An example is the probable extinction of the isolated Huleh population of the semi-aquatic, primarily Euro-Siberian leaf beetle *Donacia bicolor*. The extinction of this *Donacia* population was apparently caused by the nearly complete extermination of its hostplant, *Sparganium neglectum*, as a result of the drainage. Some general biology of the genus *Donacia* is presented, along with the first record (1863) of a second species *(D. thalassina)* from the Huleh. Since 1971, the Huleh Nature Reserve has undergone rehabilitation in an attempt to restore habitat and biota closer to that existing before its drainage.

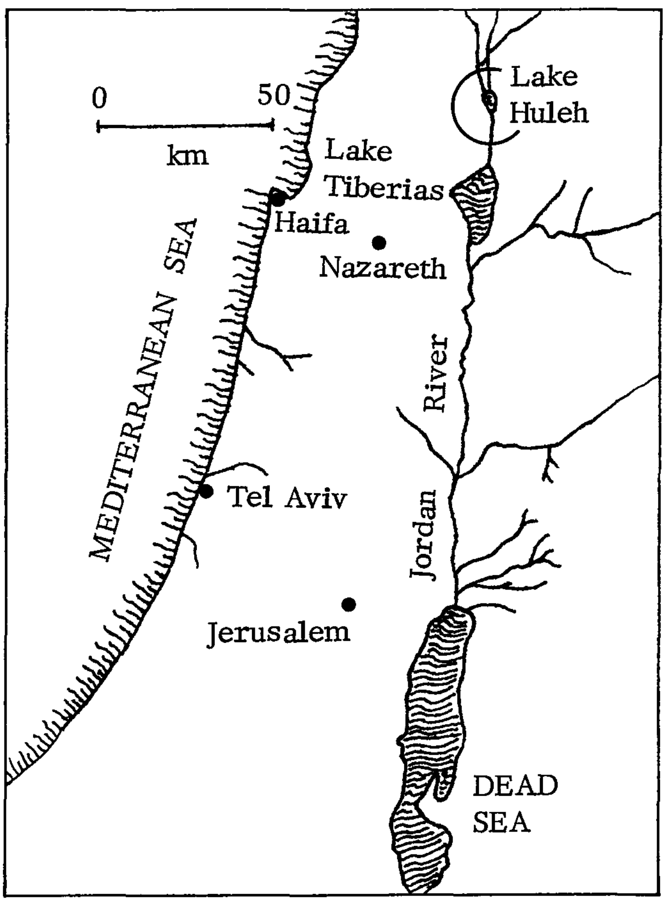

Figure 1: Jordan River System and location of Lake Huleh (after Kugler & Wool, 1968).

Introduction

In the land of the Bible existed a mysterious lake surrounded by extensive swamps known as the Waters of Merom. Aside from its Biblical mention, few travelers to the Holy Land have mentioned it and even fewer have recorded any aspects of its natural history. In more recent times, this area has been known as the Huleh (or Hula) Lake and Swamps (although "Swamps" is used throughout this paper, the Huleh wetlands were actually marshes in the technical sense). The Huleh Lake was at the head of the Jordan Valley where the major sources of the Jordan River merged (Fig. 1). It was the major part of the narrow Huleh Plain or Valley set between the eastern, high, basaltic plateau of the Golan Heights and the western, limestone, Upper Galilean mountains located in present-day Israel. The lake's surface was 67 meters (220 feet) above sea level, as opposed to its southern neighbor, Lake Tiberias (Sea of Galilee), which is 212 meters (696 feet) below sea level.

The Huleh's unique environment provided a refuge for many unusual plants and animals, including some endemics. Of special interest is the fact that the Huleh (as well as other parts of the Jordan Valley System) was and still is a refugium for a surprising number of tropical African (Ethiopian) plants and animals; this is presumably because the Jordan Valley is part of the Great Rift Valley of East Africa. The Huleh was the largest hydrophytic area in Palestine and Syria (Zohary & Orshansky, 1947). In spite of its large size and biological uniqueness, little scientific investigation took place there until relatively recently.

