Morpho-Functional Classification of the Planet's Humipedons

Subjects: Soil Science

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A morpho-functional classification of the humipedons could be defined as this: 1) Classification: ordering things = summarizing the complexity of reality = putting nature in boxes, to "possess" nature, to "enumerate", divide, understand nature, get to know our home (oikos) = putting a name on things (just like names for people); 2) Type of classification: Morpho-functional; not objects but "machines" has to be classified, "running systems", "natural clocks" full of interconnected cogwheels and that may indicate the time, systems that inform us about how they live; morpho stays for visible forms that characterize each "machine" and which communicate with us: if there are those visible forms, then we are facing that type of "system"; 3) Some soil scientists classify (morpho-functionally) only humipedons (not all the soil profiles), only the organic (H and O) and organo-mineral (A) horizons of the soil profile. Because they think these horizons are highly connected to the present day evolution of the ecosystems. The other parts of the soil are very important too, but they don't work at the speed that interests present day evolution, from one to 100 years.

Keywords: humipedon ; humus system ; humus form ; humusica ; carbon cycle ; soil classification ; global change ; soil biodiversity

1. Introduction: A Humipedon Classification Is Needed

There are abiotic and biotic soils [1]. Abiotic soils are, for example, the rocky surfaces of bodies evolving outside the Earth's atmosphere, such as the moon, Mars, and comets or asteroids. These abiotic soils correspond to rocks transformed by the actions of physical and chemical forces, in the absence of living organisms. True terrestrial soils have new functional characteristics that are very different from those of abiotic soils. These new features are purely of biotic origin.

All terrestrial soils are biotic soils (i.e., endowed of variable biological activity) and correspond to a biotic matrix made of living and dead organic substances, mineral substances, and a periodical or continuous dynamic fluid that connects the different parts of this living soil. A biotic soil acts as an ecosystem [2][3] where plants, animals, and microorganisms interact and use the physical and chemical environment [4][5] for building a living structure. When environmental conditions become difficult for the living beings inhabiting the soil (extreme temperatures and absence of liquid water, presence of high-energy radiations) [6], terrestrial soils resemble abiotic soils. The depth of the soil depends on this aspect; at a certain depth, microorganisms change/disappear [7][8][9][10], and the soil becomes a more or less abiotic substrate. Notice that even in harsh environment, surface rocky substrates are generally rich in microorganisms, and that in geological periods many rocks are themselves biogenic (i.e., limestone, coal, oil shale…) [11].

In scientific publications with the objectives of safeguarding and managing the environment, the survival of the planet's biodiversity is now presented as linked to a living soil matrix that guarantees its dynamic recycling and influences the planet's climate [12][13][14][15][16][17][18]. Indeed, in the course of geological times, the humipedon has behaved like the planet's air, changing as a consequence of the development of the biodiversity (microbial diversity, fundamentally), while remaining closely and indelibly connected with the biosphere as a whole [19].

Soil classification is important for exchanging knowledge among scientists and understanding how soil works [2]. In this moment of crisis in the planet's biodiversity [20][21][22][23][24], the ability to classify the soil becomes essential because a large number of living beings are found in the "topsoil" (which from now on in the text will be referred to as "humipedon") [25][26][27][28][29]. The humipedon corresponds to the organic (OL, OF, OH, and H) and organomineral (A, AE) soil-surface horizons, roughly the top 30–40 cm of a biotic earthly soil [30][31]. Knowing how to link the quantity and quality of organic matter (OM) in the soil [15][32][33][34][35] to the type of humipedon, enables a sustainable use of the soil for agricultural and forest purposes, and can contribute to climate-change mitigation [36][37][38][39][40][41][42]. A morpho-functional classification of the humipedon is now available [43]; accessible by direct naked-eye observation, or with the help of a 10 × magnification lens, some morphological characters allow a first understanding of the soil functioning. In particular, the observation reveals the vertical structure in horizons of the soil, and the biological actors of such a spatial organization. For example, it is possible to know how long it takes in natural conditions for a specific litter type to be integrated into the mineral soil [44]; or to recognize the main animal groups associated with the biodegradation (mineralization and humification), or the shape and size of their excrements [45].

