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Towards the adoption of an international standard for biomonitoring with lichens—Consistency of assessment performed by experts from six European countries

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ABSTRACT

Simultaneous assessment of epiphytic lichen diversity by teams from six European countries, following the procedures defined in the recently adopted European standard, revealed several sources of error (e.g. location of plot, selection of trees, identification of taxa). Routine training and further improvement of Standard Operating Procedures (SOPs) are suggested to boost the harmonization process of the European guidelines, which promises to be an effective tool for standardizing the assessment of lichen diversity.

1. Introduction

The mapping of epiphytic lichen diversity to assess change at population and/or community level is an increasingly common biomonitoring approach in Europe (Larsen et al., 2007; Nimis et al., 2002). The optimization of the 'lichen bioindication' method has been attempted over the past decade (Asta et al., 2002), and a new European standard has been recently adopted under the Comité Européen de Normalization (CEN) framework (Ambient air – Biomonitoring with lichens – Assessing epiphytic lichen diversity. European Standard EN 16413:2014). This CEN standard aims at (i) providing reliable, consistent and objective Standard Operating Procedures (SOPs) for assessing epiphytic lichen diversity, and, therefore, (ii) improving data quality and comparability across space and time. CEN SOPs include sampling design (plot allocation and tree selection) as well as lichen diversity assessment. A national comparative test to identify critical issues was carried out in Italy (Brunialti et al., 2012) and demonstrated that the frequently reported observer error (Giordani et al., 2009) may be inflated by additional factors such as inappropriate plot allocation, tree selection within the plot, and positioning of the observation grid on the trees. Given that the new CEN SOPs are designed to serve the entire Europe, a new test was carried out applying the proposed CEN SOPs to evaluate data consistency among teams from different European countries, with various "traditions" in monitoring approaches. The results of this test presented here have clear relevance for the success of the harmonization process that the CEN SOPs intend to promote across Europe.

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Table 1
Standard trees identified and selected on plot A and plot B by control team and test teams. Frequency of agreement (*n* and %) is also reported.

	Tree code	Control	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Frequency of agreement	
									n	%
Plot A	**3**	●	●	●	●	●	●	●	7	**100**
	8	●	●	●	●	●	●	●	7	**100**
	11	●	●	●	●	●	●	●	7	**100**
	13	●	●	●	●	●	●	●	7	**100**
	14					●			1	14
	Selected trees	**4**	**4**	**4**	**4**	**5**	**4**	**4**		
Plot B	**18**	●	●	●	●	●	●	●	7	**100**
	11	●	●	●		●	●	●	6	**86**
	17	●	●	●		●		●	5	**71**
	27	●	●	●		●	●		5	**71**
	2	●	●	●		●			4	**57**
	13			●		●	●	●	4	57
	20		●			●	●	●	4	57
	1				●	●		●	3	43
	3	●		●				●	**3**	**43**
	23			●		●	●		3	43
	26		●		●		●		3	43
	4				●		●		2	29
	19				●	●			2	29
	10				●				1	14
	15							●	1	14
	24				●				1	14
	25				●				1	14
	28					●			1	14
	Selected trees	**6**	**7**	**8**	**8**	**11**	**8**	**8**		

In bold standard trees selected by the control team.

2. Materials and methods

2.1. Study area

The study was carried out in the Natural Park Paneveggio – Pale di San Martino (46°11.977′ N, 011°51.970′ E – Trentino, north Italy), a 197 km^2 mountain area with a mean elevation above 1500 m a.s.l., characterized by spruce forests, high altitude grasslands and rocky outcrops. Mean annual temperature is 2.4 °C, and mean annual rainfall is 1200–1300 mm year^{-1}.

2.2. CEN Standard Operating Procedures (SOPs)

In 2010, six independent teams (see below) applied the SOPs described in the draft of the European standard for the lichen diversity assessment (CEN European Standard EN 16413:2014) recently adopted, using the following definitions as prescribed by these SOPs:

Sampling units. A 30 m radius sampling plot for selecting the standard trees.

Standard trees. Defined as: (i) suitable species (*Tilia* spp. and *Abies alba*, in this study); (ii) trunk circumference between 50 and 250 cm at 130 cm above the ground; (iii) bole inclination <20° at 130 cm above the ground; (iv) portion of the trunk to be monitored should be integral (i.e. no damage, decortication, branches, knots and/or other epiphytes over more than 20% of the area of the trunk). Each standard tree in the plot must be surveyed.

Lichen survey. Based on species counts carried out by a 10 × 50 cm observation grid (5 quadrats of 10 × 10 cm) placed on the trunk at 100 cm above the ground (considering the lower edge of the grid) and at the four compass directions (N, S, E, W). Although other diversity indicators are common in biomonitoring surveys (e.g., Lichen Diversity Value, Asta et al., 2002), the SOPs define lichen diversity as species richness (=the total number of species) found within the grids at the four cardinal points.

2.3. Test participants, concept and structure

The test was performed by nine experts from six countries (Estonia, Italy, Portugal, Slovenia, Spain, United Kingdom) grouped into six national teams (test teams). Three teams consisted of one expert each, while the other three teams worked in pairs. An additional team of three Italian experts ran a control assessment (control team). CEN SOPs were used by all teams; participants received a specific key for lichen identification within the study area (http://dbiodbs.units.it/carso/chiavi_pub21?sc=445).

Plot location, standard tree selection, lichen diversity assessment and training effect were evaluated in order to define key error sources. Teams were asked to carry out the following exercises in two sampling sites with very different environmental features (open site, with flat terrain and scattered trees; mixed dense forest, rough terrain).

Exercise on point XY: by using their own GPS, the teams were asked to locate the centre of a virtual plot with defined coordinates (point XY) on the ground. Such a plot centre had been previously identified and marked (in a non obvious fashion) by the control team.

Exercise on plot A (open site): plot A, centred on a path with scattered *Tilia* sp. and *Acer* sp., represents a situation typical of biomonitoring studies in urban environment. From a well-identified plot centre, teams were asked to establish the plot area (30 m radius), select all possible standard trees of *Tilia* sp., and carry out lichen diversity assessment on these trees. This exercise was repeated after the training session.

Exercise on plot B (dense forest): plot B was placed in a forest dominated by *A. alba* Mill. and *Picea abies* (L.) Karts. A total of 28 trees, deliberately including several species, with standard and