The Italian skill network of soil biological quality assessed by microarthropods' community

Lorenzo D'Avino[1], Cristina Menta[2], Carlo Jacomini[3], Fabrizio Cassi[4], Giovanni L'Abate[1], Antonietta La Terza[5], Francesca Staffilani[6], Francesca Pocaterra[7], Mauro Piazzi[4], Vittorio Parisi[8]*

[1]CREA Research Centre of Agriculture and Environment,via di Lanciola 12/a, Florence,IT. lorenzo.davino@crea.gov.it
[2]Dept of Chemistry, Life Sciences and Environmental Sustainability, Parco Area delleScienze 11/A, Parma, Italy
[3]Institute for Environmental Protection and Research (ISPRA/SNPA), Rome, Italy
[4]Timesis srl, Via Niccolini 7, San Giuliano Terme (PI), Italy
[5]School of Biosciences and Veterinary Medicine, University of Camerino, Via Gentile III da Varano, Camerino, Italy
[6]Geological, Seismic and Soil Survey - Emilia-Romagna Region, Vialedella Fiera, 8, 40127 Bologna, Italy
[7]ARPA Veneto, Soil and environmental remediation center, Via Santa Barbara 5/A, Treviso, Italy
[8]QBS-ar index inventor, Parma, Italy

Abstract summary

In December 2017, during the 42nd Congress of the Italian Society of Soil Science (SISS), the working group of the QBS-ar index (Soil Biological Quality based on soil arthropods) was established. The aim of this group is to create a network of skillfulness on the well-known and widespread QBS-ar index, conceived by Vittorio Parisi in 2001. The index allows to easily assess soil biological quality analysing the presence of soil dwelling microarthropods. The working group is hosted by SISS and, at present, accounts 57 members expert in this methodology working in 14 different Italian Region, mainly in research public institutions but also in the national System of Environmental Protection Agencies and private bodies. Without any own funds, it already realized 5 workshops and a public seminary at the national scale, a database containing more than 500 files concerning QBS-ar, a SWOT analysis here reported, and a public tender for the graphical Logo.

Keywords: edaphic biodiversity, mesofauna, soil quality assessment, soil management effects, bioindicators

Introduction, scope and main objectives

Since December 2017, the national working group on Soil Biological Quality Index (QBS-ar) aims to be a co-ordination reference for the development, implementation, and standardization of the QBS-ar proposed by Parisi in 2001. QBS-ar provides an assessment of soil microarthropod communities in relation to their peculiar soil adaptation level and can potentially vary between 0 (biological vacuum) and more than 300 (high biodiversity). The method was widely applied throughout Italy at different local levels and it is attracting increasing interest also at the international level (Menta *et al.*, 2018), as it provides fast and reliable assessment of the local soil communities of microarthropods. The working group members work in 14 different Italian regions (Figure 1) and share its achievements twice a year. The 4th workshop, performed on the occasion of the World Soil Day (December 5, 2019) was followed by a public seminary, to disseminate its topics and results, as well as to raise awareness among various stakeholders on the functional importance of soil biodiversity.

In this regard, soils host an immense and still unknown reservoir of organisms that performs pivotal ecosystem functions and services, e.g. soil formation, nutrient cycling and pest control (Pascual *et al.,* 2015). However, an ever-increasing number of studies have shown that anthropogenic activities such as land use changes, compaction, pollution etc., can greatly affect soil living communities, limiting and/or even halting their capacity to provide these critical functions. For these reasons, soil bioindicators are highly effective in to assessing soil functioning and the level of its disturbance (Gardi *et al.,* 2013). In this regard, various soil taxa have been proposed as indicators of soil health and, among them, soil microarthropods (Stone *et al.*, 2016). In order to provide a robust evaluation of the performance of soil bioindicators, it is strategic to develop and standardize appropriate methodological tools to measure (in a harmonized manner) microbial and faunal diversity and thus, to make possible the comparison across different data sets and studies. Several recent EU projects (e.g. ENVASSO, EcoFINDERS, Excalibur etc.) approached these tasks and contributed some ISO standards (Philippot *et al.*, 2012). Nevertheless, most of the developed standards provide insight about the analysis of abundance, structure, and activity of soil microorganisms and, only a few are available for the faunal component of soil. In this regard, ISO standards have been developed for sampling earthworms, enchytraeids, nematodes, macroinvertebrates as well as microarthropods but, in this case, primarily taking into account the most abundant taxa of Collembola and Acarina, and not the less abundant and well-adapted (euedaphic) taxa of Pseudoscorpionida, Protura, Symphyla, Diplura, Palpigrada etc. as instead proposed by the QBS-ar index (Parisi *et al.,* 2005).

