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Toward a European humus forms reference base

Augusto ZANELLA[1*], Bernard JABIOL[2], Jean-François PONGE[3], Giacomo SARTORI[4], Rein DE WAAL[5], Bas VAN DELFT[5], Ulfert GRAEFE[6], Nathalie COOLS[7], Klaus KATZENSTEINER[8], Herbert HAGER[8], Michael ENGLISH[9] & Alain BRETHES[10]

[1] Department Land and Agro-Forestry Ecosystems, University of Padova, Viale dell'Università 16, 35020 Legnaro (PD), Italy
[2] Ecole AgroParisTech – Engref, Laboratoire d'étude des ressources forêt-bois (LERFOB), 14 rue Girardet, 54042 Nancy, France
[3] Museum National Histoire Naturelle de Paris, 1 Avenue du Petit Château, 91800 Brunoy, France
[4] Museo Tridentino di Scienze Naturali, Via Calepina 14, 38122 Trento, Italy
[5] Centre Ecosystems Studies, Alterra, Droevendaalse steeg 3, Postbox 47, 6700 AA Wageningen, The Netherlands
[6] Institut für Angewandte Bodenbiologie GmbH, Sodenkamp 62, 22337 Hamburg, Germany
[7] Research Institute for Nature and Forest, Gaverstraat 4, 9500 Geraardsbergen, Belgium
[8] Deptartment of Forest and Soil Sciences, Institute of Forest Ecology, University of Natural Resources and Applied Life Sciences (BOKU) Vienna, Peter Jordanstr. 82, 1190 Wien, Austria
[9] Bundesamt für Wald, Unit Site and Vegetation, Department of Forest Ecology and Soil, Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Seckendorff-Gudent-Weg 8, 1131 Vienna, Austria
[10] Office National des Eaux et Forêts, 45760 Boigny-sur-Bionne, France
[*] Corresponding author e-mail: *augusto.zanella@unipd.it*

SUMMARY - *Toward a European humus forms reference base* - A network of European humus researchers was founded in Trento (Italy) in 2003. The aim of the Group's work was to prepare a synthesis of the knowledge about humus forms which could be used as a field key for classifying and interpreting humus forms within an ecological framework. Stages: the first European classification of terrestrial humus forms, prepared in Vienna (Austria, 2004) from a French plan, presented at EUROSOIL 2004 in Freiburg (Germany, 2004); the new form (*Amphi*) admitted as main humus form (Italy, 2005); the first European classification of semi-terrestrial humus forms, from a Dutch pattern (Italy, 2005); poster at the 18th Congress of Soil Science (Philadelphia, 2006); the enlargement of the *Amphi* category towards some Mediterranean humus forms (Italy, 2007); the definitive agreement for a complete classification key, EUROSOIL (Austria, 2008). Protocols for assessment and sampling of organic and organo-mineral layers were set up, as well as definitions for specific horizons. After six years of exchanges among specialists from 12 European countries, the outcome of this European set-up is briefly presented here as a succession of figures.

RIASSUNTO - *Verso una base di riferimento per le forme di humus europee* - Nel 2003 venne fondato a Trento un gruppo europeo di ricercatori sull'humus, che si propose di realizzare una sintesi delle conoscenze sulle forme di humus da poter usare in campo come chiave di classificazione e di interpretazione di tali forme su basi ecologiche. Le tappe di questo processo sono state le seguenti: la prima classificazione europea delle forme di humus terrestri, preparata a Vienna (Austria, 2004) a partire da uno schema francese e presentata all'EUROSOIL 2004 di Friburgo (Germania, 2004); l'ammissione di una nuova forma (*Amphi*) tra le unità di primo livello (Italia, 2005); la prima classificazione europea delle forme di humus semi-terrestri, a partire da uno schema olandese (Italia, 2005); un poster al diciottesimo Congresso della Scienza del Suolo (Philadelphia, 2006); l'allargamento della forma *Amphi* verso alcune forme mediterranee (Italia, 2007); il definitivo consenso per una chiave di classificazione completa, EUROSOIL (Austria, 2008). I protocolli di riconoscimento e campionamento degli orizzonti organici e organo-minerali sono stati redatti insieme alle definizioni riguardanti alcuni orizzonti più specifici. Dopo sei anni di scambi tra specialisti di dodici paesi europei, viene qui illustrata la sintesi di questo lavoro.

Key words: humus, humus classification, humus form, European Humus Group
Parole chiave: humus, classificazione degli humus, forma di humus, Gruppo Humus Europeo

1. HISTORICAL PATH

A network of European researchers working on humus forms was created in Trento (Italy) in 2003. In July 2004, the commission "Classification of (European) Humus Forms" met in Vienna (Austria) and drafted a taxonomic key of the main terrestrial humus forms based on response to environmental conditions and specific biological activities (Ponge 2003; Graefe & Beylich 2003). This draft was presented in Freiburg (Germany) at the EUROSOIL 2004 congress (Jabiol *et al*. 2004).

