



**NEW OCCURRENCE OF TWO EXOTIC HYDROPHYTES *AZOLLA FILICULOIDES* LAM. AND *HYDRILLA VERTICELLATA* (L. F.) ROYLE IN TIGRIS RIVER WITHIN MOSUL CITY**

Basheer A. Al-Ni'ma<sup>1</sup>, , Fathi A. Al-Mandeeel<sup>2</sup> 

Department of Biology, College of Sciences, University of Mosul, Mosul, Iraq 1

Department of Biology, College of Education for Women, University of Mosul 2

**ABSTRACT**

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**Correspondence Email:**

[babasheer2003@yahoo.com](mailto:babasheer2003@yahoo.com)

The present research is a scientific documentation of a historical environmental event, which is the invasion of two species of non-native (exotic) aquatic plants for the Tigris River flowing in Mosul city center near Al-Dandan water purification plant. One of them is *Azolla filiculoides* Lam., a fern belonging to the family Salviniaceae, the other being *Hydrilla verticellata* (L. f.) Royle, a monocotyledons plant belonging to the family Hydrocharitaceae. The most important morphological characteristics of both species' vegetative parts enable their identification. Morphological examination of *H. verticellata* leaf, revealed that it is monoecious biotype like that found in the states of America which are located in the northern latitudes, and not dioecious like the type found in southern latitudes states. It is recommend from the relevant specialists to monitor these two species and study the possibility of their conversion to invasive plants, It is also recommended from them to studying their impacts on the aquatic life of the river. Aim of the present study is to document the invasion of two alien hydrophytes to Tigris river that flow within Mosul city, North of Iraq..

College of Agriculture and Forestry, University of Mosul.

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**INTRODUCTION**

In most countries of the world, including Iraq, the human activities have severely affected the condition of freshwater ecosystems as introduction of non-native (exotic) species (Revengea *et al.*, 2005). Spreading of exotic species has become an issue of international importance. Their global impact has been recognized in the Convention on Biological Diversity which calls for the control and monitoring of exotic species that threaten ecosystems, habitats and species (UNEP, 1994). invasion is regarded as one of the primary menaces to biodiversity when outside their natural range, can jeopardize native fauna and flora (Hashemloian, 2009).

Within the last two decades, some water bodies in Iraq witness introduction of exotic hydrophyte by both natural and anthropogenic factors. Some of the species have turned from exotic to invasive plants as *Potamogeton* spp. in Tigris river stretch below Mosul dam (Al-Ni'ma and Al-Wattar, 2011). Concerning occurrence and distribution of these non-native hydrophytes, in Iraq, number of works have been published as Al-Abbawy and Al-Mayah (2010) found *Hydrilla verticellata* inhabiting three restored marshes; Al-Mandeeel (2013) documented the presence of *Hydrilla verticellata* in the Lesser Zab tributary; Al-Mayah *et al.* (2016) identified and

recorded the presence of *A. filiculoides* for the first time in Iraq from two locations, Hartha marshes north of Basrah city and Kalar about 120 km south of Sulaimanya city.; Al-Tameemi and Al-Kanani (2020) highlighted the relationship between *A. filiculoides* and its habitat components, Mahmood *et al.* (2020) proved by morphological and phylogenetic investigations that *Azolla* in Tanjaro River, was *A. filiculoides*; and Salim *et al.* (2021) denoted the presence of both alien hydrophytes (i. e) *A. filiculoides* and *H. verticellata* in Al-Dalmaj protected wetland.

Globally, *Azolla filiculoides* and *Hydrilla verticellata* are considered as an invasive species, however they have numerous advantages for human being and various living organism in addition to the ecosystems. For example, *A. filiculoides* used as a fertilizer in rice fields, in metal recovery by absorbing a large concentration of heavy metals.as exterminator in control of the weed, insects, and mosquitoes, in hydrogen and biogas production, in biodiesel production (Priya *et al.*, 2020). In the other hand *H. verticellata* has been associated with health, nutrition and overall care of mankind since time immemorial. the plant may be used to improve digestion and gastrointestinal function, circulation, neurological health, blood sugar control, to strengthen immunity (Palm and Nimse, 2006).

