Studies on Reproductive Biology: An overview

WAQAR YOUNIS, HILAL AHMAD MIR, WIKAS YOUNIS
Department of Botony
Faculty of Life Science

Introduction:

Reproductive biology is one of the fundamental fields for development of conservation protocols for elite and threatened plant species and on the other hand prevention protocols for invasive plant species which are increasingly becoming a threat to our terrestrial and aquatic ecosystems. The knowledge of reproductive biology is regarded to be of nuclear importance in developing control methods for aggressive aquatic species (Haynes, "1988). The studies on various aspects of reproductive biology help us in understanding the nature, systematics, modes of propagation, adaptation, hybridization and speciation (Anderson *et al*., "2002, 2006; Neil and Anderson, 2005").

""Aquatic plants are essential components of healthy ecosystems in freshwater lakes and ponds, producing oxygen, reducing erosion and regulating nutrient cycling (Hutchinson, 1975"). They provide food for many birds as well as habitat that supports rich communities of aquatic invertebrates and vertebrates (Sculthrope, "1967). Invasive aquatic plants, however, are not native species, and they are often destructive (Vitousek *et al*., 1996). "Non-native plants are responsible for economic losses and control costs estimated in one analysis at 137 billion per year in the United States alone (Pimental *etal*.,"2000). Invasive aquatic plants are noted for their explosive "growthpotential (Barrett, 1989) and their ability to grow from a few plants to cover hundreds of acres in a few years (Groth"*et al*., 1996). Invasive aquatic plants have caused declines in native plant populations throughout New" England"

(Scheldon, "1994).In some water bodies, invasive plants have become so abundent that they displaced native species (Langeland, "1996). Many biologists feel invasive species are second only to habitat destruction as the most serious threat to endangered species globally (Wilcove *et al*., "1998). Because of their great growth potential, invasive aquatic plants can block navigation channels, irrigation ditches and water intake pipes, and can also reduce aesthetic and recreational value of water bodies, affecting tourism and real estate values (Catling and" Dobson, 1985). In some cases, the plants have been found to increase breeding habitat for mosquitoes (Eiswerth"*et al*., 2000). Attempts to eradicate invasive plants once they become established often have failed (Anonymous, 1993; Growth *et al*., 1996; Simberloff, "1997), and their management is expensive (Center *et al*., 1997). Early identification of invasive plant populations and knowing their reproductive strategies is critically important to prevent the spread of these plants (Simberloff, "1997)"

""""The *Myriophyllum*, commonly known as watermill foil is a genus of aquatic mostly fresh water plants of the family "Haloragaceae. The genus name has originated from two Greek words "viz: Myrio means many and phyll means leaves. It is cosmopolitan in distribution (Moody and Les, 2010) and is represented by 68 species (APG II, 2003). *Myriophyllum*" is well known for its invasive species. The aggressive *Myriophyllum* "*spicatum* is native to Europe, Asia and North Africa (Couch and Nelson, 1985) and has now established on all the continents except Antarctica (Orchard, 1986; Yu *et al*., 2002). " It is distributed from Spain and UK in the west to China andJapan in the east and from Finland in the north to Morocco in the south (Meusel and Jager, 1978) and is introduced and invasive in North America, South America, India and Australia (Holm *et al*., 1979).

Distribution:

""Worldover, the family Haloragaceae comprises of 8 genera and 120 species; and these taxa are extremely diverse in their habit, ranging from small trees to submerged macrophytes" (Moody and Les, 2007). The three genera (*Glischrocaryon*, *Gonocarpus*, *Haloragis*,) are primarily

terrestrial, whereas three (*Laurembergia, Meizella,* " *Myriophyllum*) are aquatic/semi-aquatic "(Table 1).