From this event onwards, other results have been achieved:

- the definitive admission of the *Amphi* forms at the first

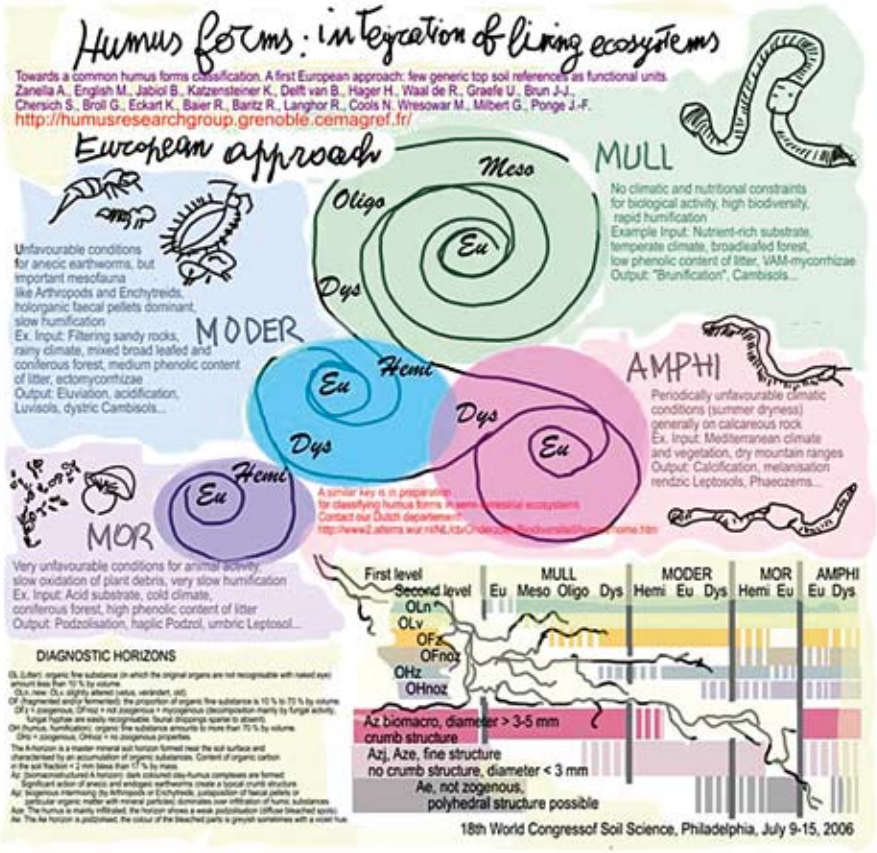

Fig. 1 - The poster at the World Congress of Soil Science in Philadelphia (2006), for disseminating the humus forms concept. It resumes the work about the humus forms two years after the foundation of the European Humus Group: 4 main humus forms, 11 second-level categories and a mild attempt to organize some ecological attractors around them.
Fig. 1 - Il poster presentato al Congresso Mondiale della Scienza del Suolo a Philadelphia (2006), per divulgare il concetto di forme di humus. Esso riassume il lavoro sulle forme di humus due anni dopo la fondazione del Gruppo Humus Europeo: 4 forme di humus principali, 11 categorie di secondo livello e un timido tentativo di organizzare intorno a esse alcuni attrattori ecologici.