2. The Environment in Which the Targeted Humipedon Is Found

Soil organisms and biota activities evolve with the environment and generate horizons and subunits in tune with it. Once the vertical structure of the soil is unveiled and the humipedon is circumscribed, it is necessary to establish in which main "ecological frame" the observed topsoil is located. On a large scale, five sets of humipedons can be identified:

- Terrestrial: humipedons that never submerged for more than a few days per year; peaty and water-filled horizons absent. These humipedons belong to Mull or non-Mull systems (Moder, Mor, Amphi, and Tangel);

- Histic Semiterrestrial: submerged humipedons characterized by peaty horizons; presence of a water table (perched or not). These humipedons belong to Fibrimoor, Mesimoor, Amphimoor, Saprimoor, and Anmoor systems;

- Aqueous Semiterrestrial: humipedons by the sea in tidal area, or submerged;

- Para systems: humipedons connected to the other three groups (Para = next to) in a dynamic way; they either precede the others in time or develop with them (overlapped, juxtaposed). These are Archaeo (extremophile microorganisms), Anaero (submerged organotrophic microorganisms), Crusto (cyanobacteria, lichens, algae, fungi), Rhizo (roots, rhizoids), Bryo (mosses), and Ligno (decaying wood agents) systems.

- Anthropic systems: Agro (natural humipedons anthropogenically transformed for agricultural purposes) and Techno (manmade imitation of natural humipedons, e.g., compost, or without a specific purpose (waste dumps, etc.)).

3. TerrHum: Humusica in Your Phones and Tablets

The TerrHum name assembles the abbreviated words Terra (planet Earth in Italian) and Humipedon (organic and organomineral humus horizons). With this application, a user can classify the Terrestrial and Histic semiterrestrial humipedons of our planet. It also contains some information on the diagnostic horizons of Para systems, such as the Bryo, Rhizo and Ligno, and on horizons disrupted by wild mammals. The application is built on the indications on the diagnostic horizons reported and illustrated in articles 4, 5, 6, 9, 10, 11, and 13.

The App is freely available on the iOS (App Store) and Android (Google Play) platforms in English, French, and Italian. TerrHum makes use of many figures that are stored in a cloud and downloaded on cellphones the first time the users recall them. Once all figures (about 140) have been opened, devices do not need to be connected to run the application.

Instead of describing the App, researchers show some figures that illustrate how it works (**Figure 1**, **Figure 2** and **Figure 3)**.

