Ice-wedge polygons as habitat for freshwater ostracods in the Indigirka Lowland, north-east Siberia

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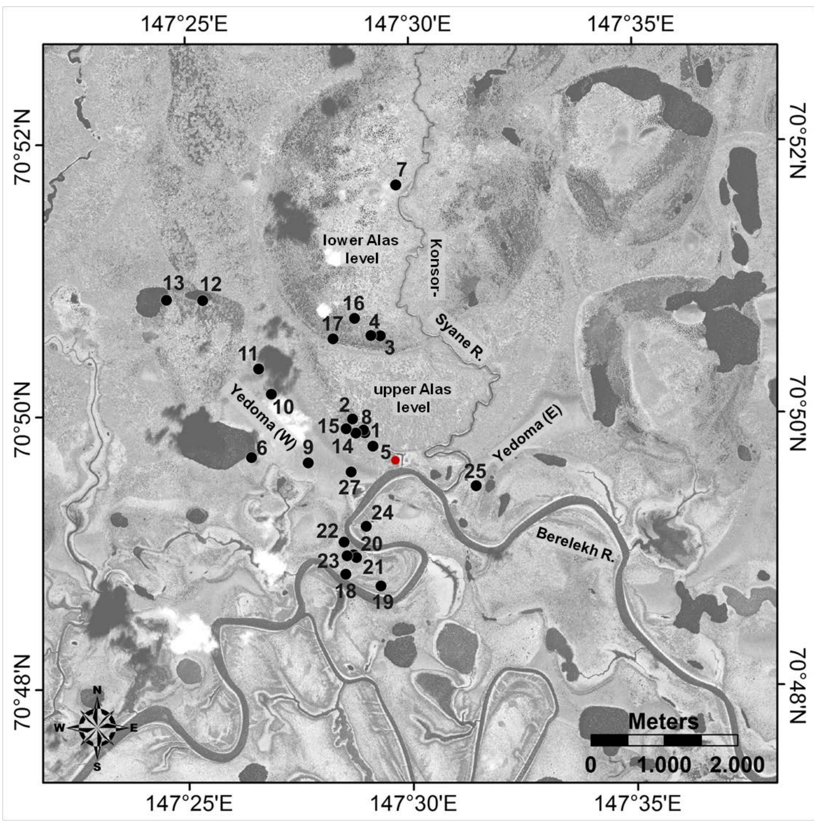
Background

Patterned ground features are typical components of arctic Siberian wetlands underlain by permafrost. Ice-wedge polygons often accommodate small and shallow periglacial surface waters. They provide suitable habitats for freshwater ostracods (Crustacea, Ostracoda). Ostracods are sensitive to environmental conditions, and have been widely used as biological indicators for past and present environmental changes in temperate regions.
Within the frame of the joint German-Russian DFG-RFBR project „Polygons in tundra wetlands: state and dynamics under climate variability in Polar Regions (POLYGON)" field studies of recent polygon dynamics were carried out in the Indigirka Lowland in 2011 (Fig. 1).to investigate the taxonomic and ecological range of ostracod assemblages and habitat conditions.



Figures 1 & 2
Location of the Kytalyk study site and its surroundings in the northeastern Siberian lowland. The numbers in the satellite image indicate the pond locations. (Map: G. Grosse; satellite image: GeoEye 4318026 from 08/2010, courtesy of J. van Huissteden (Vrije Universiteit Amsterdam).

Study site and method

The study sites were located in the flood plain and the adjacent thermokarst affected lowland along the Berelekh River near the WWF-station Kytalyk (70°83'12.1''N, 147°48'29.9''E, 11 m asl, Fig. 2). 27 periglacial water bodies located in different landscape units were studied (Figs. 3; 4). We caught >100 living ostracods per site, and sampled the pond water, pond substrate as well as precipitation for sedimentological, hydrochemical and stable water isotope analyses. Ostracod and environmental data were combined in a multivariate-statistical approach (non-metric multidimensional scaling, NMDS).

We focused the seasonal variability of a selected intrapolygon pond site (KYT-01) and its ostracod population in 4-day intervals. A monitoring program was carried out to measure changes in air and temperatures as well as water conductivity and water level fluctuations between 20 July and 26 August, 2011.

Figure 3
Intrapolygon ponds were shallow rounded water bodies with a slightly inclined bottom profile located in the central depression of low center polygons.