In this scenario, the main aim of this network will be to contribute to the correct application and dissemination of this index. In particular the network aims to: i) guarantee the correct QBS-ar use in each application phase everywhere, allowing comparison between sites; ii) create synergies among researchers applying QBS-ar index in soil monitoring programs and projects; iii) gather dataset and publication to promote knowledge in soil microarthropods communities; iv) develop a standardized protocol of QBS-ar application for different climatic zones; v) promote short training courses for beginners or experts; vi) help users to solve troubleshooting during identification.

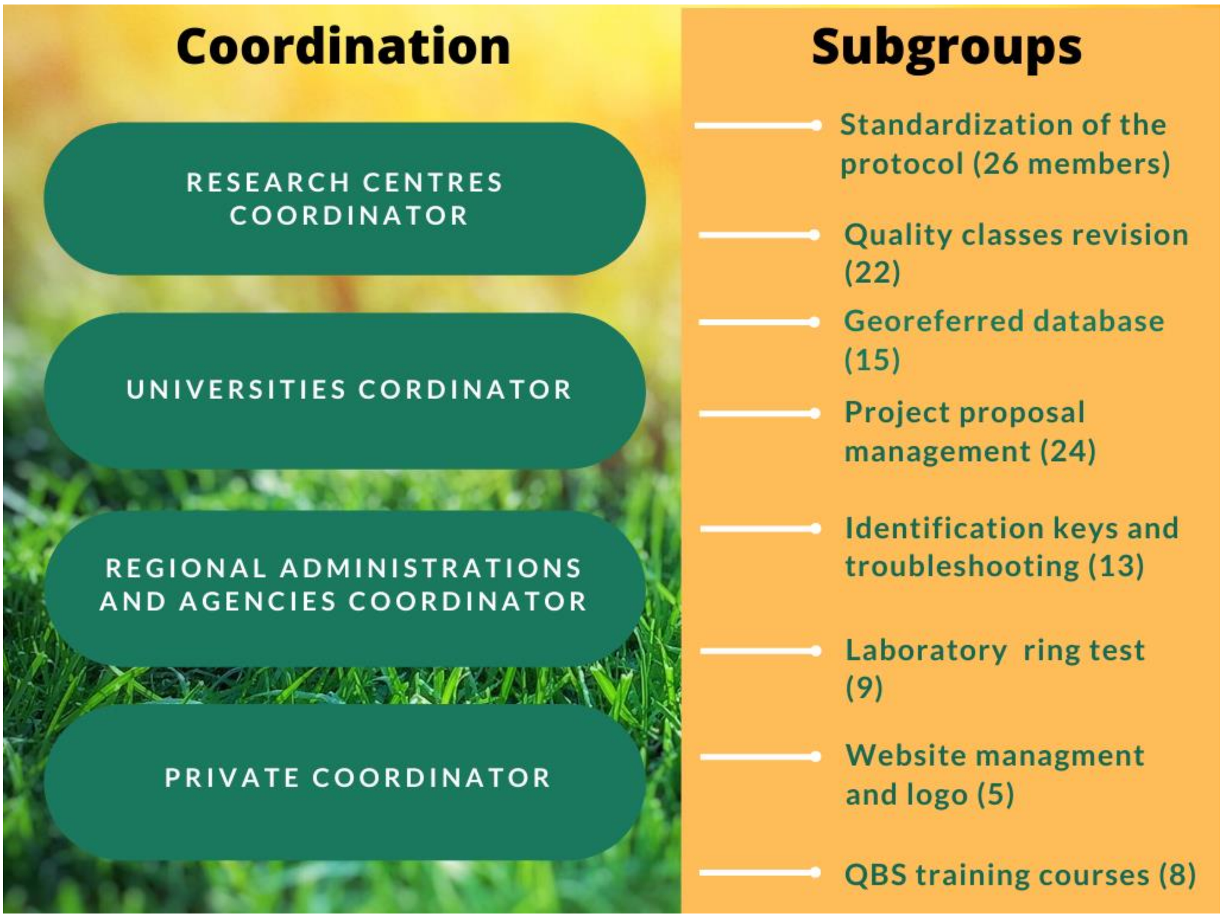

Figure 1: Organizational chart of the working group, detailing the number of members for each subgroup

Methodology

The group at present shares a Database with about 500 files on QBS-ar index experiences, organized in 71 folders, aiming to collect the most relevant and affordable publications and descriptions of the method.

The group is organized in a core-team of 4 coordinators (the first four authors of this paper), representative of the national bodies who applied this method: Public Research Centres, Universities, the System of Environmental Protection Agencies and Regional Administrations, and private bodies. Moreover, the group is structured in 8 subgroups, a coordinator and a deputy coordinator were identified for each subgroup. Every member participates from 1 to 3 subgroups (Figure 1).