Invasion of alien species, plants or animals, may occur anytime and at anywhere. An actual example on that is the recent establishment of *Azolla filiculoides* and *Hydrilla verticellata* in Tigris river at Mosul city.

In the present study the main taxonomic features for both exotic hydrophytes were given in addition to spotting the light on their occurrence in the new area.

## **MATERIALS AND METHODS**

In the 30<sup>th</sup> of October 2022, two species of exotic hydrophytes were noticed grown near the right bank of Tigris river in front of Al-Danadan water purification plant in Mosul city, north of Iraq Figure (1).

One of the specimen was a small Neustonic fern, found floating freely on surface of stagnant water, forming small single patch covering nearly 1/2 m<sup>2</sup> Figure (2a). The other one was a rooted submerged flowering plant, found in a mass of intertwined macro-hydrophytes consist of *Ceratophyllum demersum* L., *Myriophyllum verticellatum* L., *Stuckenia pectinata* (L.) Börner and *Potamogeton pusillus* L. in addition to the algae, *Cladophora glomerata* (L.) Kütz and *Chara* sp. The mass was stuck on a steel structure surrounding the intake pump Figure (2b).

Fresh specimens of both species were collected with some water and placed in a nylon bags. In the laboratory of the college of Education for women at Mosul University, the fern's specimens preserved in formalin, while that of the flowering hydrophyte preserved by pressing. Surface water sample from the river near intake pump, also, collected in a polyethylene container, for the purpose of measuring water temperature, pH, salinity and turbidity.

Specimens of both species were mounted and deposited in the herbarium of department of Forestry, College of Agriculture at University of Mosul.



Figure (1): Mosul city map showing location of specimen (Modified from://www.wpmap.org/wp-content/uploads/2017/03/Mosul)

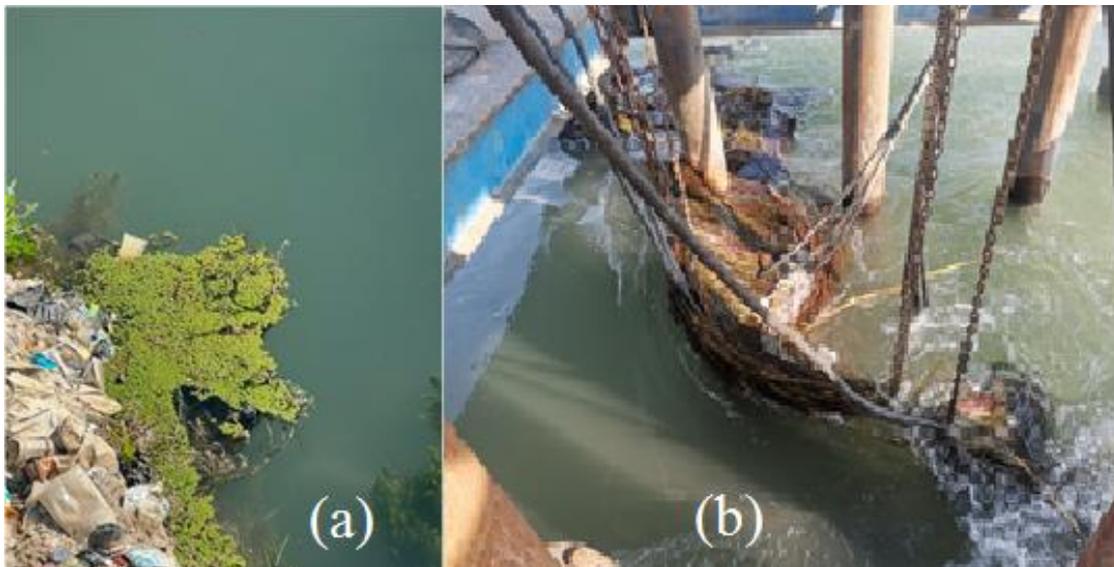


Figure (2): habitats of (a) *Azolla filiculoides*; (b) *Hydrilla verticellatum*

The specimens were identified depending upon the keys and description mentioned in:

- 1- Khoshravesh, (2009) and the web site (*Azolla* in Flora of North America @ efloras.org.) for the fern.
- 2- Maine Volunteer Lake Monitoring Program (2007) and Warrington (2001) for the flowering plant.

## RESULTS AND DISCUSSION

Identification of the specimens revealed that the small fern is *Azolla filiculoides* Lam. and the rooted submerged hydrophyte is *Hydrilla verticellata* (L. f.) Royle. Presence of both species, in Tigris river stretch in Nineveh province was not mentioned by the previous published works as (Al-Saadi and Al-Mayah, 1983; Townsend and Guest, 1985 and Al-Wattar, 2009) list, hence they are considered a new invaders for Tigris river in this stretch and the present work is considered the first scientific document for their occurrence.

### *Azolla filiculoides* Lam. 1783

Common names: Large mosquito fern; red water fern (Hussner, 2010).  
Synonyms: *Azolla japonica* Franch. and Sav. 1876, *Azolla arbuscula* Desv. 1827, *Azolla squamosa* Molina 1810, Figure (3). Some scientists consider *A. caroliniana*, *A. japonica* and *A. rubra* as independent species (op. cit.).

According to classification system of Smith *et al.* (2006), this species belongs to core Leptosporangiates Class: Polypodiopsida, Order: Salviniales, Family: Salviniaceae, Genus *Azolla* Lam. 1783.

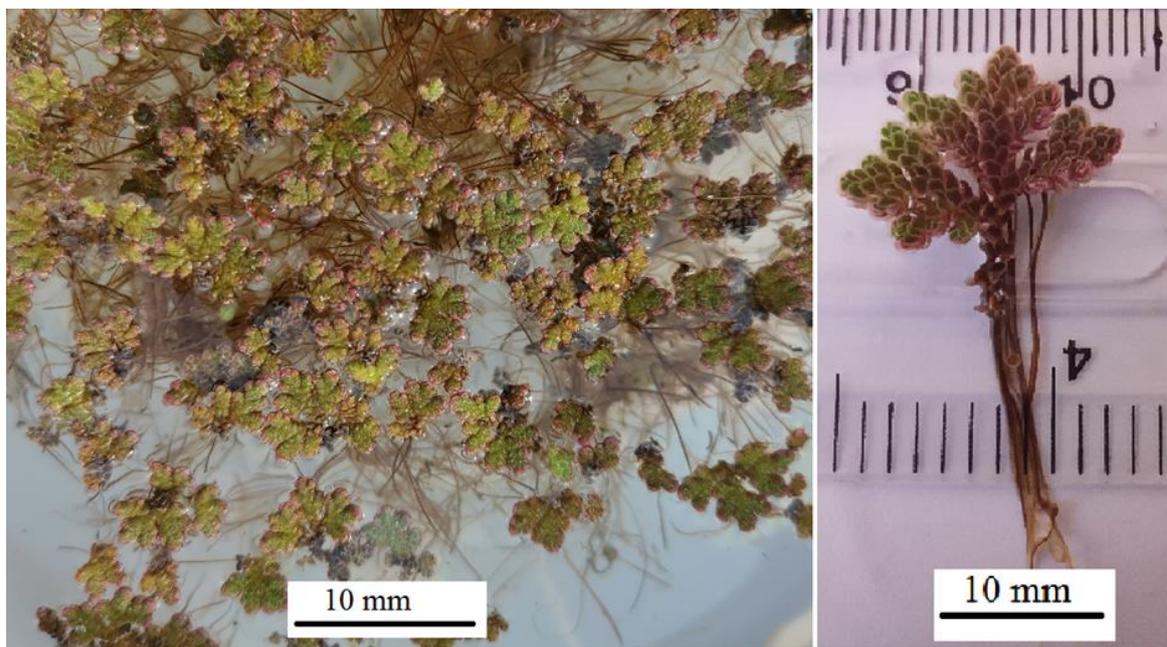


Figure (3): (a) mat of floating *A. filiculoides*, (b) single plant.