Figure 4
Interpolygon ponds occupied steep troughs created by melting ice wedges and exhibited a diverse morphology; for example, they could be X- or Y-shaped.

Pond substrate and hydrochemistry

The pond substrate consisted of unconsolidated fine grained, organic-rich material. At sites located in the river flood plain the lowest amounts of TOC (11 - 26 wt %) were found while substrate from ponds in other landscape units contained considerably higher TOC (26 - 50 wt %). TOC in interpolygon ponds was < 25 wt % while substrate from intrapolygon ponds contained from 33 - 44 wt % TOC.
Polygon ponds displayed little variability of acidity (0.4 mmol l^{-1}) and alkalinity (0.2 - 1.6 mmol l^{-1}). Well-oxygenated (O_2: 5.4 - 11.8 mg l^{-1}) and dilute ponds (EC: 19 - 53 µS cm^{-1}) with slightly acidic pH (5.5 - 7.1) hosted an abundant and diverse ostracod fauna.

Ostracod record

A total of 4849 identified ostracods from 8 species and 3 taxa represent the first record of the ostracod fauna in the Indigirka Lowland (Figs. 5; 6). Species assemblages in the studied waters were clearly dominated by *Fabaeformiscandona pedata* and juvenile Candoninae. *Fabaeformiscandona krochini*, *Fabaeformiscandona groenlandica Fabaeformiscandona* sp. I and *Fabaeformiscandona* sp. II were documented for the first time in continental Siberia.

The NMDS (Fig. 7) reflects a rather homogeneous ostracod species distribution; species that occur preferentially in certain pond types or certain landscape units are lacking. The organic content in the studied ponds' substrate seems to be controlled by the location in the different landscape units. The polygon morphology drives hydrochemical parameters such as alkalinity and ion content.