""The *Myriophyllum*, commonly known as watermilfoil, is among the species rich (68 spp.) genus of the aquatic ―Core eudicots‖ (APGII, 2003). It shows a cosmopolitan distribution (except Antarctica), with a centre of diversity in Australia (50 spp., 34" endemic); North America (16 spp., 7 endemic) and Asia (18 spp., 8 endemic) also harbor a significant continental diversity and share six common" species as listed in Table 2 (Moody and Les, 2010). *Myriophyllum* is well-known for its invasive species. The aggressive *M. spicatum* L." (Eurasian watermilfoil) and South American *M. aquaticum* (Vell) "Verdc. (Parrotfeather) are now established on mostcontinents and listed as noxious weeds in United States. The North American endemic *M. heterophyllum* reportedly is naturalized in Europe (Wimmer, 1997), Asia (Yu *et al.*," 2002), and also is considered to be invasive outside its endemic range in the northeast and northwest United States (Les and Mehrhoff, " 1999). Hybridization also has been shown to play a role in North American invasions with two hybrid lineages recognized viz: *M. spicatum* x *M. sibiricum* "and *M. heterophyllum* x *M. laxum* (Moody andLes, 2002)".

Table 1: Distribution, habit and species diversity of *Haloragaceae* genera (Moody and Les, 2007).

Genus	**Distribution**	**Habit**	**No. of species**
Glischrocaryon	Australia	Terrestrial	4
Gonocarpus	Australia, New Zealand, S.E. Asia	Terrestrial	36
Haloragis	Australia, New Zealand. S. Pacific	Terrestrial*	26
Laurembergia	Pantropical	Semiaquatic	4
Meziella	S.W. Australia	Aquatic	1
Myriophyllum	Cosmopolitan	Aquatic	60

*Three species are aquatic.

Taxonomy

““The genus *Myriophyllum* L. belongs to the watermill foil family, Haloragaceae, in the order saxifragales (Moody and Les, 2010).“*Myriophyllum* has been hypothesized as a distinct within Haloragaceae due to a combination of characters including its aquatic habit“ (also found in *Meionectes, Meziella* and“*Proserpinaca*), tendency towards monoecy (also found in *Laurembrgia*) and a fruit that splits at maturity into two or four individual nutlets (not found elsewhere in the family) (Orchard, 1986). *Myriophyllum* was found to be paraphyletic in regard to the monotypic *Meziella,* in recent phylogenetic analysis (Moody and Les, 2007). “*Meziella* is similar in habit to *Myriophyllum*
“but possesses hermaphrodite flowers and while forming four nutlets, they do not split at maturity due to a persistent exocarp (Orchard and Keighery, 1993). The other aquatic Haloragaceae genera “(*Prosperpinaca* and *Meionectes*) are distinct, having perfect, two or three merous flowers with a nut and are only distantly related (Moody and Les, “2007).“

““A taxonomic confusion exists in the genus *Myriophyllum,* particularly with respect to the taxa *Myriophyllum spicatum, M. exalbescens* and *M.verticillatum* (Couch and Nelson, 1983). *M. spicatum* and *M. verticillatum* were first described by Linnaeus in the 1700‘s (Aiken and McNeill, 1980). In 1919, Fernald described a new species for North America, *M.exalbescens* (Fernald, 1919).“ Thereafter Jepson (1925); Hulten (1947); (Patten, 1954, 1956) and Orchard (1981) found the differences between *M. spicatum* and *M.exalbescens* too significant to warrant separation. Hulten and Patten placed *M.*“*exalbescens* within the older taxon as a subspecies, where as Jepson, Nicholsand Orchard preferred the varietal level. Fernald (1919) steadfastly opposed considering *M. spicatum*“and *M. exalbescens* as one species. Love“ (1961); Reed (1977), Aiken“ (1979), Aiken and Walz“ (1979), Aiken *et al.,* (1979) agreed with Fernald and concluded that the native American species, *M.*“ *exalbescens* and *M. verticillatum*“, should be separate taxa based on differences in morphology, physiology and phenology“.