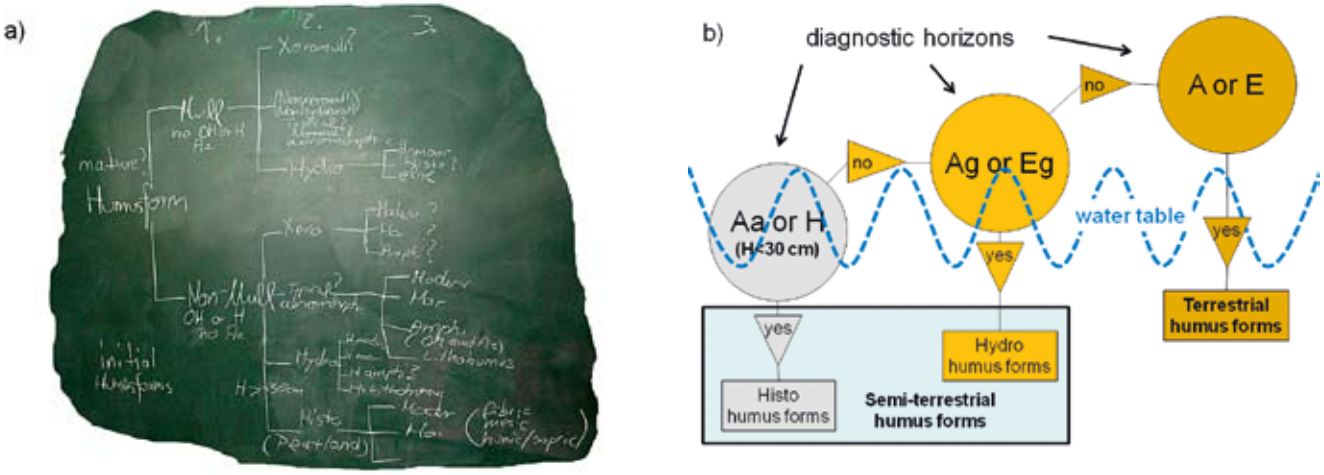

Fig. 2 - Water table level and diagnostic horizons for the semi-terrestrial and terrestrial humus forms. a. "Historical blackboard" in San Vito di Cadore, on July 2005: three main levels of classification, according to the main ecological factors (temperature, water and biological component) and many question marks. b. Present-day position: "first was the water". Aa= anmoor A; H= organic histic horizon; Ag= hydromorphic A; Eg= hydromorphic E; A= organo mineral horizon; E= mineral horizon (eluviation).
Fig. 2 - Livello della falda freatica e orizzonti diagnostici per le forme di humus semi-terrestri e terrestri. a. Lavagna storica a San Vito di Cadore, luglio 2005: tre principali livelli di classificazione, in accordo con i principali fattori ecologici (temperatura, componenti idrica e biologica) e molti punti interrogativi. b. proposizione odierna: "prima venne l'acqua". Aa= A di anmoor; H= orizzonte organico istico; Ag= A idromorfo; Eg= E idromorfo; A= orizzonte organo-minerale; E= orizzonte minerale (di eluviazione).

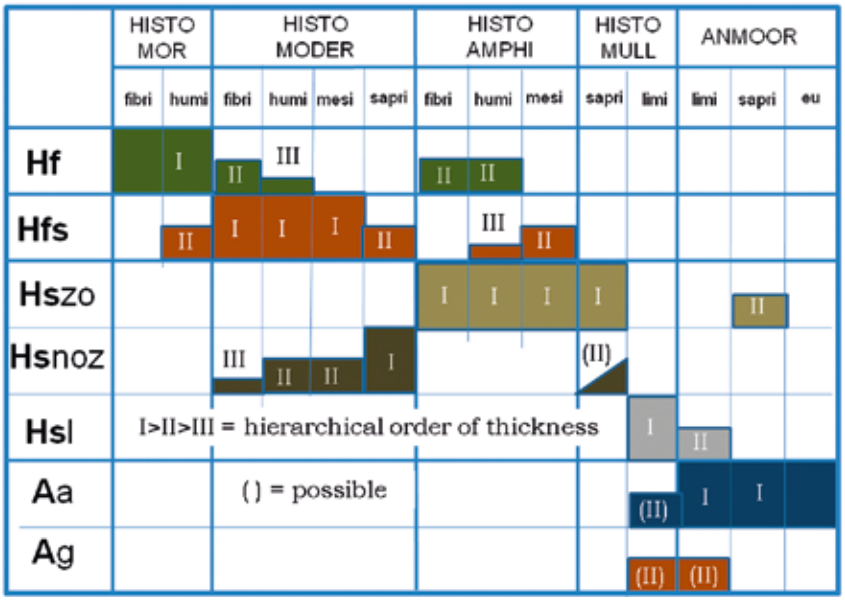

Fig. 3 - Synoptic table of Histo humus forms classification. Hf= fibric H; Hfs= fibric-sapric H; Hsnoz= sapric non zoogenous H; Hszo= sapric zoogenic H; Hsl= sapric-limnic H; Aa= anmoor A; Ag= hydromorphic A.
Fig. 3 - Tabella sinottica della classificazione delle forme di humus Histo. Hf= H fibrico; Hfs= H fibri-saprico; Hnoz= H saprico non zoogenico; Hzo= H saprico zoogenico; Hsl= H sapri-limico; Aa= A di anmoor; Ag= A idromorfo.

level of the classification during the meeting in San Vito (University of Padua, Italy, 2005). The name means "*twin* forms", differentiating from *Moder* because of the strong earthworm activity in the A horizon and from *Mull*, on the other side, because of the important accumulation of organic matter at the soil surface. The same solution has been adopted in the last version of the French Référentiel Pédologique (Baize et al. 2009);