### The distinctive characters:

*A. filiculoides* is a small aquatic fern; free floating on surface of stagnant water; the plant body is the sporophyte with reduced form (comparing with the typical fern's body); length of adult sporophyte reach 15 mm; have triangular or polygonal shape, consist of branched, prostrate and thread-like rhizome; the rhizome bearing, adventitious roots and leaves; the roots are un-branched, generated from ventral surface of the rhizome and hang down in the water; the leaves alternately arranged, each one consist of two lobes: one floating dorsal lobe and one submerged ventral lobe. the submerged lobes are usually larger than the floating.

It is worthy to mention that *A. filiculoides* plants obtain reddish-brown color due to formation of anthocyanin when they exposed to strong sunlight and also during wintertime. In shade they always remain green (Janes, 1998).

The probable scenario that facilitate introduction of the fern *A. filiculoides* to the river, in the studied area, is that an Iranian specimen of this species was brought to Mosul from Basra city by academic persons working at university of Mosul in March (2019) Then they reproduce it in their experimental fields for the purpose of being tested as a substitute food for fishes.

After one year, department of Animal production in the college of agriculture and forestry started supplying some farmers with specimens of this new fodder. Currently, the fern *Azolla* is sold in the local market at Mosul city. Through these events, in some way or another, *Azolla* got reach to the river.

The new occurrence of *A. filiculoides* in Mosul and other localities, mentioned by previously published works as (Al-Mayah *et al.*, 2016; Al Tameemi and Al-Kanani, 2020; Mahmood *et al.*, 2020; Alkhafaji *et al.*, 2022), denoted that the species was occurred in south, middle and north part of Iraq, (i. e) it has a wide range of distribution. Accordingly, *A. filiculoides* can be classified as a eurytolerant specie for different ecological parameters as temperature and salinity. This conclusion can be proved by (Kempen, *et al.* (2013) who stated that "*A. filiculoides*, is an endemic species in an area extended from Alaska to the southernmost part of South America". However, in the day of specimen collection, water temperature of Tigris river was 19.0 C°, pH 7.3, TDS 2624 mg/l, and turbidity 8.0 NTU. As a consequence of being eury-tolerant species, it is expected that *A. filiculoides* will spread quickly and widely, Within next few years, reaching most Iraqi inland surface water.

In the neighbored countries (Turkey, Iran, Kuwait, Saudi Arabia, Jordan and Syria) the species was recorded, only, in Turkey and Iran by (Ünal and Üzen, 1996; Hashemloian and Azimi, 2009) respectively. In both countries it is considered, also, as an exotic plant.

### ***Hydrilla verticellata* (L. f.) Royle**

Common names: Waterthyme; hydrilla (<https://florida.plantatlas.usf.edu>)

Synonyms include: *Elodea verticillata* (L. f.) F. Mueller, 1888; *Hydrilla ovalifolia* Richard, 1814, nom. illegit. *Serpicula verticillata* L. f., 1782; *Udora verticillata* (L. f.) Sprengel, 1824; *Anacharis pomeranica* (Reichenbach) Petermann, 1849. Figure (4A) .

According to the classification system of Angiosperm phylogeny Group four, (2016) (APG IV system), the species belongs to Kingdom Plantae, Clad Monocot, Order Alismatales, family Hydrocharitaceae.