Why all the mystery and paucity of biological knowledge? The vast marshes surrounding Huleh Lake were so dense with various reeds, rushes, and other vegetation that most of the area was virtually impenetrable to explorers. Another major reason was the presence of the malaria mosquito in the marshes. Neither of these reasons seemed to daunt the Jewish and Arab peasants who lived nearby. Even the Canon H. B. Tristram, in the first great biological treatise on the region (Tristram, 1884), recorded very little concerning the biota of the Huleh because he could not penetrate the area. Around the turn of the century, a few naturalists managed, with difficulty, to explore the area, and recorded details of the existing biota (Barrois, 1894; Annandale, 1913, 1915). However, it was not until the threat of drainage of the Huleh Lake and Swamps in 1934 that a series of comprehensive scientific investigations took place.

Because of the intentions to drain the area, many scientists became alarmed at the potential massive extinction of many endemic populations of exotic plant and animal species. As a result of this concern, the 1935 Percy Sladen Expedition of Lake Huleh took place. This was a small but rather intensive investigation conducted by a zoologist, R. Washbourn, and a botanist, R. F. Jones, both from England. The resulting samples were analyzed by various specialists, mostly from the British Museum of Natural History (Washbourn & Jones, 1936, 1938). Jones (1940) published the first botanical study of the Huleh, including detailed ecological information. Since this investigation, a series of studies on the fauna, flora, and physical environment of the Huleh Lake and Swamps has been carried out. Nevertheless, these studies were insufficient; in 1951, drainage plans were finalized, and the slow process was completed by 1959. Fortunately, a small section of the former Huleh Lake and Swamps was salvaged, and established as a Nature Reserve.

Below I will discuss the past extent, size, and character of the Huleh; the effects of the drainage of Huleh Lake and the surrounding wetlands on the biota; the apparent drainage-caused extinction of the isolated Huleh population of the leaf beetle *Donacia bicolor* Zschach; and the establishment of the Huleh Nature Reserve.

Past Extent, Size, and Character of the Huleh

The heart-shaped Huleh Lake covered about 15 square kilometers (6 square miles) and the swamps about 30 square kilometers (12 square miles) (Fig. 2). As mentioned above, primary inflows of water were the Jordan River source streams, as well as several springs, most notably Ein Einan (also called Wadi el Barid or Ein Melaha). The swamp area varied in size with the season, expanding during winter floods and shrinking during arid summers. Throughout the swamps were pools of various size and channels of open water, but most of the area was dominated by jungles of Papyrus *(Cyperus papyrus* L.) reaching 5 meters (16 feet) in height on peat soils, as well as *Polygonum acuminatum* Kunth, *Phragmites communis* L., and others. Sometimes the rhizomes of these plants, especially Papyrus, formed "islands" dense enough to support humans.

Jones (1940) mapped the ecological plant associations of Huleh Lake, and Zohary & Orshansky (1947) mapped the swamps. Many plant associations were present, all influenced by local ecological conditions. Many of these communities were eliminated or severely restricted after drainage of the lake and swamps (Paz, 1976). Water depth in the Huleh varied between 1 and 3 meters (3 to 10 feet), with a silt and mud bottom and basaltic pebbles on the eastern shores. The relative shallowness of