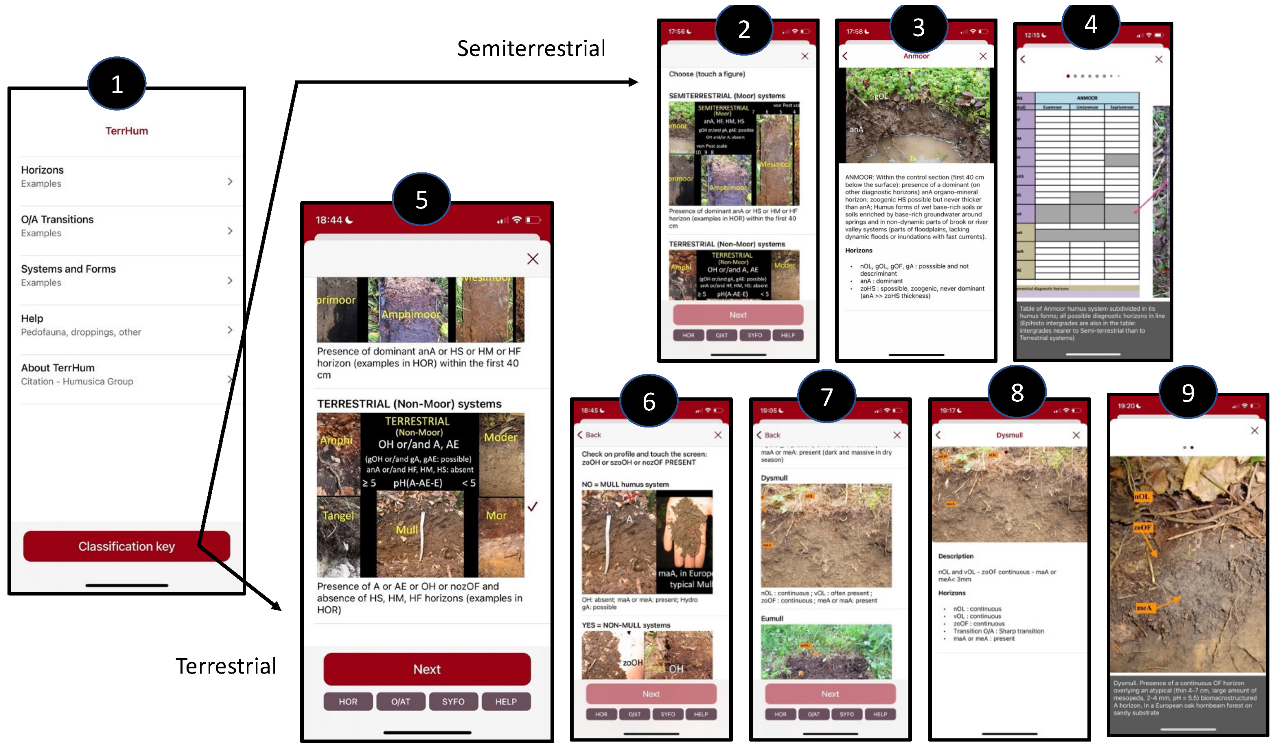

Figure 1. TerrHum is the result of a collective work and allows researchers to classify Terrestrial and Histic systems and forms. Indications are provided to also consider the Hydro transitions between Terrestrial and Histic, and also the complexifications of Terrestrial systems with Bryo, Ligno, and Rhizo systems. (1) Starting screen, iOS version (similar to the Android one). By clicking on the red button ‘Classification key’, the screen on the right opens; observing the profile to be classified, the user must choose between Semiterrestrial (2) and Terrestrial systems (5). To achieve this, they must search for the diagnostic horizons indicated on the screen. For example, to belong to the Semiterrestrial systems (2), a profile must show at least one of the following horizons: anA, HF, HM, HS; to belong to the Terrestrial systems (5), the profile must show OH, A, or AE horizons. If the user is a beginner, they can see photographic examples by tapping at the bottom of the screen (the four small brown rectangles at the bottom of screens 2, 5, 6, 7): HOR = diagnostic horizons, O/A T = O/A transitions; SYFO = systems and forms; HELP = tables, diagrams, other. These same commands correspond to the ones of the starting screen (1). Semiterrestrial example: By touching the screen at the “Semiterrestrial” level (2); ´Next ´ appears in red, which allows one to move forward and scroll among examples of these humus systems; for example, by choosing ‘Anmoor’ between them, one can display some photographs of these system profiles (3). By touching the photo, one can zoom in by spreading one’s fingers on the screen. One can view more Anmoor examples, bringing the photo to the smallest size and sliding it to the left. Tapping the photo again brings up a legend. A table (4) with the details of the humus forms of this system can be viewed by pressing “systems and forms” on the screen (1), or the equivalent command “SYFO” at the bottom of other screens (2, 5, 6, 7). As with each image, the table can be enlarged by spreading the fingers on the screen. Terrestrial example: Terrestrial horizons are present on the real profile, the operator taps the Terrestrial figure (5); ´Next´ appears in red, which allows one to move forward (6). Now the operator has to choose between Mull or non-Mull systems. If there is an absence of OH horizon in the field profile, then the NO = MULL humus system figure should be selected, followed by ´Next´, to obtain examples of Mull forms (7). Then, it always works in the same way: by touching the screen at the level of the chosen figures, examples and legends appear that can be enlarged (8, 9). If in doubt, one can ask for information by clicking on the commands on the home screen (1) or at the bottom (small brow rectangles) of the other screens (2, 5, 6, 7).

