

## ***Salvinia molesta* (SALVINIACEAE) A NEW RECORD FOR THE FLORA OF SUDAN**

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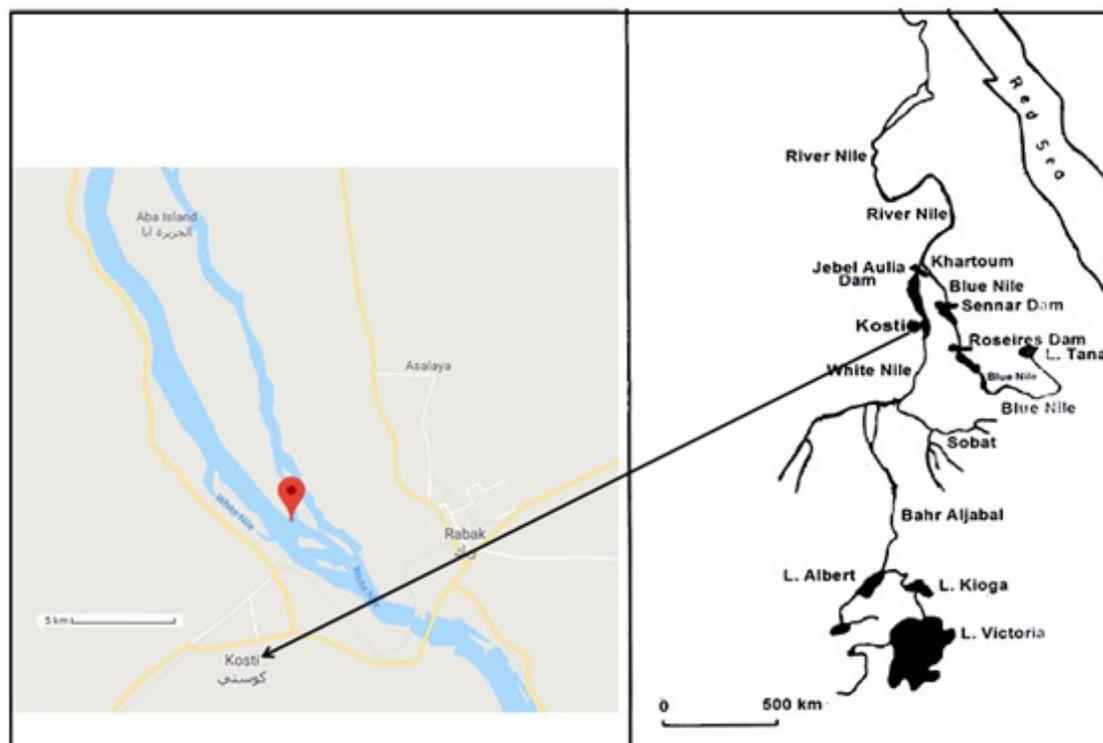
**Abstract:** This is the first documentation for the presence of *Salvinia molesta* in the White Nile, Sudan. Floating *Salvinia molesta* were encountered in the open water for the first time in Sudan near Kosti town (N 13° 11' 15.50" E 32° 40' 20.37"). Specimens of *Salvinia* were positively identified consulting relevant taxonomic keys, illustrations and descriptions. Leaf areolation patterns, sporocarps morphology, and types of hairs on the abaxial surface of the leaf were considered as key characters for identification.

