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Vallisneria spiralis L. (Hydrocharitaceae) in Lakes in the Vicinity of Konin (Kujawy Lakeland)

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Abstract: In the last eleven years *Vallisneria spiralis* L. colonized three lakes situated in the Kujawy Lakeland, i.e. Lake Licheńskie, Lake Wąsosko-Mikorzyńskie and Lake Pątnowskie, which in 1958 were included in the open cooling system of heat and power stations. The aim of the studies conducted in 2004 was to determine the seasonal dynamics of this species as dependent upon thermal variations. Phenological observations, temperature measurements, and examinations of changes in the spatial structure of *V. spiralis* communities at selected localities were performed from the end of April to the end of October. A correlation was observed between the life-cycle of *V. spiralis* and water temperature. *V. spiralis* was also found to be tolerant of a short photoperiod. Apart from great vegetative reproduction ability, these were the main factors that decided about the biogeographical success of this species.

Key words: *Vallisneria spiralis*, Hydrocharitaceae, macrophytes, adventitious plant, lake, heated water

1. Introduction

Vallisneria spiralis L. – a hydrophyte whose natural range of occurrence comprises countries of the tropical and subtropical zone in Asia, Africa, America and Southern Europe (Ant 1970; Casper & Krausch 1980), was brought to artificially heated lakes near the town of Konin probably at the beginning of the 1990s. In 1993 Protasov et al. (1994) recorded *V. spiralis* in Lake Mikorzyńskie. This species, together with predominant *Najas marina* L. and filamentous green algae of the genus *Cladophora,* occupied shallow littoral waters to a depth of 1.5 m, and with *C. glomerata* (L.) Kütz. – to 2.5 m. In 1995 *V. spiralis* was reported from three lakes in the vicinity of Konin, which were included in the open cooling system of two heat and powers stations, Konin (in 1958) and Pątnów (1970) (Socha & Zdanowski 2001).

In 2001 this species formed dense phytocoenoses in Lake Pątnowskie, Licheńskie and Wąsowskie at a depth of 0.2 to 2.0 m, and in Lake Mikorzyńskie it was found at a depth of 4.0-5.5 m (Gąbka 2002). Apart from the dominant *V. spiralis*, these hytocoenoses were also composed of *Potamogeton perfoliatus* L., *P. pectinatus* L., *Myriophyllum spicatum* L., *Nuphar lutea* (L.) Sibith. & Sm., *Ceratophyllum demersum* L. s. str., *Najas marina* L., *Phragmites australis* (Cav.) Trin. ex Steud. and *Spirogyra* sp. This characteristic combination of the above species showed that these communities should be included in the association *Potamo perfoliati-Vallisnerietum spiralis* Losev & V. Gloub 1987, described from the Lower Volga River Valley (Gąbka 2002).

In August 2002 new localities of *V. spiralis* were recorded from lakes near Konin. This species first appeared on the western shore of Lake Ślesińskie, and in August 2005 another two localities were discovered on the eastern shore of this lake (Hutorowicz *et al.* 2006).

Studies conducted in the years 2002-2003 showed that in the warmest of the lakes – Lake Licheńskie – *V. spiralis* formed almost exclusively single-species phytocoenoses along the entire shoreline, covering a total area of about 12.1 ha (August 2002). In the second half of July 2003 the littoral area occupied by this species was over two times smaller (Hutorowicz & Dziedzic 2003). This was caused by the fact that two shallow and rather extensive bays at the eastern shore of the lake were overgrown with *V. spiralis* to a slight degree only. These differences resulted most probably from a different rate of the area overgrowth in 2002 and 2003.

The aim of the present study was to determine the seasonal dynamics of *V. spiralis* in artificially heated lakes in the vicinity of Konin, as dependent upon thermal variations.