Achieved objectives

Nowadays the network accounts 57 QBS-ar experts throughout Italy, mainly academic researchers (Figure2). The workflow chart and operational perspective for every subgroup is shown in table 1. The group has already catalogued 232 stereoscope images of microarthropods, assigning them the correct echo-morphological index (EMI) value. The group organized a public tender to have a Logo receiving several tens of proposals. Winning logo, representing a stylized Oribatid mites that goes down to the soil, is reported in Figure 3.

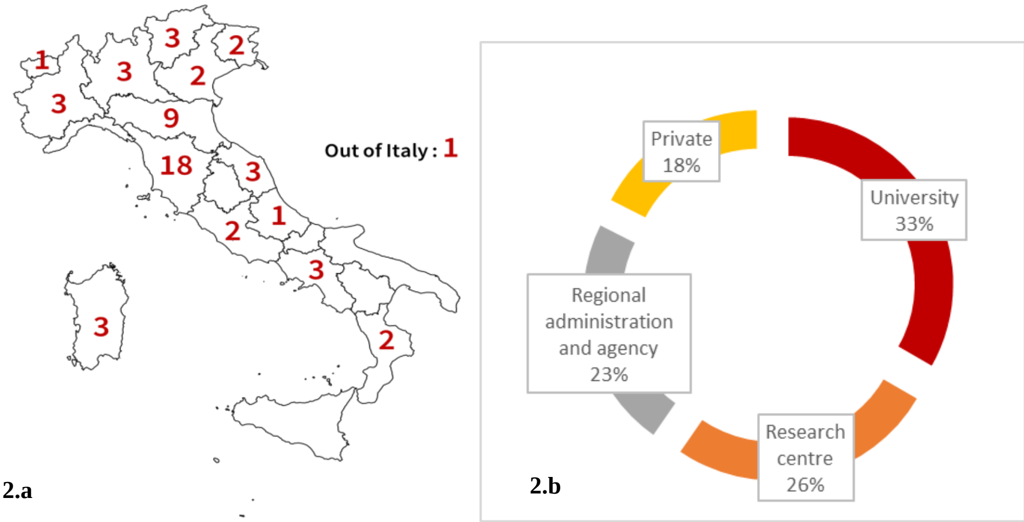

Figure 2: Membership distribution on QBS-ar skill network (a) and composition by institution types (b)

Table 1: Group and subgroups activity time schedule (setting phase, ■ operational phase)

	2017	2018	2019	2020	2021	2022	…
Plenary meeting							
1.standardization							
2.classes							
3.database							
4.projects							
5.identification							
6.ring test							
7.communication							
8.training courses							

Figure 3: Working group logo that won the call for tender

The number of examined soil sites quoted in 100 publications is more than 2600. The analysis of extant publications shows a sharp increase in number and quality of publications (Figure 4).