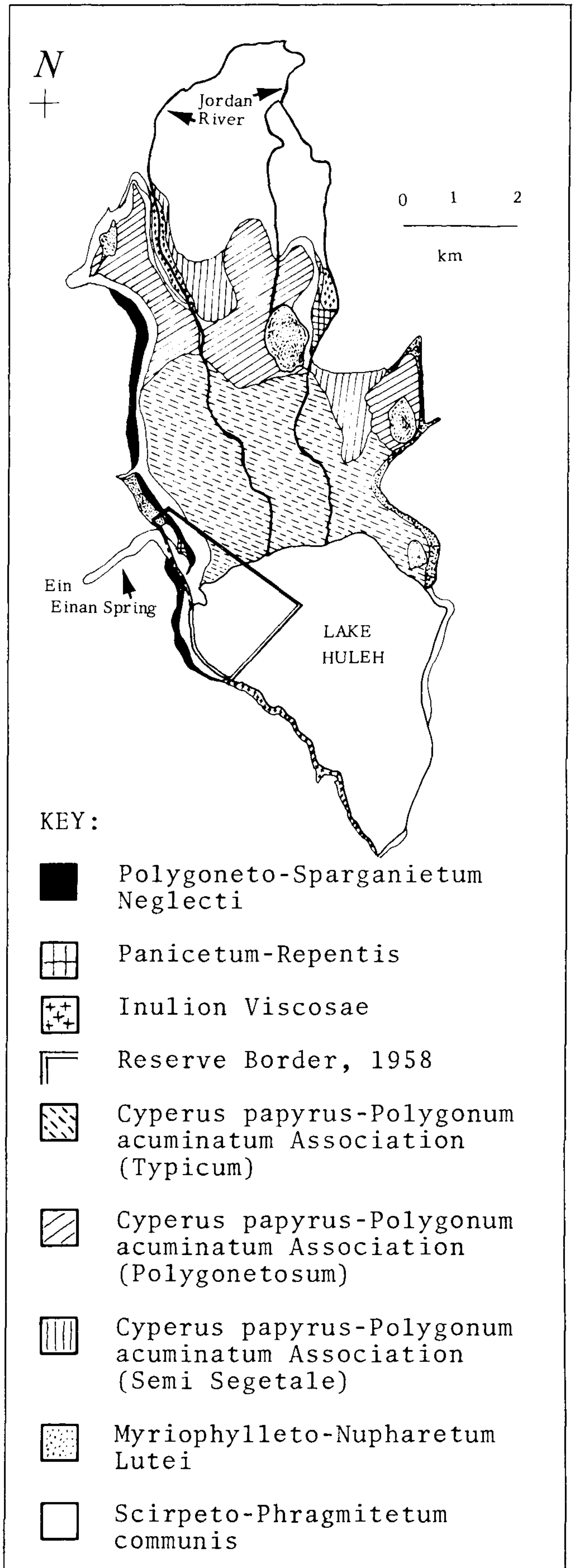

Figure 2: Huleh Swamp vegetational associations (after Zohary & Orshansky, 1947).

the lake prevented stratification into warm epilimnion and cold hypolimnion (Jones, 1940). Both the lake bottom composition and depth apparently affected the ecological plant associations (Paz, 1976). There were distinct differences in water quality between the swamps and the lake (Jones, 1940). The lake had approximately six times more oxygen than the swamps, a higher, alkaline pH of 7.9 in contrast to 7.3 in the swamps, and higher water temperature, less salinity, and less organic matter.

Those ecological factors which affected the plant associations probably also directly affected even non-phytophagous animals. Herbivores were often distributed in the Huleh according to the distribution of their foodplants. This type of relationship may have been so inflexible that when the host was endangered or eliminated, so was the herbivore.

The Huleh Valley was, and to some extent still is, the northernmost enclave for many tropical African (Ethiopian) biotic elements. In his classic work on the fauna and flora, Tristram (1884) first recorded the surprising amount of tropical African biotic elements in Palestine (comprising 30 percent of Palestinian mammals, for example). Tristram, Annandale (1913), and others claimed that no distinctly Ethiopian invertebrate elements were present in Lake Tiberias (Sea of Galilee). However, after further study, Bodenheimer (1935) demonstrated a rather high percentage of Ethiopian invertebrate species in some groups, especially insects (e.g., Orthoptera and Odonata). Ethiopian species were also found in vertebrate groups such as mammals, breeding birds, and fresh water fishes. He illustrated the unique zoogeographic position of Israel as a crossroads of various sections of the Palearctic and Ethiopian Regions. I have summarized much of the biogeographic information about Israel, including some relatively recent extinctions (Furth, 1975).

Bytinski-Salz (1961) noted that among insects, the Ethiopian species are migrants, are associated with fresh water, or are dependent on Ethiopian hostplants. These three factors probably have played and are playing an important role for many other Ethiopian animals in the Huleh Valley. The percentage of Ethiopian biota in the Jordan Valley Rift System is much higher than for Israel as a whole; examples include various species of *Acacia,* the African Monarch Butterfly *(Danaus chrysippus chrysippus* L.), and the Leopard *(Panthera pardus* L. — now endangered there). Kugler & Wool (1968) discovered that over 50 percent of the midges (Diptera: Chironomidae) in the Huleh Nature Reserve during 1965-1966 were Ethiopian elements. These included some species not found in larger Lake Tiberias which lies just to the south in the Jordan Valley and has a milder climate. There may have been even more tropical midges in the Huleh prior to its drainage; we will never know. Perhaps the two most integral elements in the pre- and post-drainage of the Huleh are tropical African species — the cichlid fishes *(Tilapia* spp.), now a mainstay in the fish industry there, and the legendary Papyrus that still dominates the Huleh Reserve. Thus the former Lake Huleh and Swamps were, and to a lesser extent still are, the northernmost locality in the Great Rift Valley for many Ethiopian species.