ECOLOGY

2. Material and methods

Phenological observations were carried out from April 27 to October 27, 2004, in the littoral zone of Lake Licheńskie and Lake Ślesińskie. Both lakes are natural, ribbon water bodies covering an area of 153.6 ha and 148.1 ha respectively (Zdanowski 1994). Lake Licheńskie, Lake Pątnowskie, Lake Gosławskie and the southern part of Lake Wąsosko-Mikorzyńskie were included in the open cooling system of the Konin Heat and Power Station in 1958, and the northern part of Lake Wąsosko-Mikorzyńskie and Lake Ślesińskie – in 1970. Warm water is supplied to Lake Licheńskie all year round, whereas to Lake Ślesińskie – in the summer only. In the years 1995-2000 the maximum water temperature in Lake Licheńskie was 30.9°C, and in Lake Ślesińskie 27.7°C (Socha & Zdanowski 2001).

The studies were conducted at three research sites, i.e. (1) in a shallow bay at the eastern shore of Lake Licheńskie, near the village Stary Licheń, (2) at the western shore of this lake, opposite the outlet of the channel supplying warm water to Lake Licheńskie, and (3) at the western shore of Lake Ślesińskie (Fig. 1). In addition, observations were also performed throughout the year along the shores of Lake Licheńskie. Information that enabled to determine phenological spectra was collected, and water temperature was measured with a thermometer to an accuracy of 0.1°C, on seven different dates (26-27 April; 28-30 June; 26-27 July; 18 August; 1 September; 28-30 September; 26 October). A GPS device was used to determine the spatial distribution of *V. spiralis* on a 115 x 60 m area (site 1). Direct observations were carried out to a depth of 1.2 m, and in deeper waters a boat and a plant anchor were used. After dense patches of *V. spiralis* were formed, water temperature was measured at this site at several points, and on October 27 – at 38 points. The results of these measurements provided a basis for drawing a map of temperature variations within the phytoceonosis.

3. Results and discussion

In 2004, the *V. spiralis* appeared at the earliest site 2. On April 27, when water surface temperature was higher than 22°C (Fig. 2), compact clusters of ramets were found at a the depth of about 1 m. At this time *V. spiralis* was not present in the other two localities in the shallow littoral zone. Water temperature at these sites ranged from 15 to 20°C. At the end of June tight clusters of *V. spiralis* were also observed at the research site 2, where water temperature exceeded 25°C. The presence of this species at the site 3 was confirmed as late as the end of July, when water temperature was above 21°C.

The first flowering *V. spiralis* plants were reported from Lake Licheńskie as early as the end of June (Fig. 3), but the flowering peak was observed in all localities, both for Lake Licheńskie and Lake Ślesińskie, from