““All Haloragaceae species are herbs, “submersed in quiet waters or rooted on muddy shores. The similarity of the species has led to much confusion about species identity and most species in the family cannot be separated using only individual specimens or without flowers (Johnson *et al.,* 1998). “A phylogenetic study based on nr DNA ITS sequence reveals that *M. spicatum* is most closely related to the holarctic“ species*M. sibiricum* and *M. alterniflorum*. There is also close relationship to *M. verticillatum* and the *M. quitense*. All other species analysed i.e., “*M. heterophyllum, M. laxum, M. hippuroides, M. tenellum,*“*M.pinnatum, M. farwellii* and *M. humile* are well separated from *M. spicatum* (Moody, 2004“).

““*M. spicatum* was found to hybridize with the *M. sibiricum* in NorthAmerican (Moody & Les, 2002). While *M. spicatum* and *M. sibiricum* can be distinguished by morphological characters related to leaf segments and the presence (*M. sibiricum)* or absence (*M. spicatum)* of turions, hybrids overlap with both parents in leaf characters and lack turions, thus can only be distinguished using molecular analysis (Moody and Les, “2010). *M.* “*spicatum* is variable in appearance with long stems, and usually 12 to 21 leaflet pairs, which are not stiff when out of the water, in contrast the very similar *M.sibiricum*“usually have five to 10 leaf pairs with leaflets that stay rigid when outof the water, so leaf morphology can be used to separate these two very similar species successfully (Gerber“ and Les, 1994“).

“As per Crow and Hellquist (2000), following taxonomic characters are used to identify *M.* “*spicatum.*

1. “Leaves pinnately divided, with filiform segments; vegetative stems elongate.
2. Leaves whorled.
3. Bracts usually twice as long as“ pistillate flowers.
4. Bracts of upper portion of inflorescence lanceolate, entire to denticulate, not glaucous.
5. Middle leaves with 12 or more segments on each side of rachis; many of the uppermost leaves truncate at apex; “ stem diameter below in florescence greater, up to twice the diameter of the lower stem, stem tips usually reddish; winter buds not formed.

Reproductive characters are the most important characters in the identification of the species. In the absence of flowers and/or seeds, the most distinctive characters are the reddish tips, the 12 or more filaments on each side of the central axis of each leaf and the truncated leaf tips.

Conclusion:

"The present work was carried out on *Myriophyllum spicatum* belonging to the genus *Myriophyllum* (Haloragaceae) which is an aquatic genus having cosmopolitan distribution (Moody and Les, 2010). It is native to Europe, Asia and North Africa (Couch and Nelson, 1985). During the present study *M. spicatum* was found in all the major Lakes of the valley viz. Dal Lake, Mansbal Lake, Anchar Lake, Wular Lake, Nilnag Lake; wetlands which include Hygam wetland, Hookarsar wetland, river Jhelum, Achabal spring, Shalimar stream, Chanderhama irrigation canal, Bal kol and almost in all fresh water bodies and irrigation channels. The observations of Kaul and Zutshi (1965) and Kak (1990) on the distribution of *M. spicatum* in Kashmir valley support our results.

The present study revealed that the species is a perennial rhizomatous herb with adventitious roots having a long stem distinguished into nodes and internodes with leaves in whorls of 3-5(4) at nodes, pinnately divided into 25-37 filiform leaflets, with four flowers in each whorl aggregated on aerial spike with upper male and lower female; staminate flowers axillary with three bracts, four pinkish petals and eight stamens; pistillate flowers without perianth, bracts three, pectinate with tetragonal ovary having four deep furrows and four stigmas; fruit globular schizocarp dark brown dehiscing by four longitudinal sutures, splitting at maturity into four individual seeds called nutlets; seed trigonal with two flat and an outer convex side. These results are in agreement with various studies at global level (Kak, A.M, 1978; Aiken and McNeill, 1980; Aiken, 1981; Haynes, 1988; Orchard, 1986; Donaldson and Johnson, 1998; Johnson *et al*., 1998; Crow and Hellquist, 2000 and Moody and Les, 2010)."

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