The Effects of Drainage on Huleh Biota

Human impact in the region was noticeable even before drainage of the Huleh. In the 13th century the Mamluks built a bridge over the narrows of the Jordan River (south of the Huleh) and this had a damming effect, raising the water level. In the early 1900's this effect was diminished when the bridge was widened

Figure 3: *Donacia bicolor* Zschach.

(Paz, 1976). Villagers around the Huleh engaged in a small fishing industry, massive harvest of Papyrus for huts or various woven products, and the domestication of large numbers of Water Buffalo *(Bubalus bubalis* L.) (Washbourn & Jones, 1938). These activities all had distinct effects on the ecology and structure of the lake and swamps, but were not nearly as damaging as the drainage during the 1950's.

Why were the Huleh Lake and Swamps drained between 1951 and 1959? The reason was two-fold: to attempt eradication of malaria, and to reclaim arable land for new settlements. The incidence of malaria was once as high as 30 percent among Jewish settlers. By 1945, due to the introduction of certain mosquito-eating fish *(Gambusia* spp.) and the extensive use of proper clothing and netting on dwellings, the malaria rate had dropped to three percent (Paz, 1976). DDT, which I have seen used indiscriminately by the Israel Ministry of Health to control malaria-bearing anopheline mosquitoes (Furth, 1969), was applied to the Huleh in 1946, and malaria cases in the region were reduced to less than one percent (Paz, 1976). It is quite possible that subsequent indiscriminate use of DDT in the Huleh may have caused eradications of other aquatic invertebrates before the drainage. It is apparent, as Paz pointed out, that malaria was actually sufficiently suppressed before the drainage commenced. Much of the land reclaimed through Huleh drainage was of little agricultural use. Thus, it appears that the drainage and its consequent prodigious reductions and extinctions of many endemic populations of plant and animal species was mostly a folly.

Effects of the Huleh drainage are too numerous to list fully here, but I will mention some of the more important ones. This paper testifies to the fact that these effects are still coming to light.

Drainage created vast areas of dried swamp vegetation (formerly inundated by water) which in 1960 ignited and burned one-third of the Huleh Reserve (Paz, 1976). Very few of the diverse hydrophytic plant associations remained, and many characteristic plants were eliminated, such as *Marsilea*, a tropical fern; *Nymphaea*, a water lily; *Utricularia*, a bladderwort, and the only carnivorous plant; *Iris*; etc. (Paz, 1976). Many plants formerly confined to discreet sections of the Huleh Valley spread over large areas, including *Tamarix*, *Ficus*, *Cyperus papyrus*, *Phragmites communis*, and others, which created completely new, undesirable associations.

One of the most important changes after drainage was in water quality, particularly increases in salinity, hardness, and amounts of soluble and suspended solids (Paz, 1976). This greatly affected the entirely or partially submerged vegetation, as well as the animal life. Gone were many planktonic associations and various shoreline communities and associations.

Many fish species were eliminated after drainage, leaving a very unbalanced and somewhat detrimental association. One of Israel's few endemic vertebrates, a frog *(Discoglossus nigriventer* Mendelssohn & Steinitz), described in 1940, has not been seen since 1955, and is very possibly extinct (Paz, 1976). Many species of waterfowl no longer breed in the Huleh Reserve, but still survive in other parts of Israel or in nearby commercial fish ponds (Zahavi, 1957). Other species no longer breed at all in Israel, since their habitats in the Huleh were destroyed. Mammal diversity and abundance has also been greatly altered by drainage.

Apparently little is known about effects of the drainage on the invertebrate fauna. This is largely due to lack of pre-drainage surveys and research. Among the insects, only recent study by a few specialists in appropriate groups has uncovered some evidence of possible extinctions. The Belgian odonatist H. Dumont has indicated *(in litt.)* that the subspecies of two tropical African libellulid dragonflies *(Rhyothemis semihyalina* Desj. and *Urothemis edwardsi* Selys) which occurred in the Huleh are probably extinct. A spongillafly of the order Neuroptera *(Sisyra trilobita* Flint) that parasitizes sponges is known only from the Sea of Galilee, and may now be extinct there due to recent water quality changes (J. Kugler, personal communication). Since sponges did exist in the Huleh Lake (Barrois, 1894; Washbourn & Jones, 1938), it is possible that this spongillafly was also living there; if so, it is probably extinct.