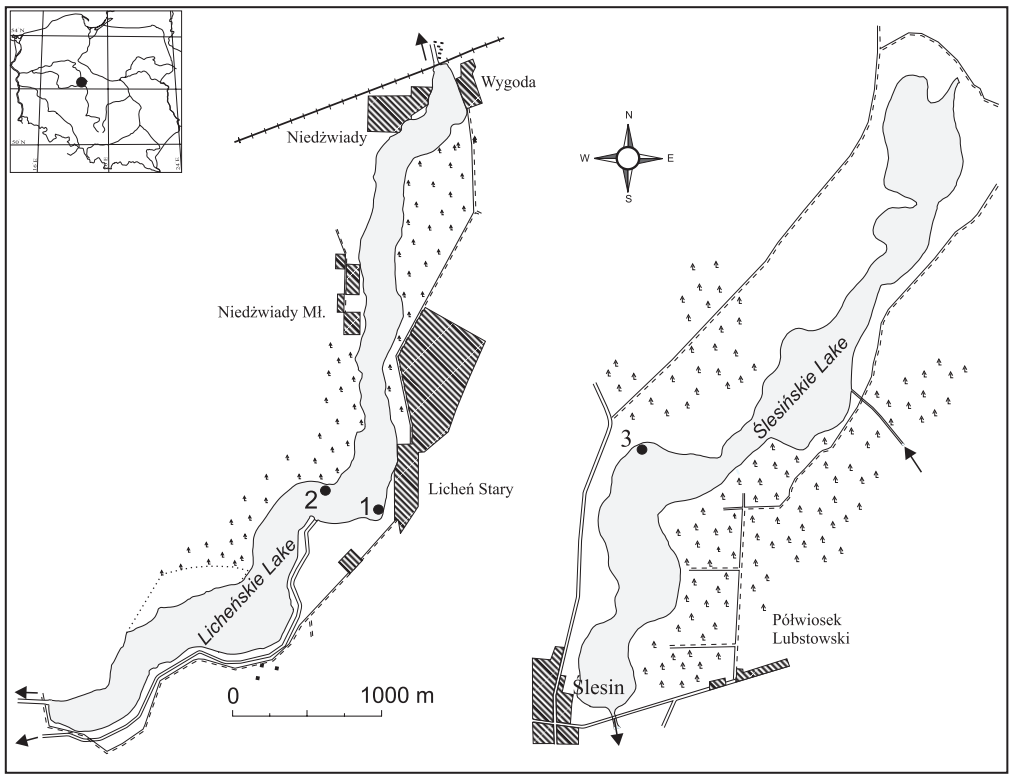

Fig. 1. Localities of *Vallisneria spiralis* in Lake Licheńskie and Lake Ślesińskie
Explanation: 1, 2, 3 – research sites

the end of September to the end of October, when water temperature ranged from 15.7 to 20.4°C (in September), and from 11.7 to 18.2°C (in October) (Fig. 2). Only female flowers were recorded, similarly as in the studies conducted by Gąbka (2002). A comparison of the flowering peak and daylength in Poland indicates that *V. spiralis* is a short-day plant (Fig. 3). This is confirmed by the intensive flowering of *V. spiralis* at the end of April 2005. The plants survived the winter in a vegetative state or developed very early in the channel which supplies heated water to Lake Wąsosko-Mikorzyńskie.

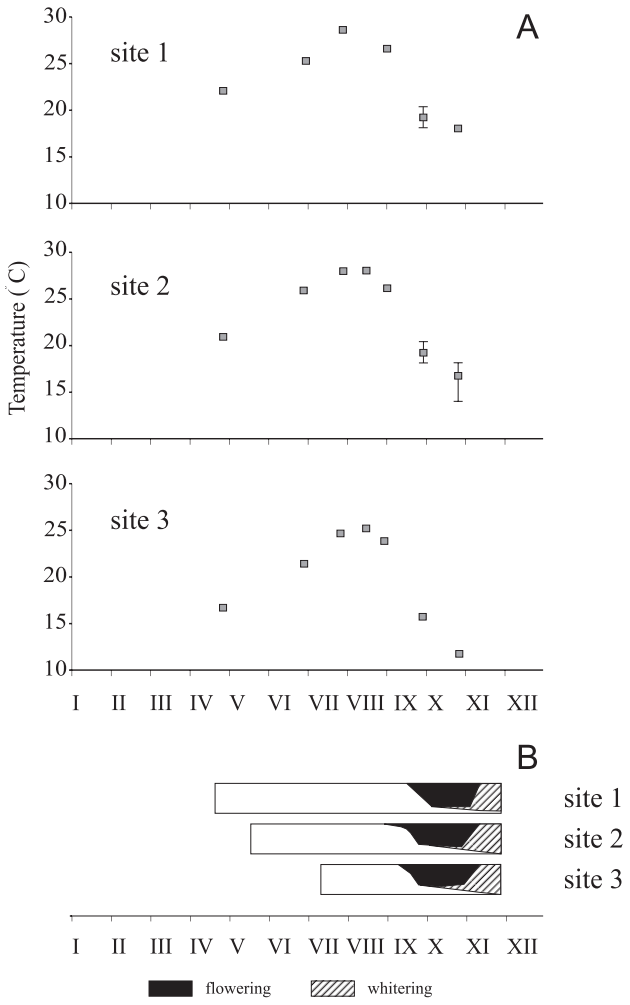

Fig. 2. Water temperature (A) in the littoral zone of Lake Licheńskie (research site 1 and 2) and in Lake Ślesińskie (site 3), and the phenological spectrum of *Vallisneria spiralis* in the above localities (B)

Visible symptoms of *V. spiralis* dying out were observed from the end of September. In October, when *N. lutea* have already withered, *V. spiralis* was still in a very good condition in Lake Licheńskie, but much worse in Lake Ślesińskie (site 3), with the coldest water.