**Keywords:** *Salvinia molesta*; White Nile; Sudan; new record.

### **Introduction**

*Salvinia molesta* D.S. Mitchell (Salviniaceae) is a floating water fern which infest tropical and subtropical wetlands worldwide. Several authors reported that *S. molesta* is native to South America, particularly south-eastern Brazil (Mitchell and Thomas, 1972; Forno, 1983). It has been spread widely throughout the world during the past 80 years. In Africa it has been reported in Benin, Botswana, Burkina Faso, Cameroon, Democratic Republic of the Congo, Republic of the Congo, Cote d'Ivoire, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Mozambique, Namibia, Nigeria, Senegal, South Africa, Swaziland, Tanzania, Zambia, Zimbabwe (Julien *et al.*, 2009) and recently in Uganda (Andama *et al.*, 2017). It spread to the Indian sub-continent, south-east Asia, Australia, New Zealand, Mexico and southern USA (Forno and Harley, 1979; Thomas and Room, 1986). The family Salviniaceae has only one genus *Salvinia* and 10 species reported worldwide, eight of which grow in South America (de la Sota, 2001). *Salvinia molesta* was originally reported as a form of *S. auriculata* but was later reclassified as *S. molesta*, based on details of the male sporocarps (Mitchell and Thomas, 1972). It is part of the *S. auriculata* complex which consists of four extremely similar-looking species that include *S. biloba* Raddi, *S. herzogii* de la Sota, and *S. auriculata* Aubl. in which the abaxial surface of each leaf has many tiny hairs that split then rejoin at the tips to form an egg beater-like structure (Forno, 1983; Mitchell, 1972). Members of the complex can be distinguished by sporocarp shape, the arrangement of the sporangia

and the pattern of leaf areolation (Mitchell and Thomas, 1972; Forno, 1983). During a routine field trip organised by the Natural History Museum, University of Khartoum to the White Nile (Sudan) on September 2018 a surprisingly large numbers of floating *Salvinia molesta* were encountered in the open water for the first time in Sudan near Kosti town (N 13° 11' 15.50" E 32° 40' 20.37") a location 320 km by boat south of Khartoum (Map Figure 1). Mats of *S. molesta* have only been observed in some parts at the banks of the White Nile at Kosti town where the plants become compressed together. According to the fishermen who work in the vicinity of Kosti town, this plant species is new to the White Nile. It seems that the present alien *Salvinia* species is now growing aggressively but not surpassing the growth of the notorious weed *Eichhornia crassipes* (Mart.) Solms which was first reported in the White Nile in 1957 (Gay, 1958, 1960). However, several submersed indigenous aquatic macrophytes may suffer from the shading effect of the floating *Salvinia* in the open water. *Salvinia* has not been reported before by any of the several workers who listed the aquatic macrophytes of the Sudan particularly the flora of the White Nile. Migahid (1948) in his extensive study of the aquatic macrophytes of the Sudd region during February-April 1946 did not encounter *Salvinia*. Similarly, MaCleay (1951, 1953, 1955) made exhausted lists of Pteridophyta of several regions of northern and south Sudan including eight aquatic ferns of the Nile without mentioning *Salvinia*. Denny (1984) and Ali (2009) presented comprehensive lists of aquatic macrophytes of the Sudd including few aquatic ferns but not *Salvinia*. *Salvinia molesta* has been reported in many African countries. It has recently been found in Lake Kioga, Uganda, which is part of the Nile basin (Andama et al. 2017). The source of infestation of *Salvinia* in the White Nile was probably Lake Kioga which eventually flows into the White Nile. The floating fern is probably drifted along by water current of the Bahr El Jebel which winds through the papyrus swamps of the Sudd region in South Sudan before flowing northwards towards the Sudan as the White Nile.



**Figure 1.** Map of the Nile basin showing the location of the *Salvinia molesta* near Kosti town

### Materials and Methods

*Salvinia* was collected randomly from the open water of the White Nile at Kosti town using a hand net hauled from a fishing boat. The specimens were placed in plastic buckets containing river water and transported to the laboratory in Khartoum for processing. The plant was preserved in formalin and on herbarium sheet. Part of the fresh specimens were cultured in the green house. To confirm the identification of *Salvinia*, the pattern of areolation was determined. Fresh leaves were cleared and stained after gently scraping the hairs following the modified method in Hickey (1973). Pigments were cleared using 20% commercial bleaching solution. The leaves were then stained with 1% safranin in 50% alcohol. The cleared stained leaves were examined under a dissecting stereomicroscope using toluene as the mounting medium. The pattern of venation was photographed using a digital camera. Chains of sporocarps were examined under the dissecting stereomicroscope. Sporocarps on the fertile axis were drawn by hand to scale. Sporocarps surrounded by globose indusia were examined under the light microscope and photographed.