Apparent Extinction of *Donacia bicolor*

There is evidence for the extinction of the Huleh population of a semi-aquatic leaf beetle, *Donacia bicolor* Zschach (Coleoptera: Chrysomelidae: Donaciinae) (Fig.3), which is recorded from Europe to Siberia, southeast to Turkey, Caucasus, and Israel. This species was last collected in the Huleh by H. Bytinski-Salz, between March and May 1942, 1945, and 1946, on *Sparganium neglectum* Beeby. Another rather mysterious record is from the North Coastal Plain of Israel, in July 1940. These specimens are in the collections of Professor Bytinski-Salz and Tel Aviv University. Recently I discovered a specimen of *Donacia* at Harvard University's Museum of Comparative Zoology, collected in the Huleh, 1863-1864, by B. Lowne; however, this specimen was apparently correctly identified as *D. thalassina* Germer, a very close relative of *bicolor* known to occur in association with *Scirpus lacustris* L. in Europe. This is another mysterious record, and both unusual records warrant further investigation. It is quite possible that more than one species of *Donacia* existed in the Huleh at one time, since most of the worldwide genera of hosts (listed below) of all species of *Donacia* grew in the Huleh before drainage.

There have been no Huleh records of *D. bicolor* since 1946, and it seems very likely that this beetle may have become extinct (or nearly so) after the Huleh drainage. Even though no one may have been expressly searching for it during the last 30 years, its bright metallic green or coppery-green color, as well as its relatively large size (up to 11 millimeters, or about 0.5 inch) should have made it apparent were it still extant.

Donaciinae is a primitive, well known, semi-aquatic, primarily Holarctic subfamily of the leaf beetle family Chrysomelidae. *Donacia* is by far the largest genus. These beetles are of little economic importance except as minor pests of cultivated rice in parts of the Far East (Jolivet, 1972a). Their host preferences are usually rather specialized, at least to host genus; however, some feed on several hosts, whereas in others one host species may support several donaciine species (Marx, 1957). According to Hoffman (1940b) and Mohr (1966), the following host genera are known for most Holarctic *Donacia: Alisma, Baldingera, Butomus, Carex, Castalia, Eleocharis, Glyceria, Myriophyllum, Nuphar, Nymphaea, Phragmites, Pontederia, Potamogeton, Ranunculus, Sagittaria, Scirpus, Sparganium,* and *Typha.*

The larvae spend their entire existence submerged eating leaf petioles, stems, or roots. Some *Sparganium* feeders feed between two overlapping leaves. In order to feed under water they have specialized caudal spines on their dorsal side with spiracles at their bases (Leech & Chandler, 1963) (Fig. 4). This spine is used to puncture submerged plants and take air from the plant tissues through the spiracles (Jolivet, 1972a). Hoffman (1940a) also discovered that cutaneous respiration exists in the larvae. The larvae in most regions overwinter in the later instars, but in a few species, the adults overwinter (Jolivet, 1972b; and Hoffman, 1940a).

Waterproof silken cocoons for the pupae, possibly spun from oral glands or short Malpighian tubules, are placed on the punctured sites, usually near where the larvae fed (Leech & Chandler, 1963; Arnett, 1968). The pupal stage is of variable duration, but may last almost one year.

The bright, metallic-hued beetles usually feed on the exposed parts of the host, but a few species eat pollen, and some are known to spend their entire lives submerged. Adult respiration under water is accomplished by oxygen diffusion from the thin film of air captured over most of the body of the beetle by tiny hydrofuse hairs. This air film is often spread over the body by the antennae (Arnett, 1968). The adults often are rather specialized ecologically and ethologically, and often occur in somewhat

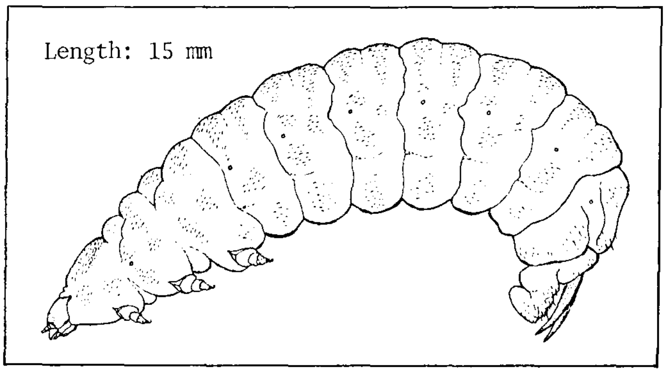

Figure 4: Larva of *Donacia* (after Peterson, 1960).