- a draft of a European key of classification has been presented in the form of a poster (Fig. 1) at the 18th Congress of Soil Science, USA, Philadelphia (Zanella *et al.* 2006);
- the first level of the proposed classification key has been implemented and integrated into the manual of the UN-ECE–ICP Forests program available on Internet (http://www.icp-forests.org/Manual.htm);
- an agreement has been reached for characterizing the structure of the A horizon within the European humus forms classification. The soil structure defined in the USDA Soil Survey Manual (1993), also used in the World Reference Base for Soil Resources (IUSS Working Group WRB 2006) and the FAO Guidelines 2006, has been adopted in the new characterization of the five diagnostic A horizons;
- a workshop was made to improve and extend the *Amphi* classification draft in order to include some typical Mediterranean humus forms (meeting at the University of Cagliari, Italy, 2007);
- the most recent version of the key, re-elaborated thanks to a workshop organized during the EUROSOIL 2008 congress (Vienna, Austria), includes the *Tangel* humus form, which has a relatively broad distribution in the calcareous Alpine ecosystems;
- starting from a first attempt presented by the Dutch members of the humus group (Alterra) during a meeting in San Vito (Italy, 2005), the *semi-terrestrial* humus forms have been considered and included in the classification. A final agreement was found only after the Eurosoil 2008 meeting (Fig. 2). Diagnostic horizons for the first and second-level references have been established, and new *Histo* forms have been placed in synoptic tables (Fig. 3);
- with the aim of completing the humus classification panel, definitions for *Hydro*, *Litho*, *Peyro*, *Psammo*, *Rhizo* and *Ligno* forms were recently established exchanging a sharable draft (Figs 4-7).

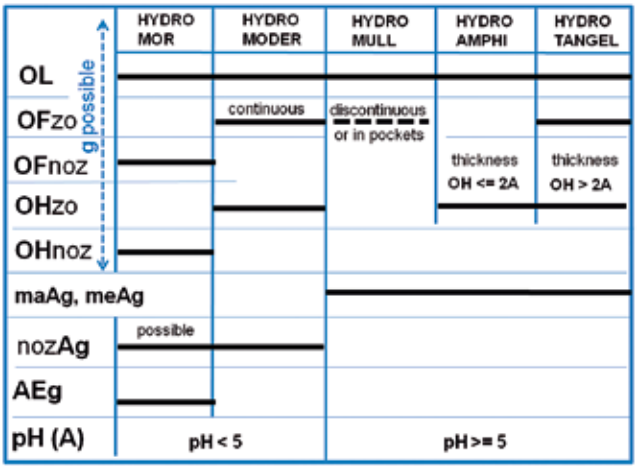

Fig. 4 - Synoptic table of Hidro forms classification. OL, OF, OH= organic horizons; A= organo-mineral horizon ; E= mineral horizon; zo= zoogenous; noz= non zoogenous; ma= biomacrostructured; me= biomesostructured; g= hydromorphic. The pH is measured in water.
Fig. 4 - Tabella sinottica della classificazione delle forme di humus Hidro. OL, OF, OH= orizzonti organici; E= orizzonte minerale; zo= zoogenico; noz= non zoogenico; ma= biomacrostrutturato; me= biomesostrutturato; g= idromorfo. Il pH è misurato in acqua.

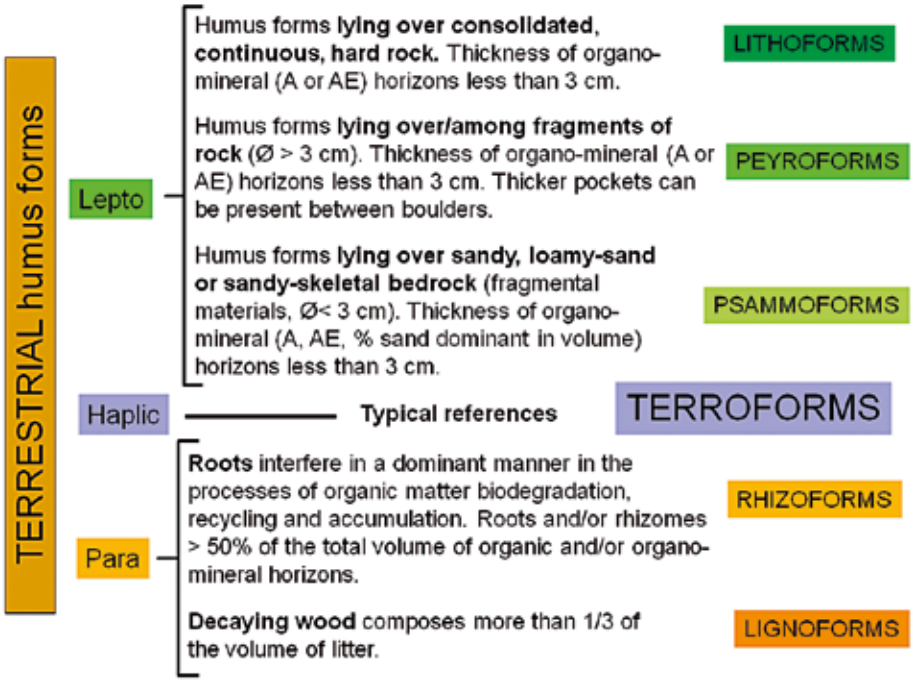

Fig. 5 - Terrestrial humus forms subdivision based on strongly expressed morphological properties.
Fig. 5 - Suddivisione delle forme di humus terrestri basata su proprietà morfologiche fortemente espresse.