### Results and discussion

Free floating *Salvinia molesta* was seen in large numbers in the open water. Mats have only been observed in some parts at the banks of White Nile at Kosti town where the

plants become compressed together (Figure 2). Specimens collected from the bank possess short internodes while those collected from the open water have long internodes. *Salvinia* is made up of a brittle horizontal rhizome which carries short stalked leaves in whorls of three. A pair of opposite green to brown, ovate to orbicular, deeply keeled floating leaves with distinct midribs, 1.8-3.3 X 1.5-3.7 cm (length X width), float while the third one is submersed and highly dissected. The latter looks like and functions as a root (Figure 3). As crowding increases at the bank, the internodes get shorter and leaves are pushed upward to become erect.

The upper surface of each leaf has many hairs forming the egg beater-like structure (Figure 4). Specimens of *Salvinia* were positively identified with confidence after comparing its features with the taxonomic keys, illustrations and descriptions of leaf areolation patterns and sporocarps given by Mitchell and Thomas (1972), Forno (1983) and Riefner Jr and Smith (2009). Pubescent, ovoid, apiculate at apex, short-stalked sporocarps about 1 mm in diameter are carried alternately in two rows down the length of the submersed leaf in long chains. The male sub-sessile sporocarp is surrounded by a globose indusium with numerous sporangia carrying mussulae of many microspores (Figure 5). Female sporocarps have not been recognized during the present study. Leaf areolation shows that the number and pattern of leaf venation in the present *Salvinia* are in conformity with the illustration and description given in Forno (1983) for *Salvinia molesta*. There are 6-9 areoles from the keel to the margin of a leaf lobe. Areoles towards the margin of the leaf are approximately equal in size while those towards the mid-rib are considerably longer than wide (Figure 6). However, we cannot positively exclude the presence of other species in the *S. auriculata* complex in the White Nile.

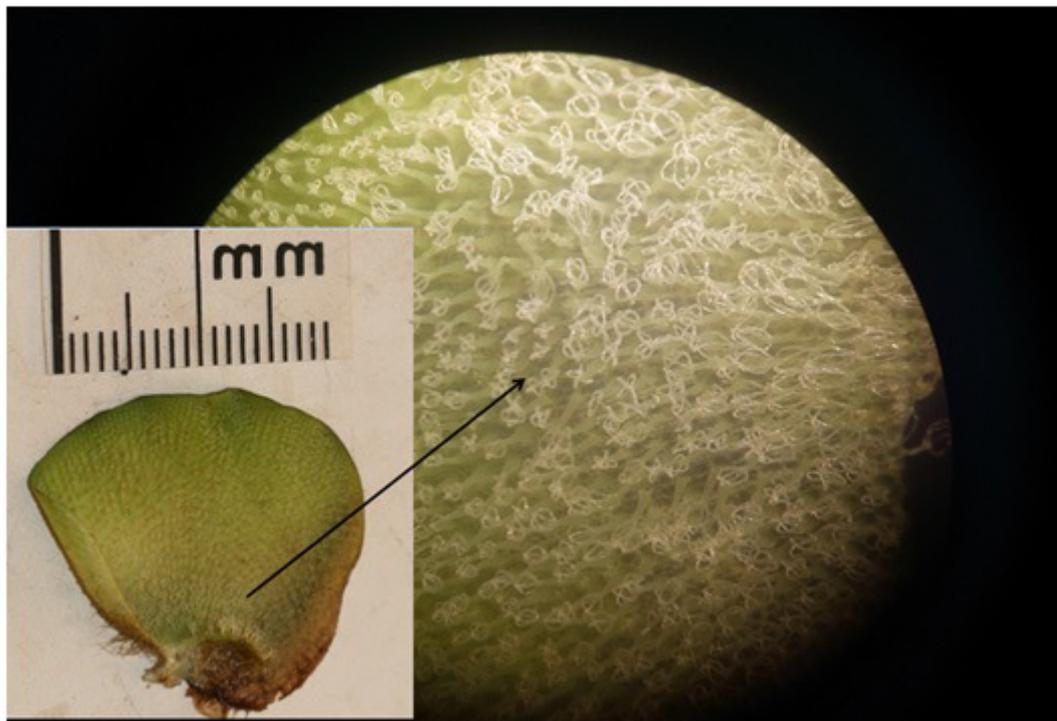
*Salvinia molesta* is notorious for its invasiveness. It ranks second to *Eichhornia crassipes* as one of the most aggressive alien aquatic plants in the world because of its environmental, economic and human health impacts. Dangerous effects of *S. molesta* occur when mats serve as breeding sites for vectors of human diseases such as encephalitis, dengue, malaria (Oliver 1993), and schistosomiasis (Bennett 1975). It has been recently added to the list of the world's 100 most invasive species (Luque *et al.*, 2014).