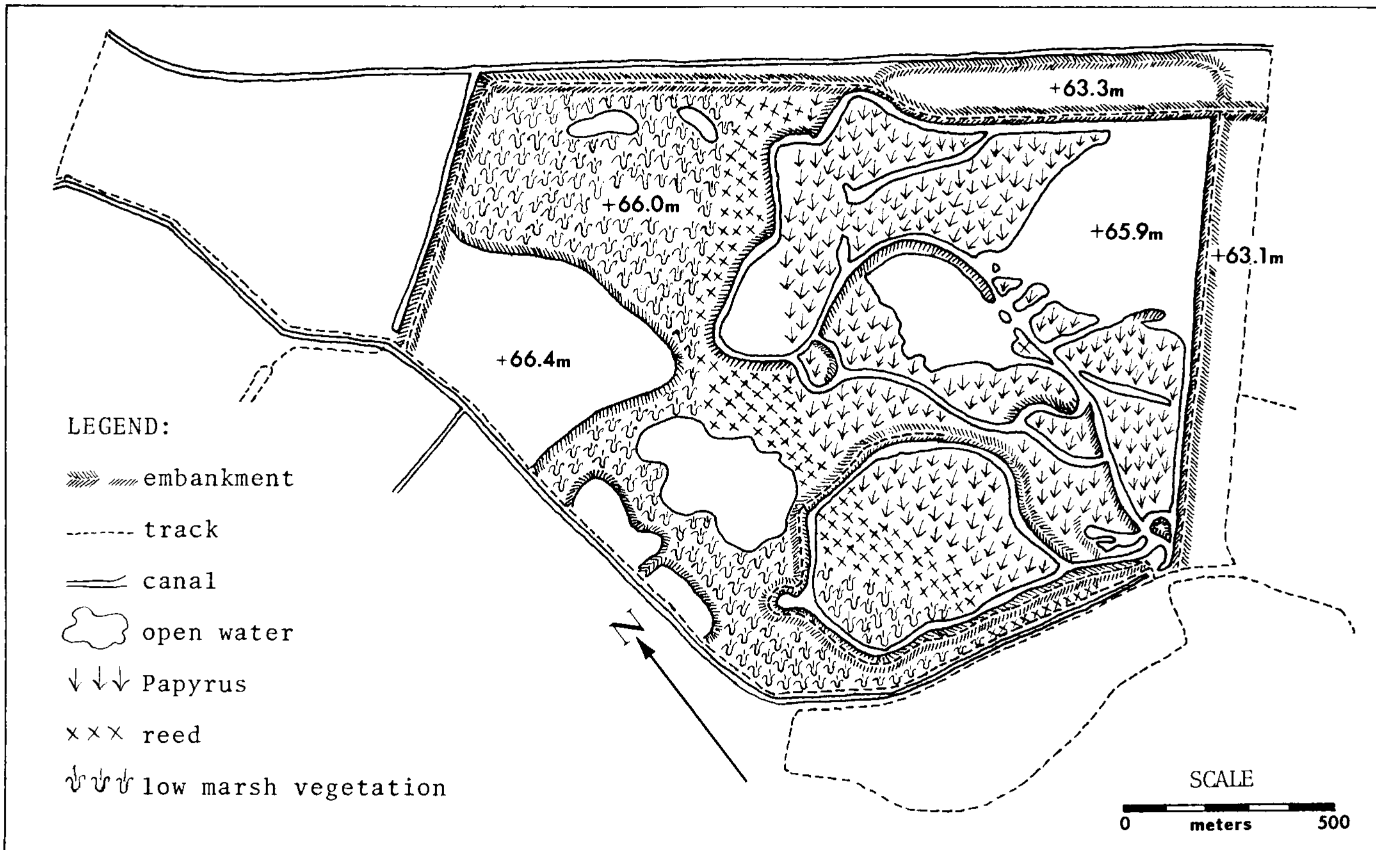

Figure 5: Huleh Nature Reserve development plan, situation after reconstruction (after Paz, 1976).

localized populations. Adults of many species of *Donacia* are known to be efficient fliers that flush easily (Marx, 1957). Eggs are deposited beneath the water surface. The life cycle may last two years in some species, and there may or may not be distinct broods present (Hoffman, 1940b). One Palearctic donaciine species breeds in fringe marine waters -- very unusual for Coleoptera (Jolivet, 1972a).