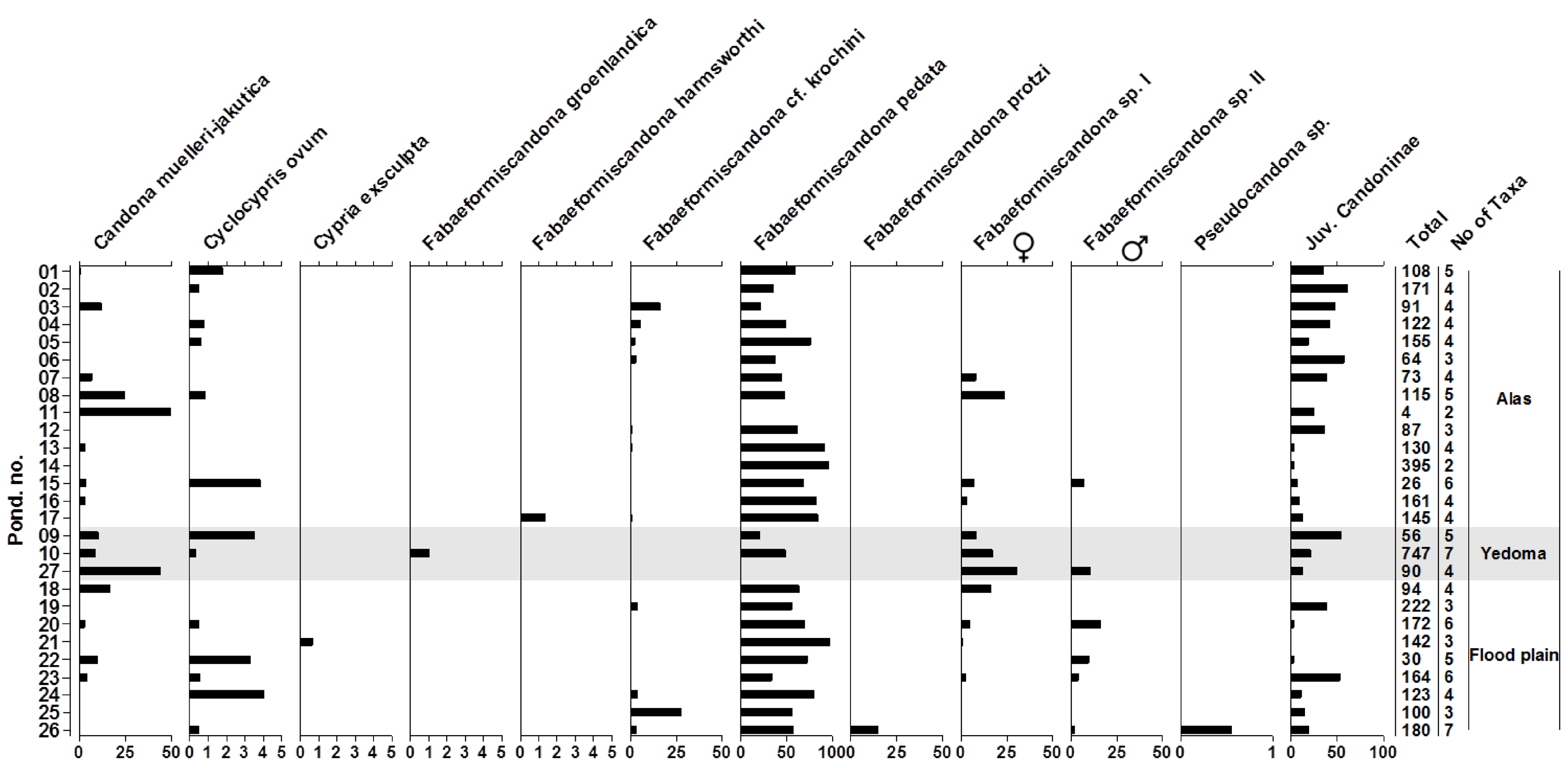


Figure 5
Ostracod record from 27 studied water bodies in the Kytalyk area in percent, grouped according to the major landscape units. Note varying scales.