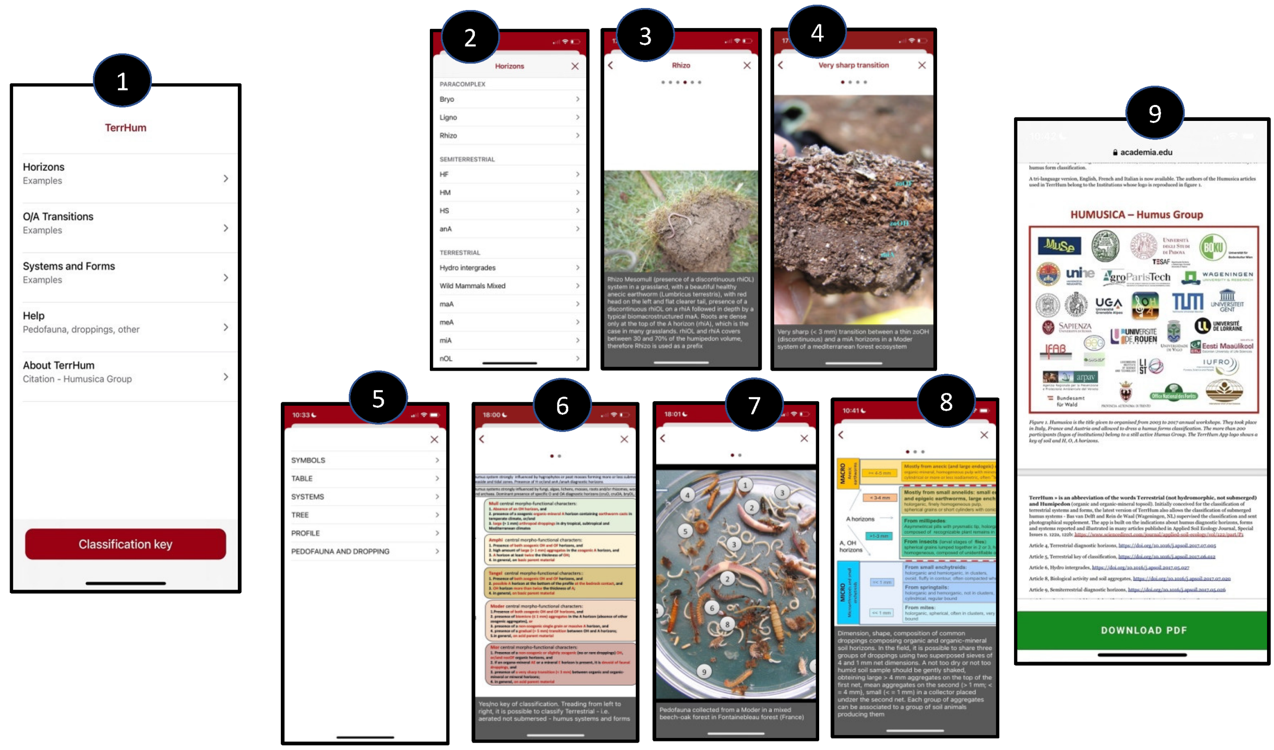

Figure 2. Main screen commands (1): 'horizons', 'O/A transitions', 'systems and forms', 'help' and 'about TerrHum'. 'Horizon' command opens screen (2). To list available horizons, just touch a horizon code on the screen and scroll for examples of this horizon. The user selected ´Rhizo´ (3); the dots above the figure indicate the number of possible views, and the 4th view corresponds to that of a Mesomull A horizon. A thin Rhizo system occupies the top. By spreading one's fingers on the figure, one can zoom in. Touching the figure displays a legend. To go back, just touch the cross at the top right. 'O/A Transition' button allows one to see examples of gradual, sharp, and very sharp transitions between O and A horizons. The one enlarged on the screen (4) is a very sharp transition. 'Systems and forms' command is a shortcut for experts. It gives direct access to all the Semiterrestrial humus systems (to have the details of the Semiterrestrial humus forms, it is necessary to activate the 'Help' command and view the corresponding tables) and to all the Terrestrial humus forms, in alphabetical order. Just touch the name of a system or a form of humus to obtain examples of them. 'Help' button leads to a list of new commands (5): SYMBOLS = a list of symbols to be used in the field for the description of the diagnostic horizons (they were used in the field a few years ago; today researchers prefer to take a photo and write on it; however, sometimes batteries run out …); TABLE = humus systems classification tables and schemes; SYSTEMS = humus forms classification tables; TREE: dichotomous classification schemes (6); PROFILE = graphs on the soil structure in horizons; PEDOFAUNA AND DROPPING: photographs of animals (7) and droppings photographs and classification keys (8). ´About TerrHum´ leads to a web page with information on the Humus Group and on the articles from which the information presented with the app is taken. Researchers from all the Institutes cited in the figure (9) were called to contribute. Once at a congress, someone objected that it is too complicated to classify humipedons. The answer was that the functioning of natural ecosystems is very interesting but complex.