The data reported in scientific and technical publications include different objectives, project span and land uses. A meta-analysis showed how: i) the highest average QBS-ar value resulted in orchards, grasslands and forests, ii) lower values occurred in urban parks and soils involved in human degradation, iii) the average value is about 100 (Menta *et al.*, 2018).

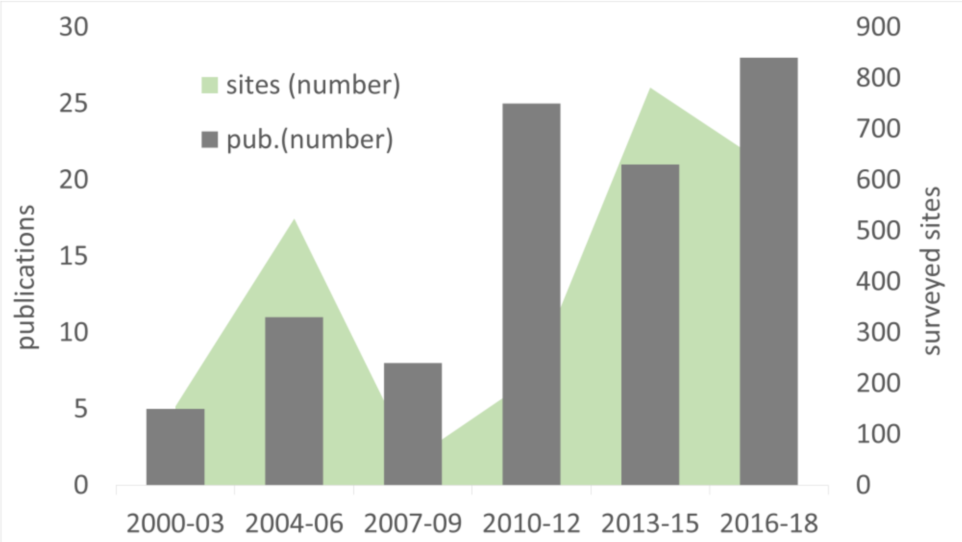

Figure 4: Trend of publications and investigated sites (reported by these publications) regarding the QBS-ar index

The publications are available in the network database

Conclusions

QBS-ar index is an easy-to-learn and cheap tool to describe soil quality and soil biodiversity, it can highlight soil degradation and pollution and can be used to assess the risk of biodiversity loss as consequence of human activities. It responds more quickly than direct measure of soil organic carbon to soil management changes. For these reasons, QBS-ar index can be chosen as indicator in soil monitoring programs to describe the current state of soil quality and to establish local reference values according to the different pedo-climatic conditions, land use and soil management. Many studies have already shown that land use and soil management have the greatest impact on soil microarthropod community, QBS-ar can be used to put in evidence how the different soil management can affect soil quality and biodiversity.

Whereas many studies have been published on QBS-ar application, this network is interested in international collaborations aimed to coordinate the index application in different environments. Moreover, the network has the scope to guarantee the correct QBS-ar use in each application phase everywhere. For this reason, the network members will organize training on the QBS-ar use regularly.

QBS-ar index was recently included within the set of biodiversity indicators in a voluntary certification protocol in agriculture namely Biodiversity Alliance (CCPB, 2017). Maintaining the certification involves checking, usually on an annual basis, the biodiversity parameters of a single farm or an agricultural products supply chain. This monitoring activity takes advantage from the sensitivity of the QBS-ar index in recording the effects on the soil induced by different methods of agronomic management. These statements are fully reflected in the analysis of strengths, weaknesses, opportunities and threats (SWOT) performed by the QBS-ar skill network.