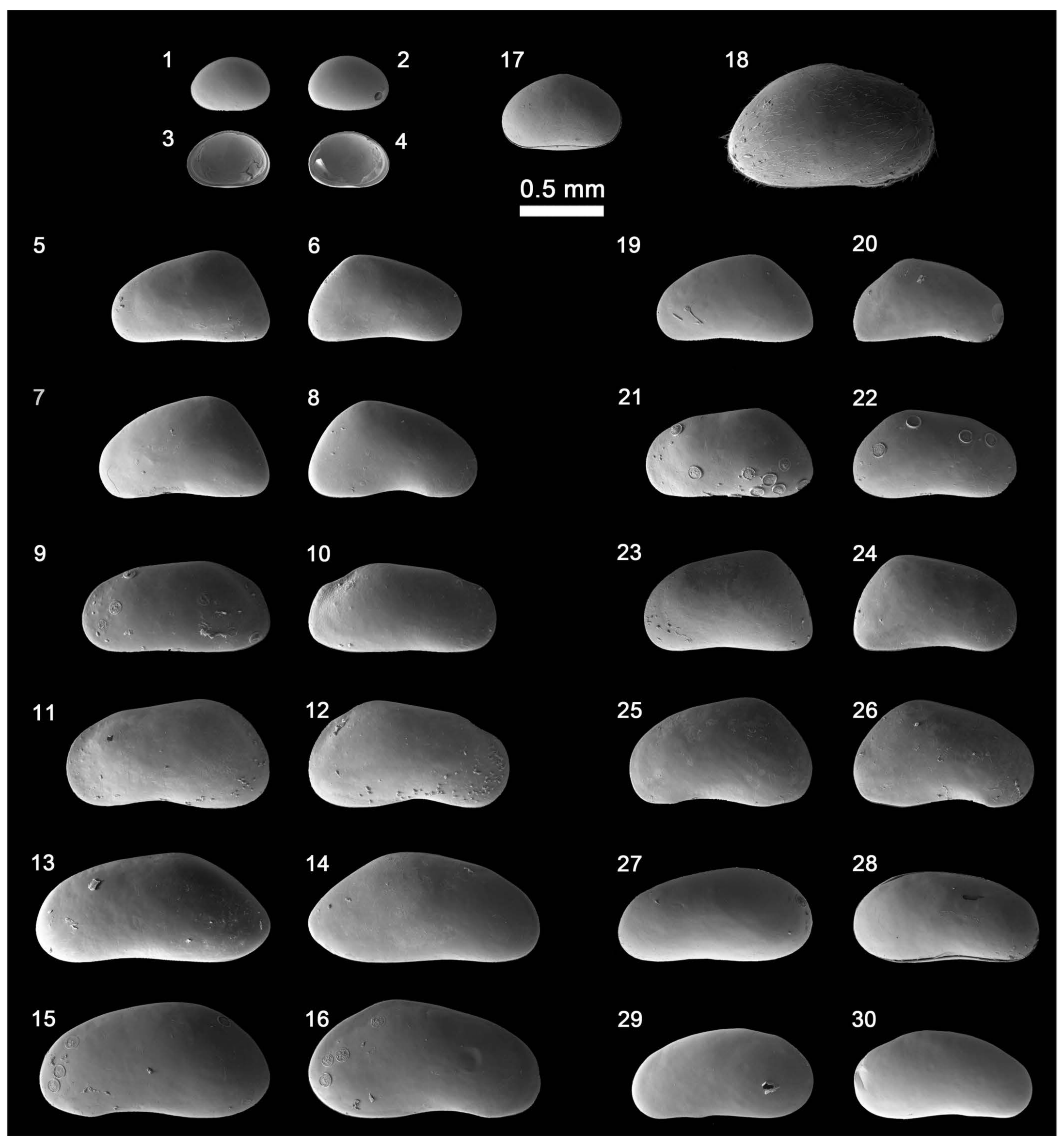


Figure 6
SEM images of ostracod valves from the Indigirka Lowland at x70 magnification.

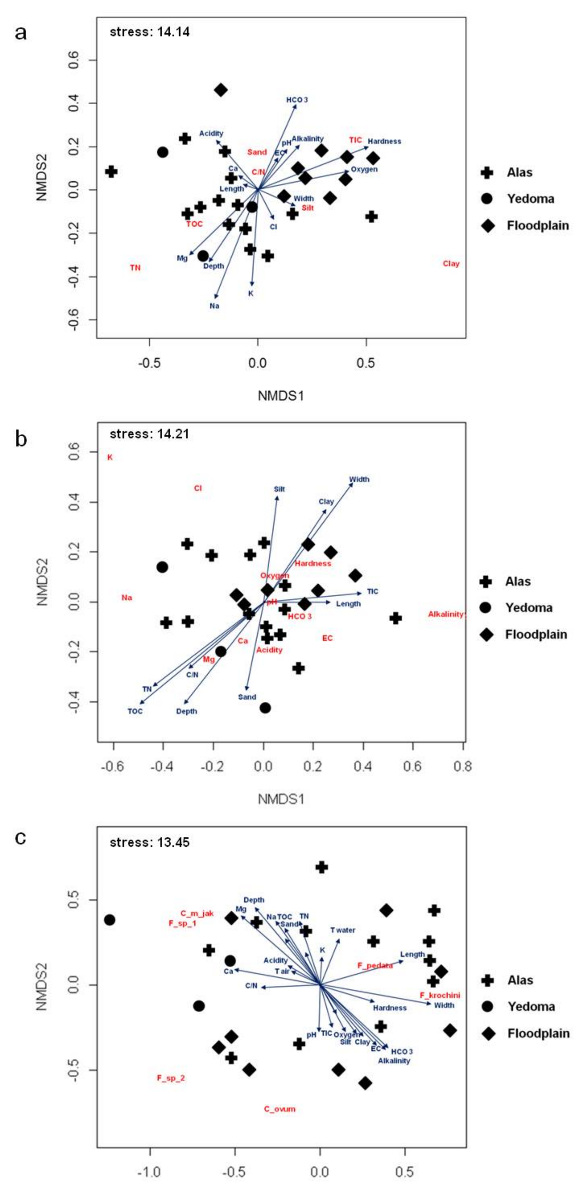


Figure 7
NMDS biplot of the **(a)** substrate properties, **(b)** hydrochemical variables, **(c)** ostracod species assemblages according to the major landscape units. Environmental parameters are superimposed.

Monitoring of an ostracod assemblage

Monitored site KYT-01 (Fig. 8) accommodated an 11.5 x 13.5 m wide intrapolygon pond. A boggy moss-sedge zone, polygon walls, and frost cracks completely enclosed the pond. The thaw depth below the pond centre was 40 - 58 cm while it was 19 - 24 cm at the polygon rims.

Repeated sampling of a low-center polygon pond revealed detailed insights in the population dynamics of *F. pedata* (Fig. 9). During 40 days, in total 990 ostracods were caught in pond KYT-01. The number of juvenile *F. pedata* declined from 98 % to 22 % when they were growing to adulthood. Adult male specimens were present early and their numbers remained stable at a low level (11 – 18 %). In contrast, adult female specimens appeared from early August on and reached high numbers (up to 66 %). Thus, at the end of the 2011 summer the ostracod assemblage in the monitored pond was not only dominated by *F. pedata*, but also by adult female specimens.