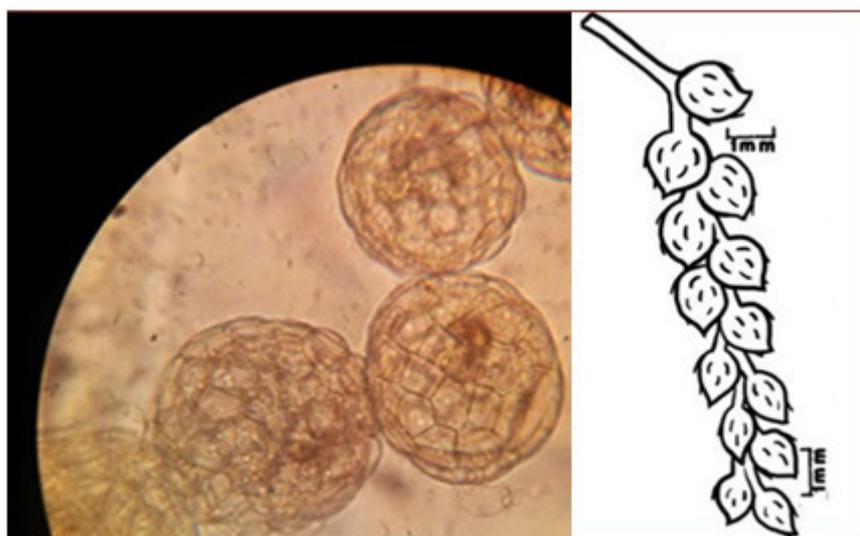
**Figure 2:** Mats of *Salvinia molesta* observed in some parts at the banks of White Nile



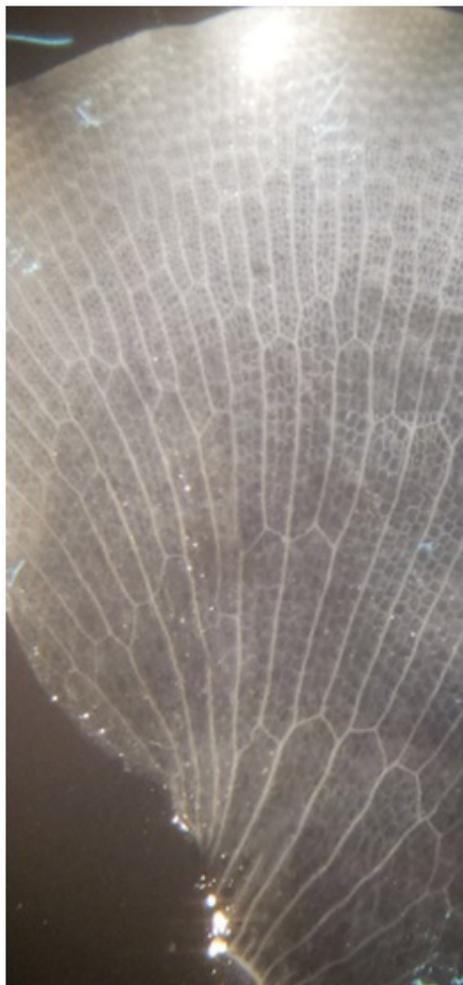
**Figure 3:** Floating and submersed leaves of *Salvinia molesta*



**Figure 4:** Hairs on the abaxial surface of the leaf of *Salvinia molesta* (x40)



**Figure 5:** Sporocarps: Whole chain and individuals surrounded by globose indusia



**Figure 6:** Leaf areoles of *Salvinia molesta*

### **Conclusion**

Early reports on the introduction of *Salvinia molesta*, as the outcome of the present paper, will help to give early warning of potential impacts of the introduced invasive plant in order to take necessary measures to eradicate the alien plant.

### **Acknowledgment**

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### **References**

[1] Ali, O.M.M., 2009. Aquatic plants of the Sudan. In H.J. Dumont The Nile: Origin, Environments, Limnology and Human Use. Monographiae Biologicae 89: 479-494. Springer, Dordrecht.