The detailed observations of the development of clonal *V. spiralis* in the locality 1 showed that the process of the area overgrowth started from two different directions, i.e. from the belt of rushes composed of *Phragmites australis* and from the depths of water. In June, dense single-species patches (100% cover) formed a belt next to the reeds (Fig. 4). In deeper littoral regions *Vallisneria* had a stand-cluster structure, whereas in shallow littoral waters it formed sparse clusters. At the end of July the percentage of the cover of the lake bed by *V. spiralis* was much greater, but there was still a distinctive vegetation belt near the reeds. In mid-August bottom cover exceeded 75% over the entire research area. By then, almost all the patches have already merged, forming one single-species phytocoenosis of *V. spiralis*, with relatively numerous and extensive bare areas observed to a depth of 1 m (Fig. 3). By September the cover was almost complete, and no significant changes in the spatial structure were found until the end of October.

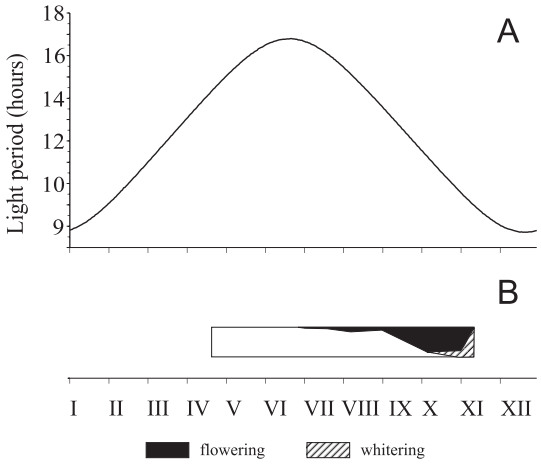

Fig. 3. Changes of daylength in Poland (A) and the phenological spectrum of *Vallisneria spiralis* in the heated lakes near Konin (B)

Since the end of July the leaves of plants growing at a depth of about 1.3 m were sufficiently long to reach the water surface, so they limited the mixing of lake water with heated water from the open zone. This resulted in considerable thermal variations in the examined patches. Considerable temperature differences were recorded, especially at the end of October, in the direction from the open zone to the lake shore. Within a 60 m stretch, a water temperature decreased by over 4°C – from 18.0°C in the zone that was in contact with the central part of the lake to 14.0°C at the shore (Fig. 5). At that time the spatial temperature gradient was 0.064°C m^{-1}.

4. Conclusions

Over an eleven-year period *Vallisneria spiralis* managed to colonize three lakes included in the open

