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Short Communication

The spiral of plants in the life cycle

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Abstract

Dialogue with Sandro Pignatti on natural evolution, considering the soil as a living matrix in which the recycling of organic matter (and DNA) takes place. We discussed the following topics:
1) the relationship between phytosociology and plants' ecology;
2) the soil as individual or ecosystem digestive machinery;
3) the hypothesis of a complemental flow of DNA pieces in relation to the recycling process that takes place in the soil.
Past and recent research in the fields of biology and evolution highlights a functional and primordial collaboration between living beings in the exploitation of the natural resources. In this process that ultimately is life, the soil plays a crucial role because it cyclically and progressively renews and enriches the sources of elementary structural bricks.

Keywords: Natural evolution; DNA; Castelporziano; soil; humus; biodiversity; biodegradation

He found me kneeling in front of a soil profile, ‘How are you Zanella? What are you looking for… in a hole?’

I turned to a jovial man; his eyes bright in the shadow of the visor of an American cap. December 6, 2010 was a sunny day in the Presidential Estate of Castelporziano (Rome).

‘Sandro Pignatti’, he then pronounced, noting the uncertainty in my gaze.

Beige waterproof jacket, a little shorter than Lieutenant Colombo's, suede boots, and blue cotton trousers with iron creases along the legs. I felt a feeling of innate sympathy: my mother had never been able to understand that to iron blue jeans was not necessary.

Standing up and shaking his hand, I said ‘We met in 1991, at the phytosociological congress organized by Jean-Marie Géhu on forests dynamics, in Bailleul, France (Géhu 1993), do you remember?’ And pointing the soil profile: ‘In the succession of horizons, this soil profile is a disaster’.

He nodded.

I was holding two soil samples (Fig. 1), an organic aggregate called the zoOH horizon (litter transformed into humus by soil animals; zo = zoogenic), and a glomerular handful of organo-mineral soil called the meA horizon (zoogenic organo-mineral aggregates; me = presence of meso-aggregates (1 < diameter ≤ 4 mm). ‘Usually, these horizons are on top of each other, but wild boars, using their nose like a plow, messed everything up; ….we will have to invent something to classify these strange cases (Zanella et al. 2022)….’

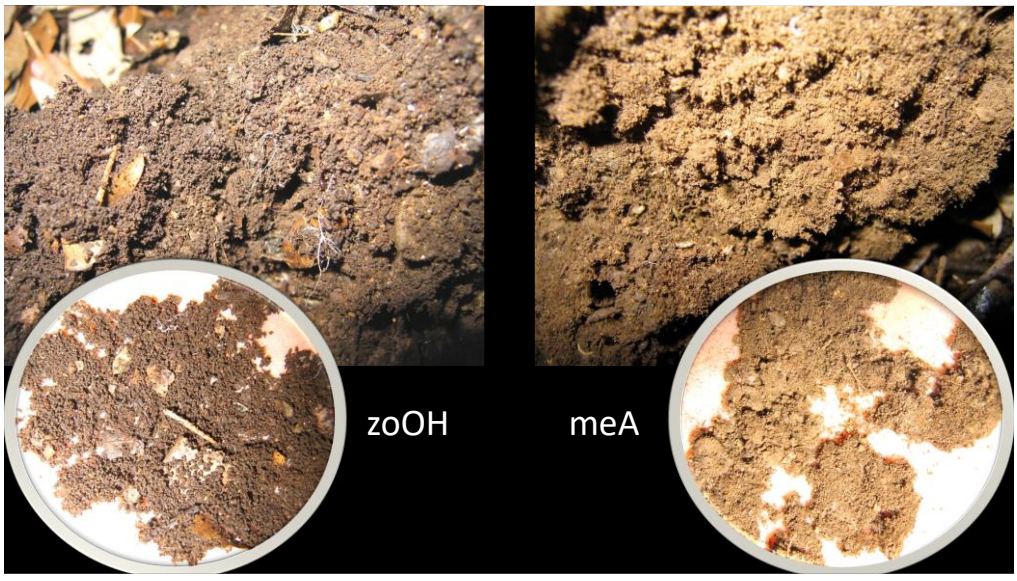

Figure 1. Left: zoOH, zo = zoogenic organic horizon, mainly originating from arthropods. This horizon is located at the soil surface below the more or less decomposed litter horizons and above a more mineral A horizon. Right: meA = organo-mineral A horizon originating from earthworms, whose feces are colonized by arthropods from the overlying horizon zoOH. "me" means horizon which has several stable aggregates

