

Records of Bacteria Endospores in Varved Lake Sediments

Abstract

Some bacteria form endospores with an extreme longevity in natural habitats. Viable endospores of a *Thermoactinomyces* species, for example, have been recorded in a 9000-year-old varved lake sediment. We used varved sediments from three lakes in N. Sweden to test the hypothesis that there is a relationship between the concentrations of dormant endospores of *Thermoactinomyces vulgaris* in lake sediments and the extent of agriculture in the catchments of the lakes. *Thermoactinomyces vulgaris* is very common in agricultural environments, but rare in natural boreal forest ecosystems. A temporal relationship was found between records of *T. vulgaris* and pollen of plants indicating agriculture in sediment cores covering the last millennium. The results support the suggestion that *T. vulgaris* is a good palaeoindicator of agricultural activity.

Analyses of bacteria have been used by palaeoecologists (Cross and Johnston, 1971; Cross and Attwell, 1974; Seaward *et al.*, 1976; Unsworth *et al.*, 1977; Granberg, 1983; Parduhn and Watterson, 1985; Nilsson and Renberg, 1990), but the potential of the method for investigating past environmental conditions from sediment archives has not yet been fully explored. Of particular interest for palaeoecological investigations are non-sediment living bacteria that form resistant endospores that can survive for thousands of years in sediments. Endospore-forming bacteria are found in the genera *Thermoactinomyces*, *Bacillus* and *Clostridium*, and endospores of *Thermoactinomyces* about 9000 years in age have already been isolated (Nilsson and Renberg, 1990). Bacteria spores (Fig. 1) are very small (about 1 μ m) and thus virtually impossible to find and count in sediments using light microscopy, but the isolation and enumeration of dormant endospores is possible using standard microbiological culturing techniques.

Most work on dormant allochthonous bacteria in lake sediments has been done on *Thermoactinomyces vulgaris*, a thermophilic bacterium that

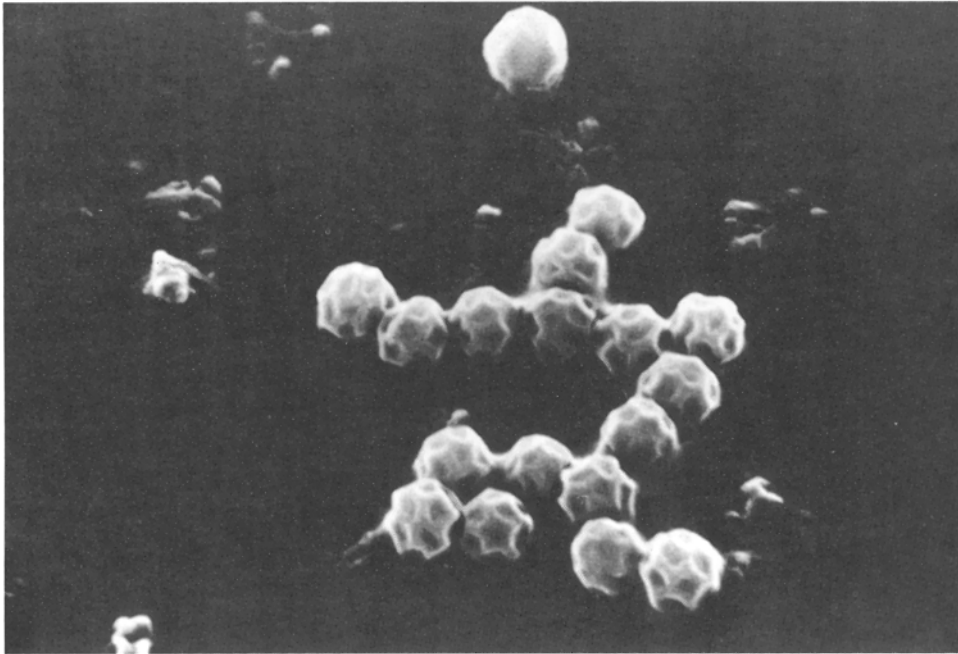


Fig. 1. Scanning electron micrographs of endospores of *Thermoactinomyces vulgaris*.

forms a white aerial mycelium. It is very common in agricultural environments such as hay, manure and compost, but it is rare in natural coniferous forest ecosystems.

We used lake sediments from N. Sweden to test the hypothesis that there is a relationship between the concentration of dormant, viable endospores of *Thermoactinomyces vulgaris* in lake sediments and the extent of agriculture in the catchments of the lakes. We used two approaches. The first comprised analysis of surface sediments (0,1 cm) from forest lakes and lakes in agricultural areas. Although the number of lakes was too small to allow any firm conclusions to be made, it seems that there is a correlation between the number of endospores in the surface sediments and the area of cultivated land near the lakes (Fig. 2).