2. THE EUROPEAN HUMUS FORMS CLASSIFICATION

The first general principles of a European classification of *terrestrial haplic* forms have now been finalized (Figs 8-9). Protocols for the assessment and sampling of organic and organo-mineral horizons are set up as well as definitions of the different kinds of organic and mineral horizons and their designation. The *recognizable remains* are separated from *humic* and *mineral components*. In fact, the Babel (1980) definition of "fine organic matter", used in other systems of humus forms classification, did not work in an efficient way in order to describe the organic horizons with an appreciable content of large organo-mineral large structures (earthworm faeces). The definitions of *zoogenic* and *non zoogenic materials* allow to better differentiate between some key diagnostic horizons, improving the field estimate of the part of the organic matter degraded by fungi. Concerning *Histo* forms, *fibric* and *sapric components* of the horizons were defined.

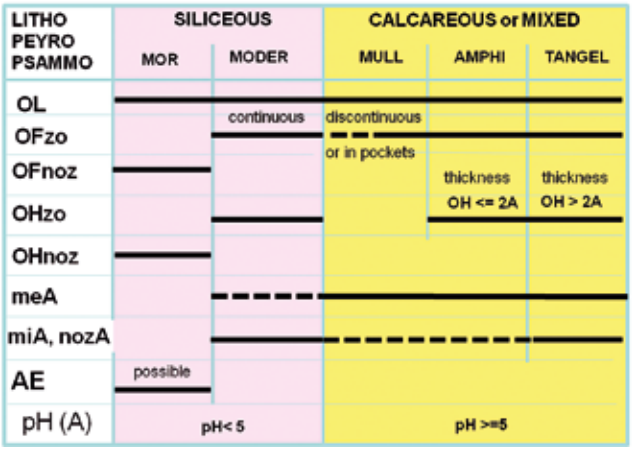

Fig. 6 - Lepto terrestrial forms on siliceous or calcareous substrates. OL, OF, OH= organic horizons; A= organo-mineral horizon; E = mineral horizon (eluviation); zo= zoogenous; noz= non zoogenous; me= biomesostructured; mi= biomicrostructured. The pH is measured in water.
Fig. 6 - Forme terrestri Lepto, su substrati silicei o calcarei. OL, OF, OH= orizzonti organici; A= orizzonte organo-menerale; E= orizzonte minerale (eluviazione); zo= zoogenico; noz= non zoogenico; me= biomesostrutturato; mi= biomicrostrutturato; g= idromorfo. Il pH è misurato in acqua.

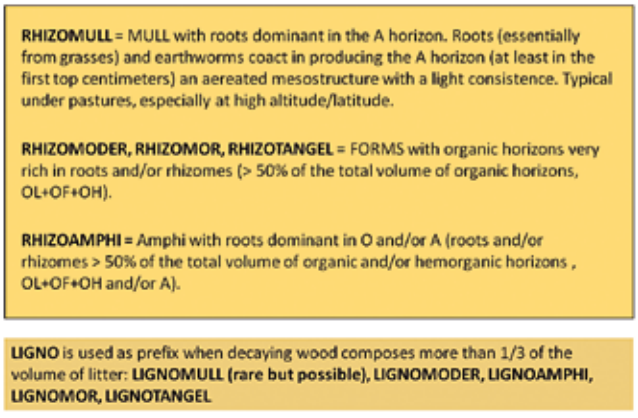

Fig. 7 - Rhizo humus forms. OL, OF, OH= organic horizons.
Fig. 7 - Forme di humus Rhizo. OL, OF, OH= orizzonti organici.