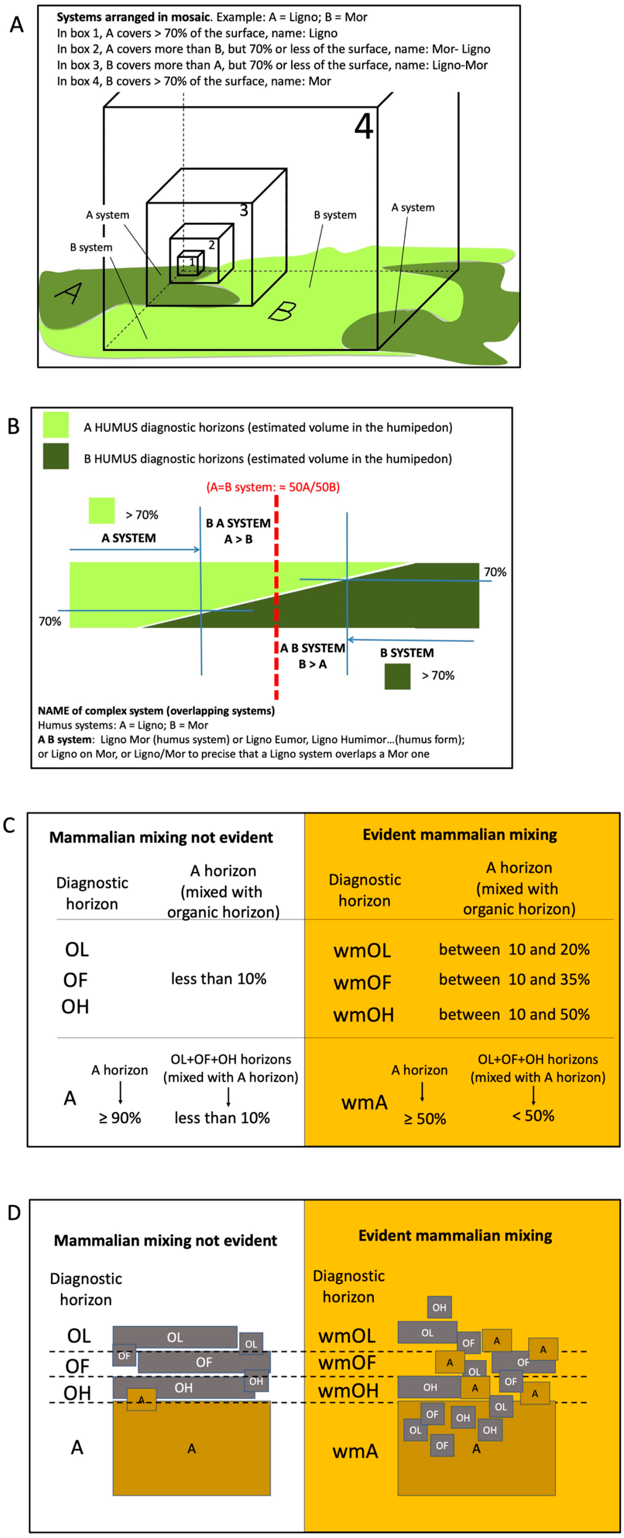

Figure 3. To simplify complexity: humus systems arranged in mosaic (**A**) or overlapping (**B**); diagnostic horizons broken down by wild mammals, definition (**C**) and schematic drawing (**D**). Generally, humus systems juxtapose like pieces of a puzzle (**A**). To perceive this reality, it is necessary to investigate the environment at different scales and recognize the elementary humus systems. The interpretation of the landscape that follows depends on the observation scale. The figure shows an example of two humus systems, Ligno (dark green = a decaying stump) and Moder (light green = area without dead wood). In the smaller cube, there is only the Ligno system, in all the other larger cubes there are two systems. The name assigned to the system found in the studied environment depends on the dominance of one system over the other in the cube that contains that environment. Overlapping humus systems (**B**). This happens when studying series of soils along a large time gradient. In general, new systems arise under older systems. The genesis is recognized thanks to the presence of diagnostic horizons typical of different systems. The name that can be assigned to the humipedon analyzed depends on the thickness in the horizon profile typical of each system. TerrHum path: Main screen > Horizons > Ligno > Second (**A**) and third (**B**) pictures. Mammals, such as mice, moles, wolves, foxes, deer, wild boars, etc., can break down the horizons of a humipedon. These are based on the mixture of organic horizons with the organomineral A horizon (**C**,**D**). It is simply tolerated that in the event of obvious and localized turmoil caused by these animals, an organic horizon may

contain more horizon A than usual, and that an A horizon may contain more organic material than usual. TerrHum path: Main screen > Horizons > Wild Mammals Mixed > First (**C**) and second (**D**) pictures.

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