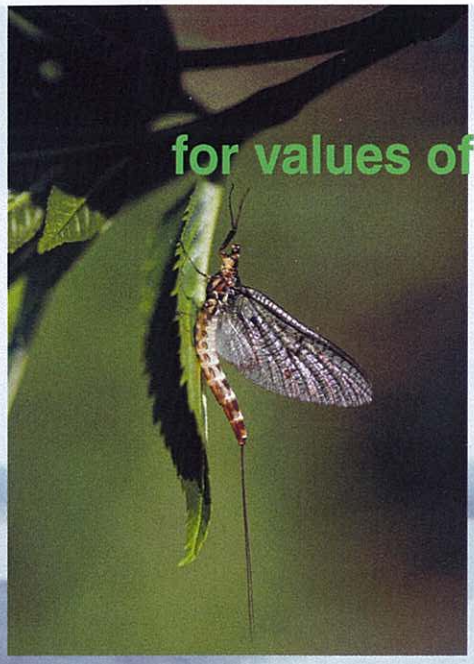

Estimating confidence limits for values of the Danish Stream Fauna Index (DSFI) by the bootstrap method

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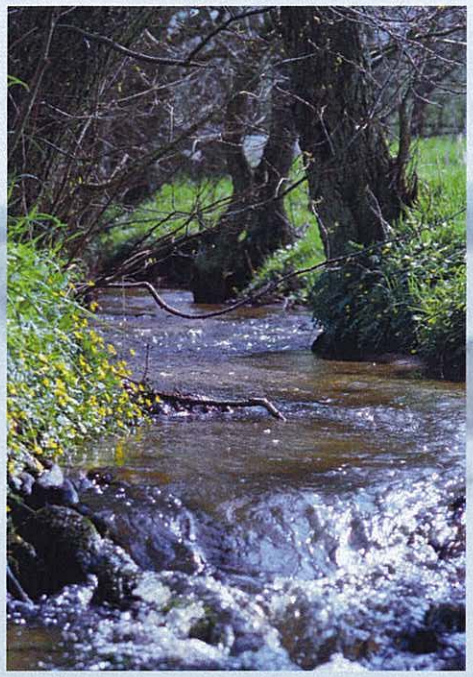


Introduction

The Danish Stream Fauna Index (DSFI) is a biotic index used in Denmark for biological stream assessment (Skriver et al. 2000).

DSFI is based on benthic macroinvertebrates collected by standardised hand net and kick sampling. The index incorporates information on indicator taxa and information on selected diversity groups. Index values are expressed in integers from 1 (strongly impacted) to 7 (no or little impact).

According to the sampling procedure no replicate samples are collected. Nevertheless, if several samples are collected it may result in two or more different DSFI values. It is therefore necessary with some measure of the variability of the DSFI value.

The aim of this study is to investigate whether random sampling with replacement (bootstrap) can be used as an alternative to replicate samples in generating confidence limits for DSFI values.

Methods

Macroinvertebrate samples have been collected at 43 Danish stream sites. Twelve individual kicksamples were collected at each site. Usually all 12 kicks are pooled as one sample, but in this investigation they were kept separate. After identification two different resampling methods were used to generate a large number of new fauna lists from each stream site (Efron & Tibshirani 1993):

In resampling **method 1**, the 12 individual kick samples were kept separate. For each taxa, a bootstrap sample with replacement was generated using the 12 numbers of individuals for the given taxa. This was done for each taxa and a total of 500 bootstrap samples (fauna lists) were generated.

In resampling **method 2**, the identified fauna were pooled and the number of individuals in each bootstrap sample was equal to the total number of individuals. Individuals are sampled one at a time with replacement. A total of 500 bootstrap samples (fauna lists) were generated.

Finally, the DSFI value for each fauna list was estimated.

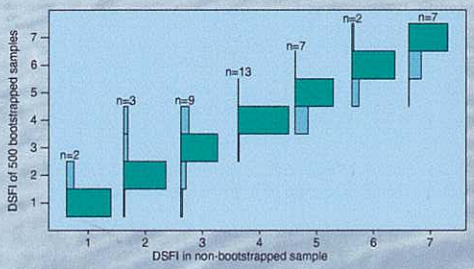


Figure 1.
Random sampling with replacement (bootstrap) using all 43 stream sites. The 12 individual kicks from each stream site have been used to generate 500 new fauna lists (resampling **method 1**). The majority of the new fauna lists have the same DSFI index value as the original fauna list. But 20-25% of the new fauna lists has a higher or lower DSFI value than the original fauna list. A similar result was obtained using bootstrap on pooled data (resampling **method 2**).

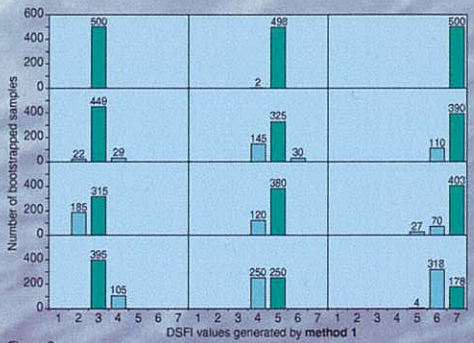


Figure 2.
Examples of distribution of the 500 new estimated DSFI values from each of the 12 selected stream sites (resampling **method 1**). Four examples from each of the DSFI values 3, 5 and 7 calculated using the original pooled sample are shown. The distribution of the DSFI values shows considerable differences between stream sites. Typically, two or three and in some cases even four DSFI values could be calculated from the original fauna list. At 3 out of 43 stream sites the most likely DSFI value (using both resampling methods) was different from the DSFI value calculated from the non-bootstrapped fauna list.

Results and discussion

The non-bootstrapped DSFI index value was compared with the DSFI values generated by bootstrapping using the **method 1** and **2** (Fig. 1 and 2).

Both bootstrap methods typically generated more than one DSFI values indicating both the direction and the variability of DSFI as compared to the original single value of the index (Fig. 2).

Comparing the results of bootstrap **method 1** and **2** there were found only minor differences between the two resampling methods (not shown).

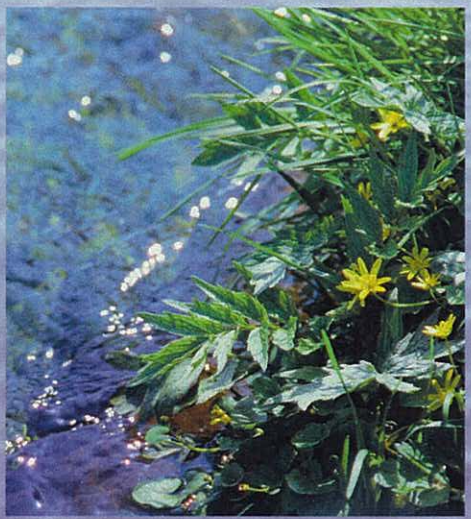
This indicates that the pooled fauna list used presently in the Danish Stream Fauna Index can be used to generate confidence limits as an alternative to replicate samples.

The 500 computed DSFI values can be used directly to generate the 95% confidence limits of the mean DSFI value.

Conclusion

Resampling using the bootstrap method was found to describe the variability of DSFI and therefore to give a more precise picture of the ecological quality. It was also found that resampling on the original pooled kick sample gave similar results as resampling on separate kicks.

Resampling on the pooled sample is therefore the most cost effective method and should be preferred.



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