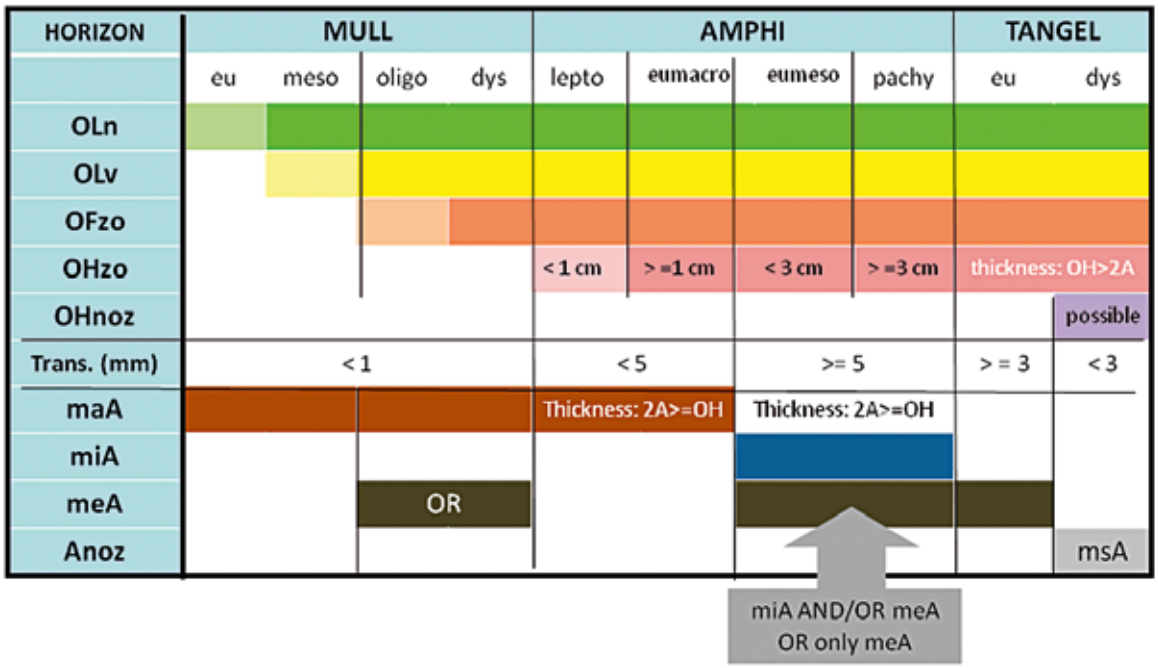

Fig. 8 - Terroforms on calcareous or lithologically mixed substrates. OL, OF, OH= organic horizons; n= new litter; v= old litter; A= organo-mineral horizon; zo= zoogenous; noz= non zoogenous; ma= biomacrostructured; me= biomesostructured; mi= biomicrostructured; Trans. (mm)= transition between organic and organo-mineral horizons (millimeters).
Fig. 8 - Terroforme su substrati calcarei o misti. OL, OF, OH= orizzonti organici; n= lettiera nuova; v= lettiera vecchia; A= orizzonte organo-menerale; zo= zoogenico; noz= non zoogenico; ma= biomesostrutturato; me= biomicrostrutturato; mi= biomicrostructured; Trans. (mm)= transizione tra orizzonti organico e organo-minerale (millimetri).

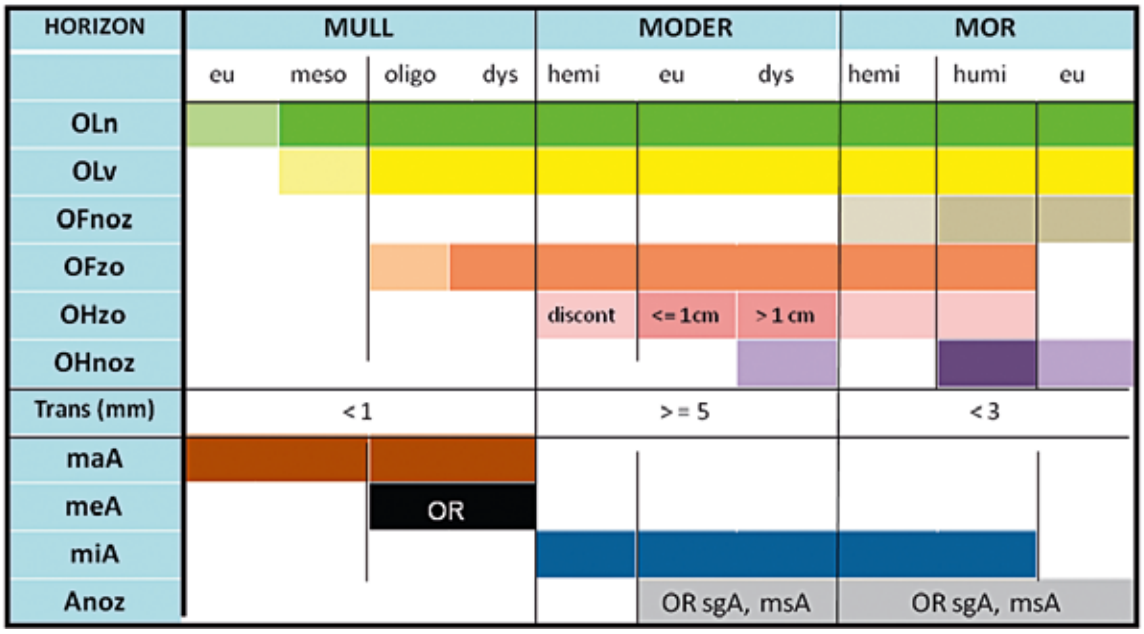

Fig. 9 - Terroforms on acid siliceous substrates. OL, OF, OH= organic horizons; n= new litter; v= old litter; A= organo-mineral horizon; zo= zoogenous; noz= non zoogenous; ma= biomacrostructured; me= biomesostructured; mi= biomicrostructured; Trans. (mm)= transition between organic and organo-mineral horizons (millimeters).
Fig. 9 - Terroforme su substrati silicei acidi. OL, OF, OH= orizzonti organici; n= lettiera nuova; v= lettiera vecchia; A= orizzonte organo-menerale; zo= zoogenico; noz= non zoogenico; ma= biomesostrutturato; me= biomicrostrutturato; mi= biomicrostructured; Trans. (mm)= transizione tra orizzonti organico e organo-minerale (millimetri).