The second approach comprised comparisons between pollen and endospore records in cores of varved lake sediments from three lakes. The varves guaranteed that no mixing of the sediments had occurred, provided the chronology and allowed the rates of both pollen and endospore accumulation to be estimated. All three lakes had little evidence of *Thermoactinomyces* endospores in the sediments deposited before agriculture began in their catchments, i.e. when the lakes were surrounded by boreal forest more than 600-800 years ago, but with the increasing extent of

agriculture, as indicated by grass, cereal and weed pollen, increasing rates of *Thermoactinomyces* endospore accumulation were recorded. The results, of which those from one of the lakes are shown in Figure 3, support the hypothesis that *Thermoactinomyces vulgaris* in sediments can be used as an

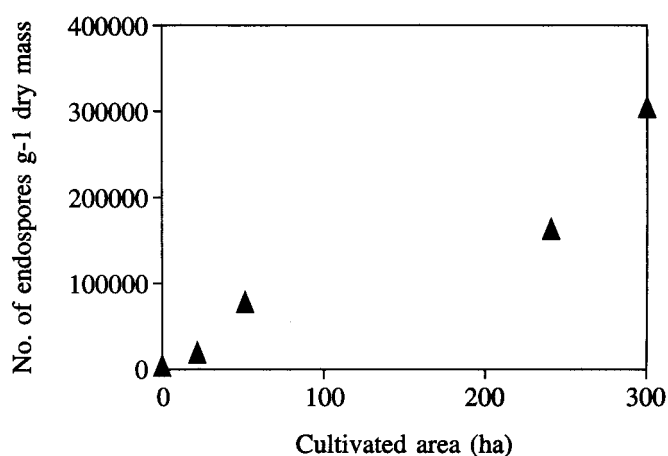


Fig. 2. Viable endospores of *Thermoactinomyces vulgaris* recovered from surface sediment samples from lakes with different areas of cultivated land in their catchments (data from Nilsson and Renberg, 1990).

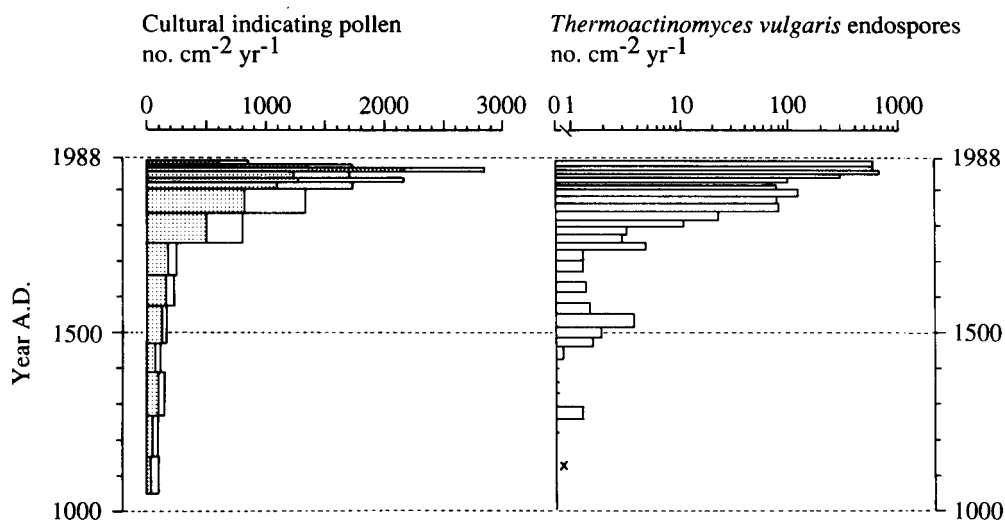


Fig. 3. Net annual pollen accumulation rates indicating agriculture (left) and viable endospores of *Thermoactinomyces vulgaris* (right) in the varved sediment of Lake Kassjön, N. Sweden. The shaded areas in the pollen histograms indicate grass and the open areas other cultural indicators such as cereals and weeds. The chronology is based on varve counting. The diagram is from Nilsson and Renberg, 1990.

indicator of past agricultural activity in boreal ecosystems. It is very likely that bacteria analyses could provide complementary information to pollen analysis, and could also be of interest for various kinds of archaeological investigations.

Ingemar R. RENBERG

Department of Ecological Botany
University of Umeå
S - 901 87 UMEÅ, Sweden

Mats NILSSON

Department of Forest Site Research
Swedish University of Agricultural Sciences
S - 901 83 UMEÅ, Sweden

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