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Pollen source areas of lakes with inflowing rivers: modern pollen influx data from Lake Baiyangdian, China

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ABSTRACT

Comparing pollen influx recorded in traps above the surface and below the surface of Lake Baiyangdian in northern China shows that the average pollen influx in the traps above the surface is much lower, at 1210 grains cm^{-2} a^{-1} (varying from 550 to 2770 grains cm^{-2} a^{-1}), than in the traps below the surface which average 8990 grains cm^{-2} a^{-1} (ranging from 430 to 22310 grains cm^{-2} a^{-1}). This suggests that about 12% of the total pollen influx is transported by air, and 88% via inflowing water. If hydrophyte pollen types are not included, the mean pollen influx in the traps above the surface decreases to 470 grains cm^{-2} a^{-1} (varying from 170 to 910 grains cm^{-2} a^{-1}) and to 5470 grains cm^{-2} a^{-1} in the traps below the surface (ranging from 270 to 12820 grains cm^{-2} a^{-1}), suggesting that the contribution of waterborne pollen to the non-hydrophyte pollen assemblages in Lake Baiyangdian is about 92%. When trap assemblages are compared with sediment–water interface samples from the same location, the differences between pollen assemblages collected using different methods are more significant than differences between assemblages collected at different sample sites in the lake using the same trapping methods. We compare the ratios of terrestrial pollen and aquicolous pollen types (T/A) between traps in the water and aerial traps, and examine pollen assemblages to determine whether proportions of long-distance taxa (i.e. those known to only grow beyond the estimated aerial source radius); these data suggest that the pollen source area of this lake is composed of three parts, an aerial component mainly carried by wind, a fluvial catchment component transported by rivers and another waterborne component transported by surface wash. Where the overall vegetation composition within the 'aerial catchment' is different from that of the hydrological catchment, the ratio between aerial and waterborne pollen influx offers a method for estimating the relative importance of these two sources, and therefore a starting point for defining a pollen source area for a lake with inflowing rivers.

1. Introduction

Lacustrine pollen is an important proxy for reconstructing paleovegetation and paleoclimate, because pollen grains are usually well preserved in lake sediments (Sun and Wu, 1987; Gasse et al., 1991; Chen et al., 2006). Interpretation of the pollen signal and reconstruction of palaeovegetation is underpinned by assumptions about the spatial area reflected by the pollen signal and the taphonomy of different pollen types.

About thirty years ago, palynological researchers began to produce quantitative estimates of a pollen source area for basins of different sizes (Jacobson and Bradshaw, 1981). The Prentice model of pollen dispersal and deposition (Prentice, 1985) allowed simulation of aerial pollen taphonomy to be used to estimate quantitative source areas for individual pollen types (Prentice et al., 1987), defined as the radius around the basin from which a defined percentage of the pollen type originated. Sugita modified this taphonomic model to incorporate mixing of pollen across a lake surface, and defined a pollen source area for the whole pollen assemblage, the Relevant Source Area of Pollen or RSAP (Sugita, 1993, 1994). The RSAP is defined in terms of the Extended R-value approach, an iterative means of estimating the parameters of the pollen dispersal and deposition model from empirical data (Parsons and Prentice, 1981; Prentice and Parsons, 1983). Where

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vegetation data are available from multiple radii around the basin, the distance at which adding further vegetation data to the analysis leads to no improvement in the likelihood function score (a measure of goodness of fit between the fitted model parameters and the empirical data) is defined as the RSAP for the whole assemblage being studied. The Prentice–Sugita model of pollen dispersal and deposition is currently being used as the primary basis for various approaches to the quantitative reconstruction of past vegetation composition and abundance such as the Landscape Reconstruction Algorithm (Sugita, 2007a, b) and the Multiple Scenario Approach (Bunting and Middleton, 2009). Sugita (1994) explores the implications in terms of RSAP for lakes of different sizes, and demonstrates that large lakes (typically >500 ha in area) record regional vegetation as if it is homogenous, with no variations in response to the spatial organization of that vegetation. The REVEALS approach software (Sugita, 2007a; Hellman et al., 2008) uses this property to reconstruct vegetation for a region 100–200 km in radius around such large lakes, but assumes that aerial transport of pollen to the sampled basin is the main taphonomic route.

Most lakes have inflowing rivers, so waterborne pollen may also make a substantial contribution to the pollen influx to the lake (McAndrews and Power, 1973; Peck, 1973, 1974; Bonny, 1978; Sun and Wu, 1987; Traverse, 1992; Huang et al., 2004; Xu et al., 2005; Brown et al., 2007). In order to attempt quantitative reconstructions of past vegetation and paleoclimate from the sedimentary record in such lakes, it is important to understand the relative importance of the different components of the pollen taphonomy and to characterize the spatial sensitivity of the record, the pollen source area.

Some empirical studies of pollen transport in rivers have been reported (e.g. Brush and Brush, 1972; Fall, 1981; Solomon et al., 1982). Flume experiments suggest that pollen grains will settle out into sediment when the water speed is lower than 0.3 m/s, and therefore that grains can remain in suspension and be transported long distance when the water speed is higher than 0.3 m/s (Brush and Brush, 1972). Pollen assemblages from the Yellow River and Luan River follow these trends (Xu et al., 1994, 1995, 1996).