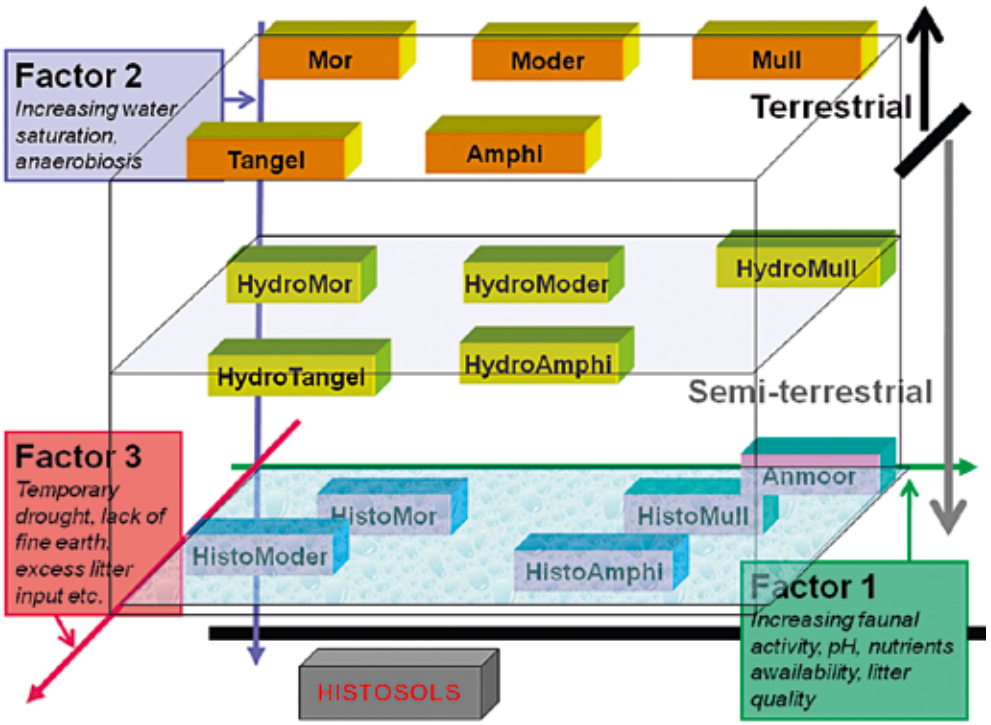

Fig. 10 - Eco-diagram for humus formation.
Fig. 10 - Eco-diagramma della formazione dell'humus.