### **The distinctive characters:**

a perennial submersed aquatic plant with slender stems; profusely branching towards the water surface; stems emerging from horizontal underground rhizomes, which produce tubers on its terminal end, and above ground stolon; the leaves are strap-like; serrated (with fine-toothed margins hardly seen by naked eyes); the leaves

are 7 to 12 mm long, 2 to 3 mm wide; mid rib reddish in color; They are typically arranged in whorls of 4 to 8; the lower leaves may be opposite or in whorls of 3; the specimen was flowerless, Figure (4B-F).

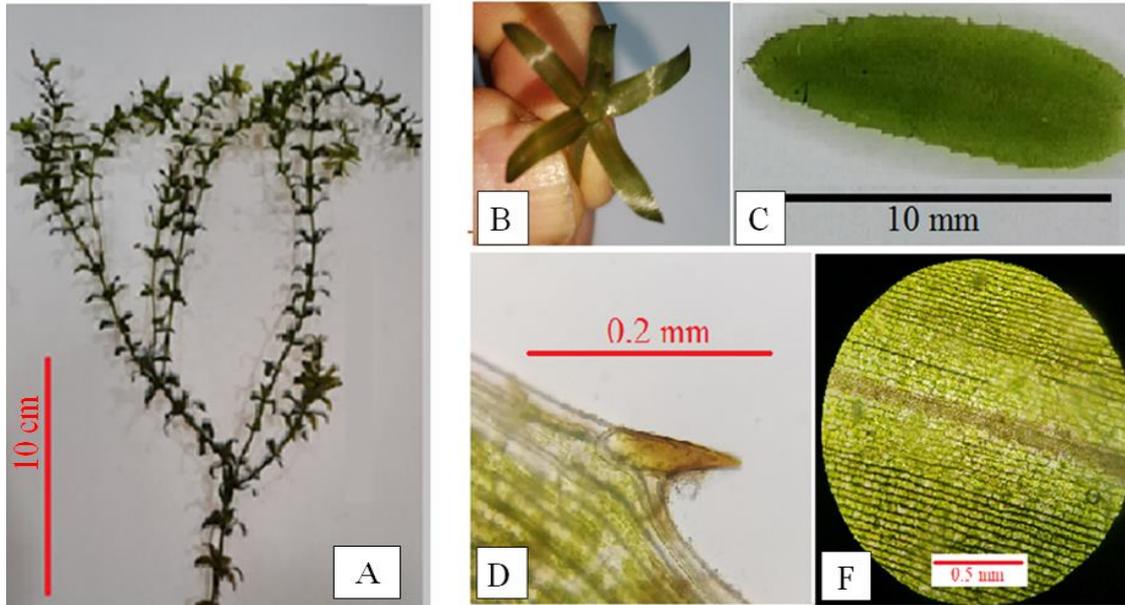


Figure (4) *Hydrilla verticellata*: (A) habit of *H. verticellata* , (B) whorls arrangement of leaves, (C) single leaf with serrated margins, (D) enlarged claw-like spine, (F) mid rib lacking spines.

There are two distinct forms of *Hydrilla verticellata* that occurring in the United States, dioecious and monoecious. The dioecious form, found primarily in more southern latitudes. While the monoecious form found primarily in northern latitudes (Maine Volunteer Lake Monitoring Program, 2007). Reviewing literatures on *H. verticellata* collected from Iraqi surface water, revealed that none of them confirmed whether their specimens were monoecious or dioecious, however, examination of the leaves showed that they were monoecious. This result was reached depending on the following characters of the leaves: Delicate, translucent, average length 4 to 10 mm, no pronounced midrib, under leaves lacking midrib spines figure (4). Re-examination for specimens from different part of Iraqi water is required to determine to which biotype they belong, monoecious or dioecious specially during flowering period.