with a diameter between 1 and 4 mm (made by earthworms). This meA horizon is typical of calcareous Mediterranean and sub-Mediterranean environments where arthropods and earthworms are called to coexist. The set of superficial horizons forms a humipedon called "Amphi"(Zanella et al. 2022), which means double, due to its double origin from arthropods and earthworms.

He smiled as he touched the two samples, and added: ‘It is always like this. You arrive on the field with clear ideas; you observe the reality that surrounds you, and you are in the mist; worse, but challenging, when it starts to thin out, the road forks and you don't know which way is the right one. Did you sleep well in the villa?’

‘Not so well. There was a buxom lady in the room, who seemed to stare at me insistently. I pretended to turn off the light to sleep, and I immediately turned it on again surprisingly, to intercept a movement of hers... Nothing, still fixed on the painting, sly like Gioconda and still too much alive. Before going to bed I also saw the stars, bumping my bare foot against a heavy vase protruding from under the bed’.

‘You were lucky; they set you in a royal room; you certainly kicked Vittorio Emanuele Second's ceramic chamber pot’, accompanying this with a smile of cordial compassion … ‘Let's go and see a forest area where the distribution of vegetation strictly depends on the characteristics of the soil; I want your opinion, follow me'.

We crossed a holm oak forest dotted with circular pools filled with shallow stagnant water, having an animated discussion about natural evolution. We started from the following empirical personal observations:

1) Mapping the phytosociological units of a plant landscape without using many unclassifiable gray areas is almost impossible. To draw the boundaries between phytosociological units in the field, characteristic plant species are used. However, by definition, these species have a narrow ecological range and are often absent along a line of demarcation between two units.

2) Due to the direct or indirect action of man, recent evolution has not been natural for at least a century. Theoretically, ecosystems should continue to evolve as if living beings and the environment forced these "volumes of nature" (trying to circumscribe Tansley's ecosystem concept (Tansley 1935)) to grow continuously into the future… In the final analysis, to realize this is "to live". For Tansley and many of us after him, of fundamental importance is the "indivisibility" of the ecosystem, although organisms may claim our primary interest. When we try to understand the essence of an ecological functioning, we cannot separate living beings from each other, nor each living being from its own environment. If the future biological complexity and evolution remain unknown to us, we can nevertheless foresee them and confine them temporarily over a few decades.

3) Even partially contradicting what we have just said about the cohesion of the ecosystem and considering the plants separately (just with the thought), even if poorly defined on the territory, the phytosociological units should exist. Evolving and changing, but composed of plants that “talk” to each other and co-evolve thanks to a common language. We can imagine this set of

plants as located in a kind of black hole, influenced by ecological attractors (Mayr 1942) which change, because themselves dependent on the rest, in the space-time of a whirlwind of light, moving and indeterminate.

‘I'm not a phytosociologist’, he said, ‘only an expert in vegetation ecology.

‘Even Lucio Susmel’, I continued, ‘wrote a well-documented essay against phytosociology (Susmel 1959). In the field, however, we are forced to imitate phytosociologists to recognize units within a landscape, using the colors and structure of the vegetation as discriminating elements. In "I Boschi d'Italia" (Bartoli et al. 1998) you wrote that one must select those plant units that occupy a “delimited by ecological factors”’ area. This principle was firmly remembered by Jean-Marie Géhu, the spiritual heir of Josias Braun-Blanquet. On one side, Jean-Marie feared the destruction of the phytosociological classification by an excessive fragmentation of its branches; on the other, he was very fond of upward complexification, and developed the notion of functional unit of the landscape, very useful in cartographic operations (Bioret et al. 2021). We can't deny that vegetational units may be organized both in an ascending and descending way, always remaining in blurred outlines.

‘I know, with Jean-Marie we discussed this aspect several times: when we (humans) do not understand a process, or when we face a new object, it is easier to code a new word than to connect such a novelty to previous knowledge’.