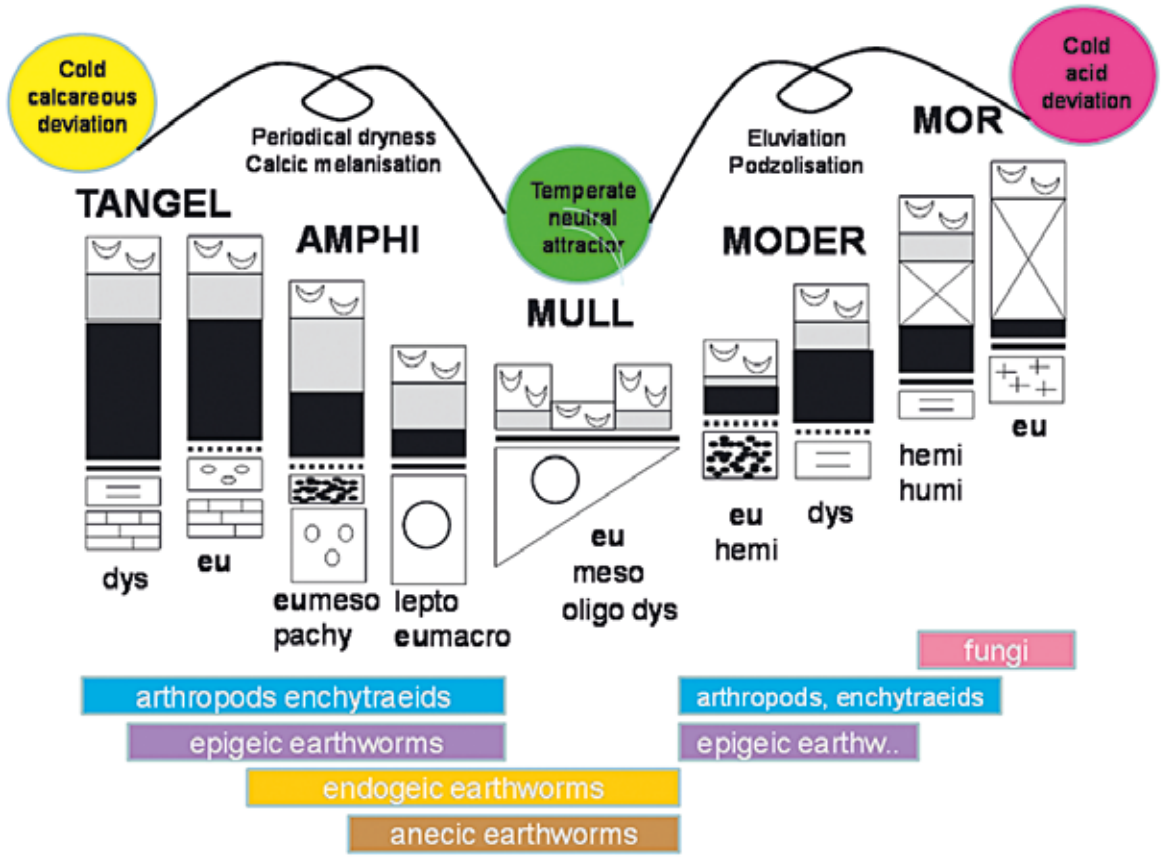

Fig. 11 - Ecological attractors and humus forms. The scheme shows a chained list of horizons and actors of biodegradation.
Fig. 11 - Attrattori ecologici e forme di humus. Lo schema mostra come la serie di orizzonti sia legata agli attori della biodegradazione.

The Humus Group considers the key of the humus forms classification as its common endeavour, a contribution to the understanding of ecosystem functioning (Fig. 10) and of nutrients cycling, and may introduce humus forms classification as a diagnostic tool for assessing the ecosystem health status. The Humus Group sees the description and the study of humus forms as a tool to characterize ecosystems or biotic communities, which evolve together in response to environmental factors, and humus forms may be indicative for these changes (Ponge 2003). We see the very abstract and simplistic procedure of humus forms classification as our common and demanding task, which makes sense only within a functional approach. An effort was done for translating field data (Sartori *et al.* 2004) and present knowledge (humus forms structure and ecology) in graphical models or tables allowing to use these concepts in ecological procedures. Groups of animals were associated to diagnostic horizons and humus forms (Fig. 11).

3. ISSUE

The publication is perceived by the Humus Group as a forum which allows us to introduce the wider scientific community to our work and to further our efforts towards an internationally agreed classification and standardization of defined humus forms. To achieve these goals the paper is organized as following:

- introduction and general synoptic tables of humus forms classification;
- *Terro* and *Histo* forms classification;
- vocabulary, definition of main horizons, synoptic tables for field classification. A biological point of view is also given for linking bio-degraders and structure of the main diagnostic horizons;
- functional aspects;
- practical value of the delivered classification.

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REFERENCES

AFES, 2009 - Référentiel Pédologique 2008, Baize D. & Girard C.M. (eds). Editions Quae, Paris: 432 pp.

Babel U., Kreutzer K., Ulrich B., Zezschwitz E. von & Zöttl H.W., 1980 - Definitionen zur Humusmorphologie der Waldböden. *Z. Pflanzenernähr. u. Bodenk*., 143: 564-568.

FAO, 2006 - Guidelines for Soil Description. 4th ed. FAO, Rome: 97 pp.

Graefe U. & Beylich A., 2003 - Critical values of soil acidification for annelid species and the decomposer community. *Newsletter on Enchytraeidae*, 8: 51-55.

IUSS Working Group WRB, 2006 - World Reference Base for Soil Resources 2006. *World Soil Resources Reports*, 103 pp.

Jabiol B., Zanella A., Englisch M., Hager H., Katzensteiner K. & de Waals R., 2004 - *Towards an European classification of terrestrial humus forms.* Eurosoil - Freiburg. September 4-12. Symposium 09 - Forest soil Monday 6th: 9.30-9.50 http:/ www.bobenkunde.uni-freiburg.de/eurosoil: 10.

Ponge J.F., 2003 - Humus forms in terrestrial ecosystems: a framework to biodiversity. *Soil Biol. Biochem*., 35: 935-945.

Sartori G., Obber S., Garlato A., Pocaterra F. & Vinci I., 2004 - *Factors controlling the Alpine humus forms distribution (Venetian Alps, Italy).* Poster at the Eurosoil Congress, Freiburg, September 2004.

Zanella A., English M., Jabiol B., Katzensteiner K., Delft Van B., Hager H., Waal de R., Graefe U., Brun J.-J, Chersich S., Broll G., Kolb E., Baier R., Baritz R., LAanghor, R., Cools N., Wresowar M., Milbert G. & Ponge J.F., 2006 - *Towards a common humus forms classification. The point in Europe: few top soil references as functioning systems. (Humus forms: integration of living ecosystems).* Poster presented at 18th Congress of Soil Science, Philadelphia, July 2006.