Figure 8
Photograph of monitored pond KYT-01; the arrow indicates the position of the data sensors in the pond centre.

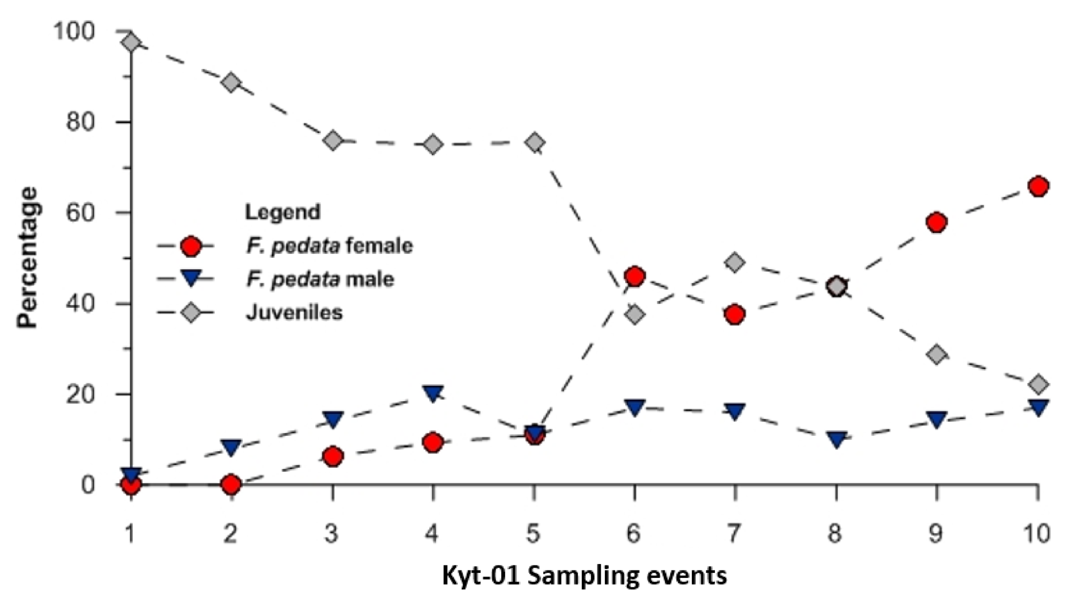


Figure 9
Population structure of *F. pedata* in the monitored pond throughout the 2011 summer season (20/07/2011 - 25/08/2011), measured at 4-day intervals.