Few steps of silent reflection.

‘When I could, I also took my family with me on excursions’, he clarified this as if he were talking to himself, in a low voice and closing his eyes with a sigh... ‘However, I am absolutely convinced that plants talk to each other, and also with animals. Simply to survive’.

‘I learned that everything dies and ends up becoming humus’, I added, ‘cyclically. Pedofauna and microorganisms transform all this necromass into elementary bricks that can be used by new generations of living beings. We have two kinds of soil: a well-known one under plants, and a less visible one in the animals’ bellies (even in our human belly), because animals also need to digest the collected food. I don't know to what extent DNA (along with everything else) is disassembled in a decomposition process that takes place in the soil under plants or inside animals, but...’

‘Interesting this double soil concept’, he underlined. ‘I have always thought that small pieces of DNA could reach new generations of living beings indirectly, outside of the reproductive pathway that we know; that DNA exist outside cells, in the environment or stored in organic matter, like the words of a vocabulary of several successive generations; potentially, such a process could explain the observed co-evolution (Khakhina 1992,Lovelock and Margulis 1974,Sapp 1994), the not-coding DNA, and DNA that belongs to organisms other than the one that houses it (Ang 2021)’.

‘How exciting!’, my silent reflection. ‘Not the sexually transmitted DNA, but the one of a co-inhabiting community of livings, the whole ecosystem interacting DNA, even the one flowing through the soil, in digestive and confined processes of death and recycling - at the ecosystem and

individual scale (are the ones we call “mitosis” or “meiosis” original, miniature recycling processes?), a DNA that evolves and combines with the one sexually transmitted, and branches out within the limits imposed by the environment (and today more than ever by man), fluid, dynamic and unpredictable. When the beaks of Darwin's finches come to mind, we don't give due importance to the joint evolution of plant seeds and insectivore prey. Let’s say that species evolve with respect for the finality acquired on a higher scale, which is that of the ecosystem that contains them, and within a hierarchy of systems contained one in the other, from the cell to the universe. Just magical (Fig. 2).