Table 2: SWOT analysis of the QBS-ar method performed by the skill network

Strenghts	Weaknesses	Opportunities	Threats
Robust	Quality Classes to be redefined	Possibility of on-line data inserting	Data Quality Control still absent
Cheap	Generic	Soil Food Webs Insights	Homogeneous Database Implementation
Easy-to-learn, to set up & to implement	Multiple Disturbance Factors	Soil Community Structure Definition	Implementation in not-applicable contexts
Fast in reckoning the final value	Actual representativeness of the sample sites	Correlation with soil resilience to specific stress factors	Mistakes in procedure implementation or in EMI assignment
Data Ecosystem Approach	Not always well-applied outside Italy	Implementation to several scales	Need of milestone sites
Numerical, non-qualitative index	Hard response to forests selective cutting	Easy method's efficacy Communication	Vertical fluctuations, soil humidity and temperature correlations at sampling moment
Short term index, expression of biodiversity	Eventual reference site need (Treatment vs. Control)	Robust Regional Dataset Implementation	Does not allow to check which soil degradation cause and needs other indexes correlation
Soil researchers appreciation	Does not consider specimens abundances	Direct relationship with soil porosity, land use and agricultural practices	Sensitive Species may determine their Faunal Unit absence
Easy to sample and easy to identify Faunal Units			

Represents soil aggregate distribution better than other diversity indexes		

Acknowledgements

The authors would like to thank the Italian Society of Soil Sciences (SISS), its President (2019-20), Professor Paola Adamo, and all the members of the National Working Group, and particularly, the chairpersons of the 8 subgroups. At present, no funding has been provided for the Working Group, whose activities are based on voluntary contributions and promoted by individual pledge and interest.

References

Control and Certification (CCPB) 2017. *Biodiversity Alliance: Technical document DTP 17*. [online]. Bologna. [Cited 29 January 2020] http://www.ccpb.it/en/blog/certificazione/biodiversity-alliance/

Gardi, C., Jeffery, S. & Saltelli, A. 2013. An estimate of potential threats levels to soil biodiversity in EU. *Global Change Biology*, 19(5): 1538–1548. https://doi.org/10.1111/gcb.12159

Menta, C., Conti, F.D., Pinto, S. & Bodini, A. 2018. Soil Biological Quality index (QBS-ar): 15 years of application at global scale. *Ecological Indicators*, 85: 773–780. https://doi.org/10.1016/j.ecolind.2017.11.030

Parisi, V., Menta, C., Gardi, C., Jacomini, C. & Mozzanica, E. 2005. Microarthropod communities as a tool to assess soil quality and biodiversity: a new approach in Italy. *Agriculture, Ecosystems & Environment*, 105(1-2): 323–333. https://doi.org/10.1016/j.agee.2004.02.002

Philippot, L., Ritz, K., Pandard, P., Hallin, S. & Martin-Laurent, F. 2012. Standardisation of methods in soil microbiology: progress and challenges. *FEMS Microbiology Ecology*, 82(1): 1–10. https://doi.org/10.1111/j.1574-6941.2012.01436.x

Pascual, U., Termansen, M., Hedlund, K., Brussaard, L., Faber, J.H., Foudi, S., Lemanceau, P. & Jørgensen, S.L. 2015. On the value of soil biodiversity and ecosystem services. *Ecosystem Services*, 15: 11–18. https://doi.org/10.1016/j.ecoser.2015.06.002

Stone, D., Ritz, K., Griffiths, B.G., Orgiazzi, A. & Creamer, R.E. 2016. Selection of biological indicators appropriate for European soil monitoring. *Applied Soil Ecology*, 97: 12–22. https://doi.org/10.1016/j.apsoil.2015.08.005