- [2] Andama, M., Ongom, R. & Lukubye, B., 2017. Proliferation of *Salvinia molesta* at Lake Kyoga Landing Sites as a Result of Anthropogenic Influences. *Journal of Geoscience and Environment Protection*, 5, 160-173.
- [3] Bennett, F.D., 1975. Insects and plant pathogens for the control of *Salvinia* and *Pistia*. In PL Brezonik and JL Fox (Eds.), *Proceedings of the biological control for water quality enhancement workshop* (pp. 28–35). Gainesville, University of Florida.
- [4] de la Sota, E.R., 2001. Sobre el tipo de *Salvinia adnata* (Salviniaceae, Pteridophyta). *Boletín de la Sociedad Argentina de Botánica*, 36(1-2): 125-129.
- [5] Denny, P., 1984. Permanent swamp vegetation of the Upper Nile. *Hydrobiologia*, 110:79-90.
- [6] Forno, I.W., 1983. Native distribution of the *Salvinia auriculata* complex and keys to species identification. *Aquatic Botany*, 17(1):71-83.
- [7] Forno, I.W. & Harley, K.L.S., 1979. The occurrence of *Salvinia molesta* in Brazil. *Aquatic Botany*, 6(2):185-187.
- [8] Gay, P.A., 1958. *Eichhornia crassipes* in the Nile of the Sudan. *Nature* 182, 538-539.
- [9] Gay, P.A., 1960. Ecological studies of *Eichhornia Crassipes* Solms. In the Sudan: I. Analysis of spread in the Nile. *Journal of Ecology*, 48 (1):183-191.
- [10] Hickey, L.J., 1973. Classification of the architecture of dicotyledonous leaves. *American Journal of Botany*, 60(1): 17-33.
- [11] Julien, M.H., Hill, M.P. & Tipping, P.W., 2009. *Salvinia molesta* DS Mitchell (Salviniaceae). *Weed Biological Control with Arthropods in the Tropics*, pp. 378–407. Cambridge University Press, Cambridge (UK).
- [12] Luque, G.M., Bellard, C., Bertelsmeier, C., Bonnaud, E., Genovesi, P., Simberloff, D., & Courchamp, F., 2014. The 100th of the world's worst invasive alien species. *Biological Invasions*, 16:981–985.
- [13] MacCleay, K.N.G., 1951. Pteridophyta recently recorded from the Sudan. *Sudan Notes and Records*, 32(1): 160-164.
- [14] MacCleay, K.N.G., 1953. Ferns and fern allies of the Sudan. *Sudan Notes and Records*, 34(2): 286-298.
- [15] MacCleay, K.N.G., 1955. Geographical relationships of the pteridophyte flora of the Sudan. *Bulletin du Jardin botanique de l'État a Bruxelles* 25 (3): 213-220.
- [16] Migahid, A.M., 1948. Report on a Botanical Excursion to the "Sudd" region. Cairo University Press, Egypt, 159 pp.

- [17] Mitchell, D. & Tur N., 1975. The rate of growth of *Salvinia molesta* (*S. auriculata*) in laboratory and natural conditions. *Journal of Applied Ecology*, 12:213-225.
- [18] Mitchell D.S. & Thomas P.A., 1972. Ecology of water weeds in the neotropics. An ecological survey of the aquatic weeds *Eichhornia crassipes* and *Salvinia* species, and their natural enemies in the neotropics. Technical papers in hydrology, No. 12. Paris, UNESCO., France 50 pp.
- [19] Mitchell, D.S., 1972. The Kariba weed: *Salvinia molesta*. *British Fern Gazette*. 10, 251-252.
- [20] Oliver, J.D., 1993. A review of the biology of Giant *Salvinia* (*Salvinia molesta* Mitchell). *Journal of Aquatic Plant Management* 31, 227-231.
- [21] Riefner, Jr, R.E. & Smith, A.R., 2009. *Salvinia minima* and *S. oblongifolia* (*Salvinioideae*) new to California, with notes on the *S. auriculata* complex. *Journal of the Botanical Research Institute of Texas*. 3 (2), 855-866.
- [22] Thomas P.A. & Room P.M., 1986. Taxonomy and control of *Salvinia molesta*. *Nature*, UK, 320 (6063):581-584.