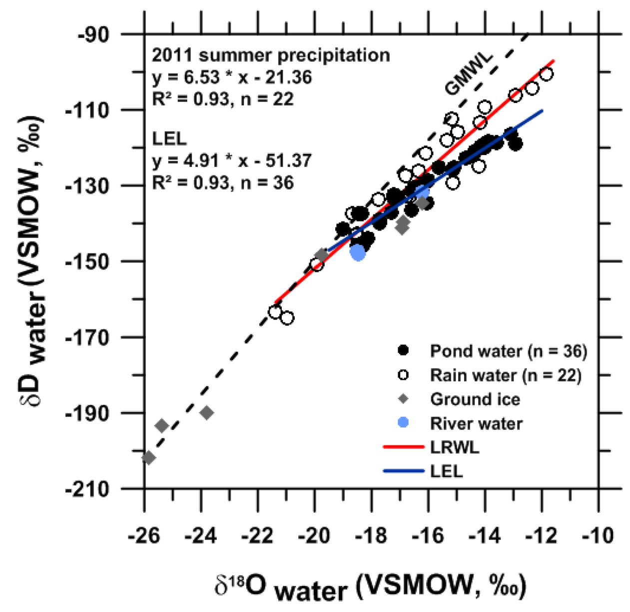
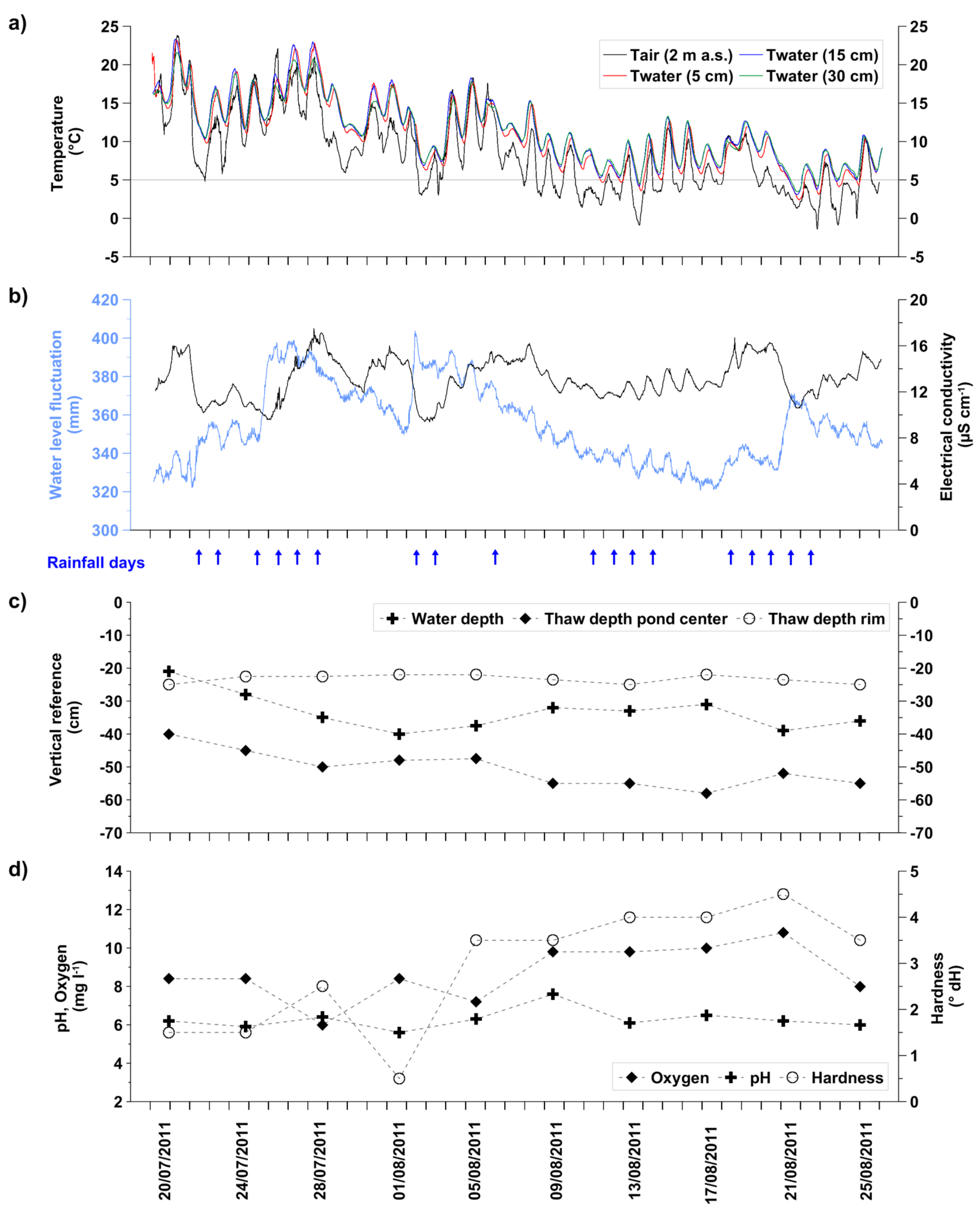


Figure 10
Stable water isotope record of different water types in the Kytalyk study area relative to the VSMOW.



Monitoring

Recorded air and water temperatures (Fig. 11a) fluctuated daily by about 10°C and a cooling trend was superimposed on these records towards the end of the monitored time period in autumn 2011.

Variations in dissolved ion content accompanied temperature fluctuations throughout the water column (Fig. 11b, c). The mean water depth was 35 cm but water level fluctuations of ± 8 cm occurred during precipitation events.

Hydrochemical data from 10 monitoring events revealed stable pH values (Fig. 11d). The amount of dissolved oxygen as well as the HCO_3-content increased towards the end of the season when air and water temperatures decreased.

The stable water isotope record (Fig. 10) suggests rainwater as primary water source for the ponds that underwent evaporation.

Air temperature and precipitation were identified as the main drivers of water temperature, ion concentration, stable water isotope composition, and water level in polygon ponds.

Figure 11
Monitoring data obtained at the Kyt-01 site (20/07/2011 - 26/08/2011).

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