Effects of waterfowl, large fish and periphyton on the spring growth of *Potamogeton pectinatus* L. in Lake Mogan, Turkey

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**Abstract**

It has been argued that waterfowl and fish may threaten growth of submerged macrophytes, especially in spring during the early growth phase when plant biomass is low. A small reduction of biomass at that time might delay growth or decrease subsequent productivity. We investigated the impact of waterfowl and large fish on the spring growth of fennel pondweed (*Potamogeton pectinatus* L.) by employing an exclosure experiment in the macrophyte-dominated clear-water Lake Mogan, Turkey. Birds and large fish were excluded from eight plots and both *in situ* vegetation and macrophytes kept in pots were compared to eight open plots. Also, to investigate the effect of periphyton on plant growth it was removed from half of the pot plants. Exclusion of waterfowl and large fish did not significantly affect the spring growth of pondweed; neither plants growing *in situ* nor kept in pots. Removal of periphyton from the plants in the pots did not favour growth. The density of macroinvertebrates was not affected by the exclusion of waterfowl and large fish, but it was positively related to aboveground biomass of fennel pondweed. We suggest that even if waterfowl and large fish are in high densities, their effect on fennel pondweed spring growth in lakes with abundant submerged vegetation, such as Lake Mogan, is low.

**Introduction**

Fennel pondweed, *Potamogeton pectinatus* is a remarkable plant. It is a cosmopolite, occurring from tropical to arctic climate on all continents, except the Antarctic (Wiegleb & Kaplan, 1998). It grows in freshwater lakes and streams as well as in brackish waters and thrives in mesotrophic to eutrophic waters, at depths where wave exposure is moderate and light is sufficient (Weisner et al., 1997). Sediment characteristics, such as softness, grain size, content of organic carbon and phosphorus, influence growth of fennel pondweed (Lehmann et al., 1997). Biotic factors such as herbivory, competition with periphyton and phytoplankton may also affect growth and persistence (Van Dijk, 1993; Weisner et al., 1997; Strand & Weisner, 2001). Herbivory by coot (*Fulica* sp.) can have a major impact on fennel pondweed biomass (Anderson & Low, 1976; Søndergaard et al., 1996; Mitchell & Perrow, 1998). Other researchers also suggest that the impact of fish may be important.
either directly through herbivory (e.g. Van Donk et al., 1994) or indirectly through reduction of water clarity when the fish search for invertebrates in the sediment (Beklioglu et al., 2003), and through predation on large-bodied daphnids so that the indirect effects of reduced light may become intensified through eutrophication (Scheffer et al., 1993). Fish like tench (Tinca tinca) and carp (Cyprinus carpio) mainly feed on benthic macro-invertebrates, and prefer habitats with abundant macrophytes. Their foraging can potentially be destructive for the plants by up-rooting or by increased turbidity and lowered light (Maitland & Campbell, 1992). Carp also consumes a considerable amount of macrophytes and Sidorkeviej et al. (1999) showed that when no other food was available in aquaria, carp grazed heavily on fennel pondweed. Fernández et al. (1998) found a negative correlation between the density of carp and the biomass of fennel pondweed in irrigation channels in Argentina. Their results also indicated that increased carp biomasses, and increased levels of nitrogen and phosphorus, were negatively correlated with the biomass of fennel pondweed.

The timing of herbivory is known to be critical. Most of the studies conducted on waterfowl (defined as all varieties of ducks, geese, swans, coots, grebes and divers) herbivory on submerged macrophytes have suggested that the most obvious impact occurs in autumn and winter when large numbers of migrating waterfowl congregate (Kiørboe 1980; Søndergaard et al., 1996; Mitchell & Perrow, 1998). However, it is also stated that consumption of a small amount of plant tissue in an early seasonal growth phase in spring may have profound effects on subsequent rate of plant biomass increase (Mitchell & Perrow, 1998). Herbivory exerted by fish probably increase with water temperature, because cyprinids such as carp consume more in warm (25 °C) than in cold (10 °C) water (Garcia & Adelman, 1985). Plant consumption rate of grass carp (Ctenopharyngodon idella Valenciennes), which is an obligatory herbivorous cyprinid, increase linearly with temperature (e.g. Spencer, 1994). Therefore, as temperature rise in spring, herbivory exerted by fish ought to increase in importance (Van Donk & Otte, 1996). Strong effects of waterfowl and fish herbivory has been recorded in several investigations, which were mostly carried out during the period of re-establishment of macrophytes in eutrophic lakes following restoration to enhance underwater light climate (Søndergaard et al., 1996; Mitchell & Perrow, 1998). During such a period, growth of submerged macrophytes seems to be highly vulnerable to herbivory and periphyton-induced light limitation. However, it is not clear whether such herbivory can also be important for determining submerged macrophyte growth in a submerged plant-dominated clear-water lake, which already has a well-established biomass. To elucidate this, the impact of waterfowl and fish herbivory, and periphyton on the early growth of P. pectinatus in spring was tested in the macrophyte-dominated clear-water Lake Mogan, Turkey, using exclosure experiments. Exclusion of waterfowl and fish may also affect predation on macroinvertebrates, why their abundance also was investigated.

Materials and methods

Study site

Lake Mogan (39° 47’ N 32° 47’ E, water surface altitude ranging from 972.5 to 973.5) is a shallow (mean depth 2.8 m) large (5.4 km²) lake situated 20 km south of Ankara. During our study the lake was in macrophyte-dominated clear-water state at moderate total phosphorus (TP) (73.5 ± 9 μg l⁻¹; mean ± SE.), low dissolved inorganic nitrogen and chlorophyll-a (197 ± 77 and 9 ± 2 μg l⁻¹, respectively). Secchi depth transparency exceeds the entire water column in summer, when macrophytes cover 70–80% of the lake area; in early spring and winter it range from 0.8–1 m (Burnak & Beklioglu, 2000). The outflow of the lake empties into downstream Lake Eymir through a wetland in the north. Reed (Phragmites australis Cav.), cattails (Typha domingensis Pers.) and two species of rush (Juncus spp.) cover its northern, northwestern and southern shores. Submerged macrophytes, such as Potamogeton pectinatus, Myriophyllum spicatum L., Ceratophyllum demersum L., Ranunculus saniculifolius Viviani, Zannichellia palustris Boenn., Chara sp., Polygonum sp. and Scirpus sp. are encountered in the open water outside the emergent macrophytes almost all around the lake (DSI, 1993). Pike (Esox lucius L.) had the highest contribution (89 kg ha⁻¹) to the