In this paper, we present an empirical study of the airborne and waterborne pollen components which compares the pollen influxes of traps above and below the lake surface with samples from the upper layer of the water–sediment interface within the lake in order to investigate the possible pollen source area and pollen deposition dynamics of a lake with substantial inflows, Lake Baiyangdian in the North China Plain.

2. Study area

Lake Baiyangdian is the largest fresh water lake in the North China Plain (Fig. 1). It is located in Anxin County of Hebei Province (115°53′8.25″–116°6′9.64″E, 38°47′1.69″–38°59′22.78″N) and has a water area of 366 km^2 and maximum water depth of 5 m (Xu et al., 1988; Wang and Su, 2008). The lake has seven major inflowing rivers, the Baigou River (the longest at 275 km), Zhulong River, Tang River, Cao River, Xiaoyi River, Pu River and Fu River (the shortest at 62 km), which all originate in the Taihang Mountains

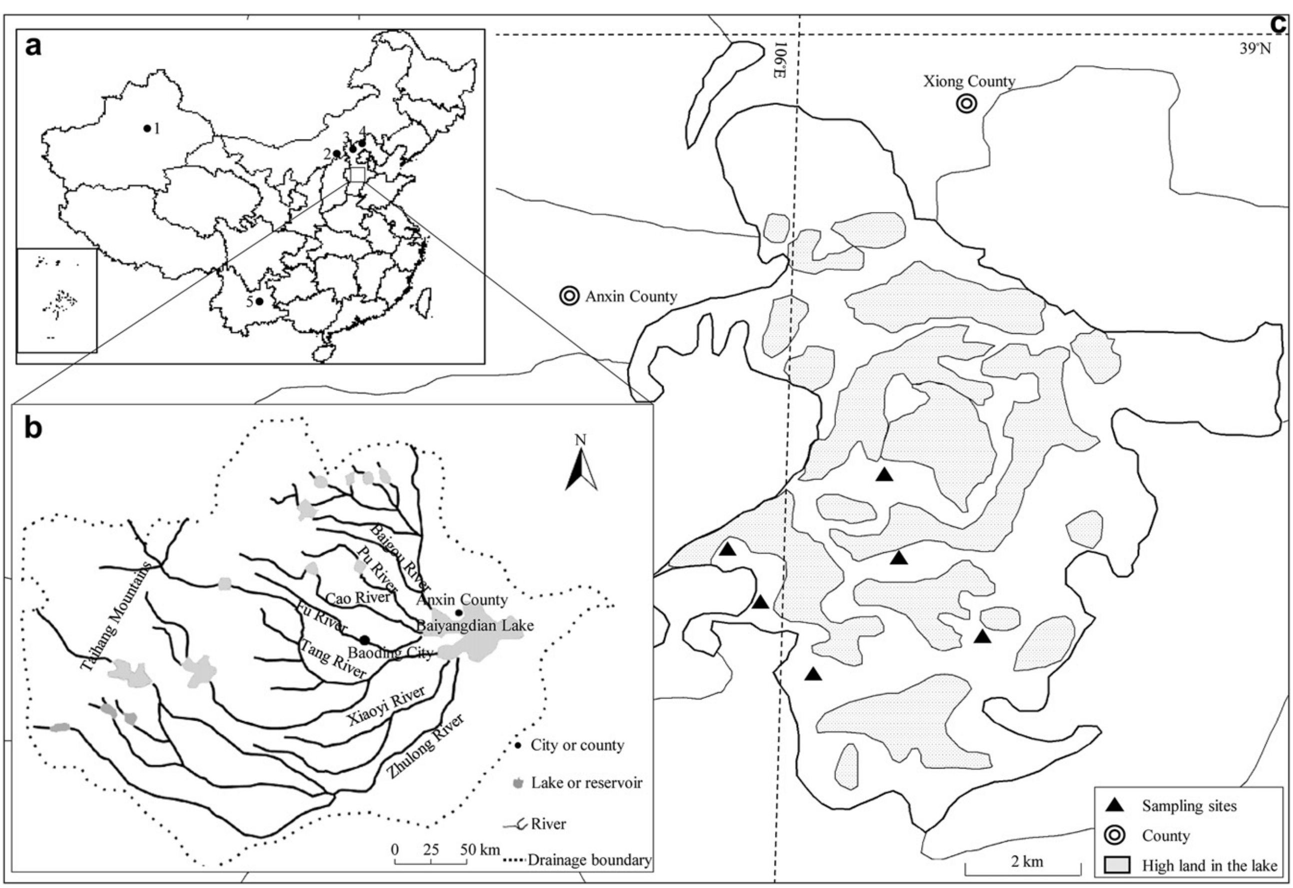

Fig. 1. Map of Lake Baiyangdian showing the locations of sampling sites. Inset a: the locations of study area and lakes mentioned in the text: 1, Lake Bosten; 2, Lake Daihai; 3, Lake Duikounao; 4, Lake Hulunnao; 5, Lake Dianchi. Inset b: the drainage area of Lake Baiyangdian modified from Liu et al., 2007. Insert c: map of Lake Baiyangdian, solid triangles show the trap sites.