Until (1983), *H. verticellata* was not mentioned by (Al-Saadi and Al-Mayah, 1983), however, the first record for the presence of this species in Abozeriq and central marshes by Alwan is dated back to (2006). In the following years, it was recorded in new areas as Al-Masehb Marsh, Southern Iraq (Al-Kenzawi, 2011); Al-Warar channel in Ramadi (Raja, *et al.*, 2021); in Tigris river at Maysan governorate (Ali and Al-Mayah, 2021); in Lesser Zab tributary before its confluent with Tigris river, 220 km north of Baghdad city (Al-Mandeel, 2013). In the present research *H. verticellata* found in Tigris river within Mosul city center, about 400 km north of Baghdad city. Distribution of the species along the country can be explained by its wide range of tolerance to a variety of stressors and aquatic pollutants which allows it to grow in almost all sorts of water chemistry conditions (Cook and Lüönd, 1982) and (Netherland, 1997) cited in (Shrivastavaa and Srivastava, 2021).

In the neighboring countries the species was recorded, only, in Turkey and Iran by (Üremiş, 2015 ; Filizadehi *et al.*, 2004) respectively.

For the relevant specialists, it is highly recommended to monitor these two species and study the possibility of their conversion to invasive plants, in addition to studying their impacts on the aquatic life of the river.

## CONCLUSIONS

Two non-native hydrophytes. *Azolla filiculoides* and *Hydrilla verticellata* were succeeded in reaching and settling in Tigris river that flows within Mosul city. Accordingly ecological problems are expecting to occurs since they are globally regarded as an invasive species.

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## CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

ظهور جديد لنوعين من النباتات المائية الغريبة. *Azolla filiculoides* Lam. و *Hydrilla verticellata* (L. f.) Royle في نهر دجلة ضمن مدينة الموصل

بشير علي بشير النعمة<sup>1</sup> / فتحي عبد الله المنديل<sup>2</sup>

قسم علوم الحياة/ كلية العلوم/ جامعة الموصل / الموصل / العراق<sup>1</sup>

قسم علوم الحياة / كلية التربية للبنات / جامعة الموصل / الموصل / العراق<sup>2</sup>

## الخلاصة

يعد البحث الحالي توثيقاً علمياً لحدث بيئي تاريخي هو اجتياح نوعين من النباتات المائية غير المحلية (الغريبة) لنهر دجلة الجاري في مدينة الموصل بالقرب من محطة تصفية ماء الدندان. أحدهما *Azolla filiculoides* Lam. وهو سرخس ينتمي للعائلة Salvinaceae والنوع الآخر هو *Hydrilla verticellata* (L. f.) Royle الذي يعد من أخطر الأنواع التي تمتلك قدرات هائلة على الانتشار وإزاحة الأنواع المتوطنة عند وصوله إلى بيئات مائية جديدة وهو من نباتات ذوات الفلقة الواحدة يعود للعائلة Hydrocharitaceae. تم في هذا البحث ذكر أهم الخصائص المظهر خارجية للأجزاء الخضرية لكلا النوعين والتي تمكن من التعرف عليهما. ومن خلال فحص الصفات المظهرية لورقة النوع *H. verticellata*، تبين أنه وحيد المسكن (ثنائي الجنس) مثل النوع (biotype) لمنتشر في الولايات الأمريكية الواقعة ضمن خطوط العرض الشمالية وليس ثنائي المسكن (وحيد الجنس) مثل النوع المنتشر ضمن خطوط العرض الجنوبية. نوصي المختصين من ذوي العلاقة بمراقبة هذين النوعين ودراسة احتمالية تحولهما إلى نباتات غازية كذلك نوصيهم

بدراسة تأثيراتهما الضارة على الأحياء المائية في النهر. الهدف من الدراسة الحالية هو توثيق اجتياح نوعين غربيان من الأحياء المائية لنهر دجلة في مدينة الموصل.  
الكلمات المفتاحية: نباتات مائية مدخلة، نباتات غازية، محطة تصفية المياه، الأنهار، العراق.

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