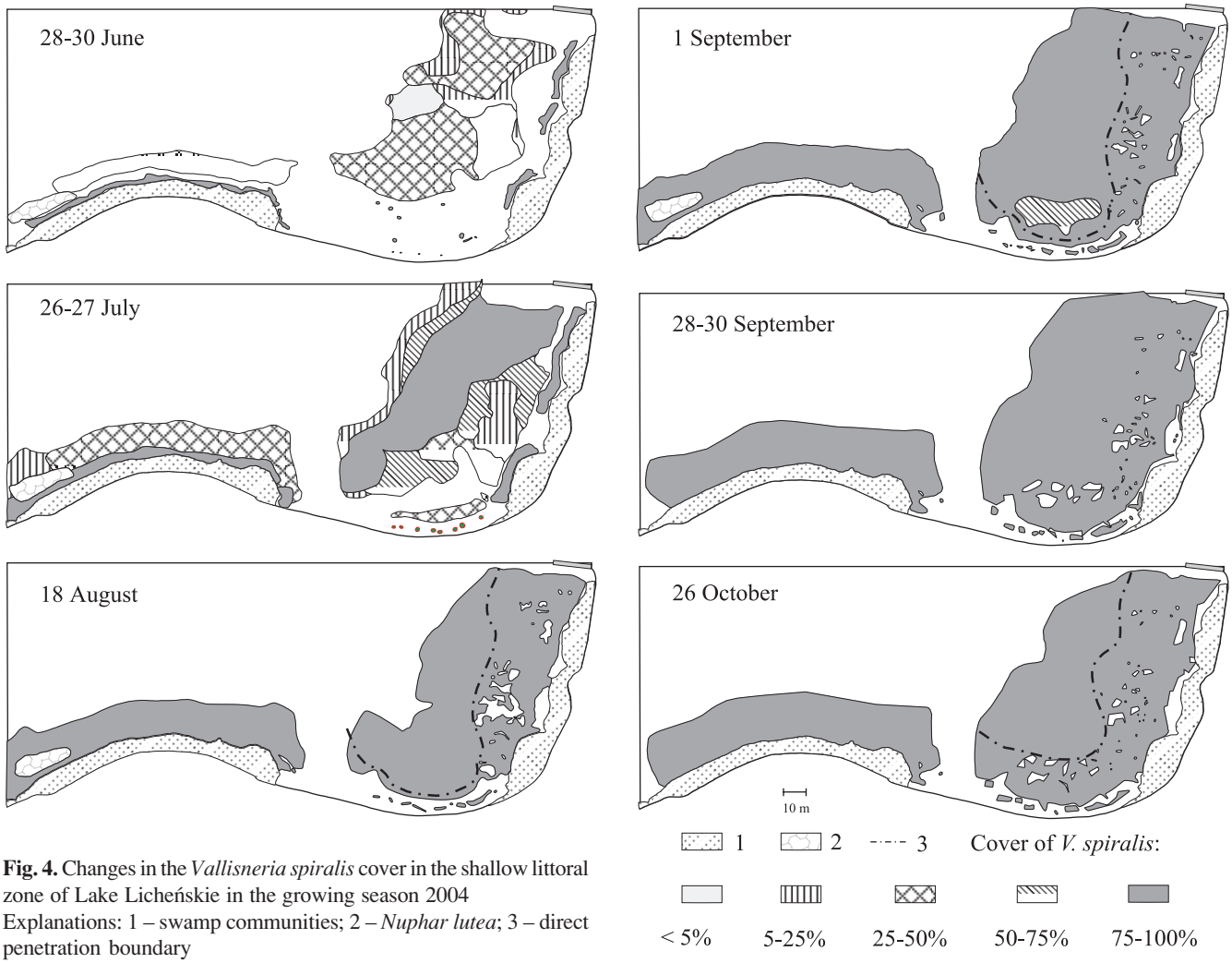

Fig. 4. Changes in the *Vallisneria spiralis* cover in the shallow littoral zone of Lake Licheńskie in the growing season 2004
Explanations: 1 – swamp communities; 2 – *Nuphar lutea*; 3 – direct penetration boundary

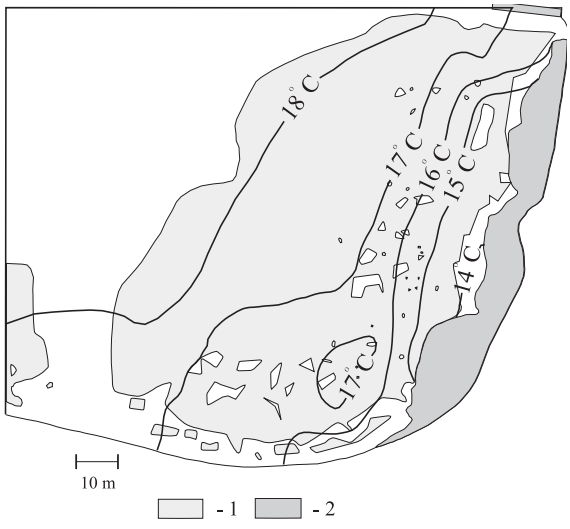

Fig. 5. Water temperature in the single-species phytocoenosis of *Vallisneria spiralis* in the littoral zone of Lake Licheńskie (site 1) on October 26, 2004
Explanations: 1 – *Vallisneria spiralis*; 2 – swamp communities

cooling system of two heat and power stations. In Lake Licheńskie it almost entirely displaced submerged hydrophytes, occupying the bottom to a depth of about 2.5 m. Recently this species has spread across Lake Ślesińskie, which has the lowest water temperature since warm water is supplied only in the summer. Apart from a water temperature, also a great vegetative reproduction ability (especially that only female clones grow in the examined lakes) and a great tolerance of a short photoperiod decided about the biogeographical success of this species.

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