The best evidence for the local extinction of *Donacia bicolor* comes from its specialized biology and close ties with the hostplant *Sparganium neglectum*. This plant was part of a relatively small ecological plant association in the Huleh Swamps and in parts of the lake near arable land. This association extended 50-100 meters (164-328 feet) across, occurred mainly on the western and some eastern fringes of the reed *(Phragmites)* belt, and was associated with *Polygonum acuminatum* (Zohary & Orshansky, 1947) (Fig. 2). This plant is also associated with the edges of newly-formed swamps. This was one of the plant communities destroyed by Huleh drainage, and was always somewhat susceptible to dessication during the dry seasons. Paz (1976) states that *S. neglectum* is extremely rare today, found only in the Ein Einan Spring. The plant association of the Einan is that of a flowing stream; and due to differing water quality and a different environment, *D. bicolor* may not be able to exist there. I would thus conclude that the elimination of its host from the normal habitat association probably was the primary cause of the extinction of this beetle from the unique and isolated Huleh ecosystem, combined with other limiting ecological factors affecting its life stages.

Establishment of the Huleh Nature Reserve

In 1955, while drainage was still proceeding, it was agreed to set aside a certain area of the Huleh Lake and Swamps as a Huleh Nature Reserve, as a result of pressure from nature lovers and scientists. The Reserve was planned to be 4.1 square kilometers (1.6 square miles) in area (later reduced to 3.2 square kilometers or 1.2 square miles), with water more than 2 meters (7 feet) deep, and containing many boating canals. In 1964 the Huleh Nature Reserve was officially established as the first national preserve in Israel (there are currently over 100 preserves there).

The location selected for the Huleh Reserve was the northwestern corner of the former lake, an area containing the fringes of several vegetational associations of the swamps and lake. Crucial to this location was the presence of the Ein Einan Spring which provided water similar to that of the original Huleh, especially the warm temperature necessary for preservation of many tropical elements.

Putting the Huleh Reserve into operation was a difficult task due to many unexpected problems. Earth embankments created to maintain a 2-meter (7-foot) water level were improperly constructed, and much water percolated through them, significantly lowering the water level and causing dessication of preserved swamps. Attempts to alter the Ein Einan Spring for water supply caused a decreased flow, and the Reserve was initially forced to use polluted waste water from nearby fish ponds as the main water source (Paz, 1976). Problems with hunters, fishermen, fires, water quality changes, and invasions of various escaped non-native plants made it difficult for the project to get underway. All of these problems, combined with those of the drainage, made the initial Huleh Reserve far from what was desired.

In 1971 work began on a carefully detailed plan of rehabilitation and enlargement of the Huleh Reserve. Its main objective was to recover and restock as many of the biotic associations of the former Huleh as possible. Many of the problems encountered in the beginning have been corrected to facilitate stable, controlled environments. Currently, most of the rehabilitation is completed, and several ecological associations lost after drainage have been partially reestablished (Fig. 5).

I have done a considerable amount of sweep collecting for chrysomelid beetles in and around the Huleh Reserve during 1972-1974, including the Ein Einan Spring area, without finding any *Donacia bicolor*. There is, of course, the possibility that it may persist in small numbers at Ein Einan Spring. If so, this would indicate fairly recent selective adaptation to an "unnatural environment" from ancestral stock in the Huleh Swamps. If a small population does still exist there, this beetle, along with its typical hostplant associations, might be re-introduced as a small part of the rehabilitation of the Huleh Lake and Swamps ecosystem, a fascinating part of the Jordan Rift Valley System.

Conclusion

It is encouraging to see an effort to save and rehabilitate such a special nature reserve as the Huleh; however, authorities in all preservation organizations should adopt the attitude of conserving arthropod populations and their habitats. These incredibly diverse animals are as important and enlightening as their vertebrate associates.

Acknowledgements

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