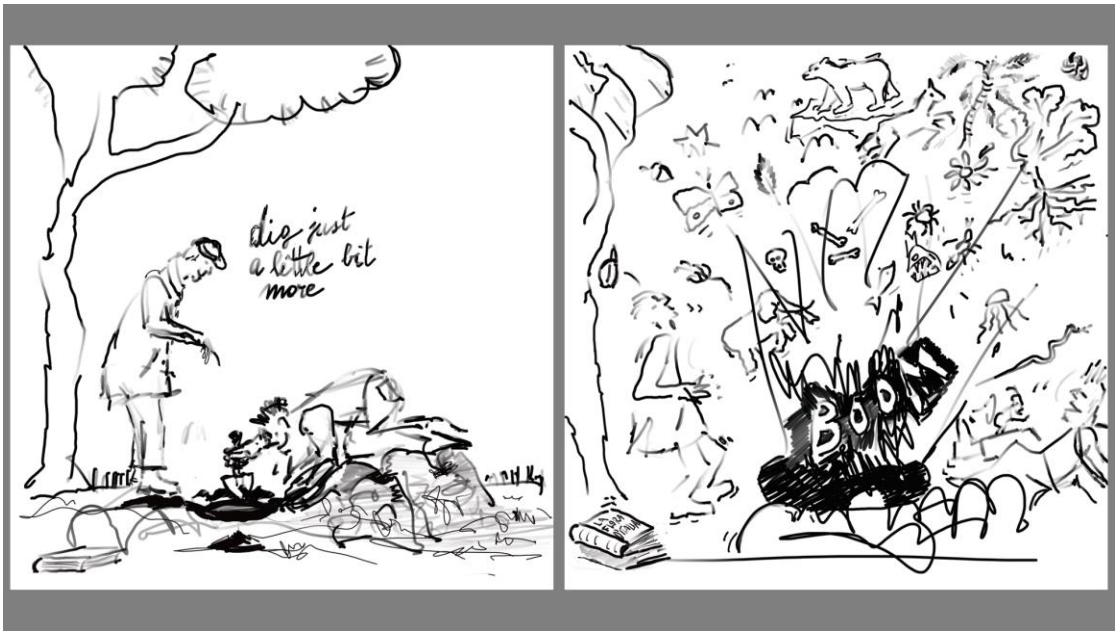

Fig. 2. Evolution takes place in a kind of soil. Life and death belong to this same cyclical process which we call evolution; the first (production phase of new functional structures) needs the second (decomposition phase of old machinery, to recycle dead branches no longer adapted to new present time and environment). The two phases must be able to occur at different scales, cyclically and continuously. At the beginning the building blocks were small systems (lumps of particles, then quarks); more recently the units of such material structures became complex, labile and malleable; this made them easier to use in “cells” of even more complex new systems. New systems grew to higher-scale and cyclical collapsed (major mass crises). All this still happens today. On Plante Earth, this process is more visible in the soil (or in soil-like processes), where life and death pass the baton.

In fact, there are published works demonstrating the action of parts of DNA in the soil, with important repercussions on biological evolution (Kooch et al. 2022,Mazzoleni et al. 2015,Zheng et al. 2022). Soil microorganisms of natural environments may have a lower biodiversity index and be phylogenetically more connected to each other than those found in equivalent more anthropized environments (Mo et al. 2022) (Fig. 3). In a just published article, Klaes et al. (Klaes et al. 2023) show an organo-mineral aggregate of the A horizon of an Andosol magnified to the micrometric scale and explain its functioning with graphs that speak for themselves: the flows of minerals and organic matter are interdependent and connected to the biological activity which

varies with the rainy periods. Each aggregate is a miniature soil. Presented in Preprint (Martins et al. 2023), the microbial biodiversity outside and inside the soil would be functionally connected; N addition significantly reduced soil bacterial diversity (−2.3%), and such effect was significant in cropland rather than grassland and forest (Wang et al. 2023). Polyspecific meadows make better use of environmental resources than monospecific's (Moeneclaey et al. 2022). An exogenous species can generate a new ecosystem (Gentili et al. 2022). The process can also be purposely designed to build up what needs to be destroyed, leaving behind only what is needed to continue in the right direction (Ameisen 1999). Like other species, Homo sapiens may be just a link in the chain.

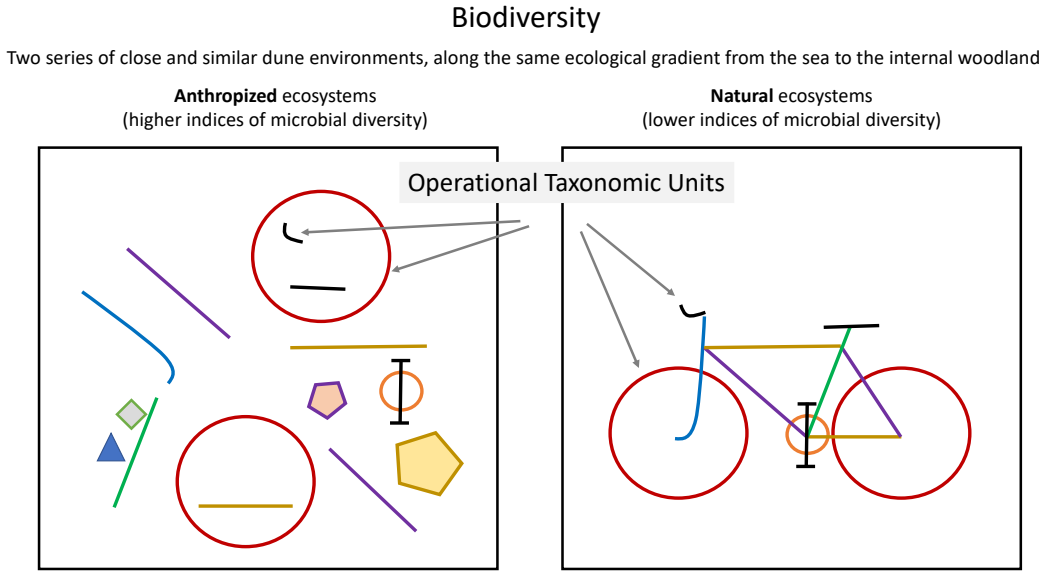

Figure 3. From (Mo et al. 2022), with permission. Higher biodiversity may be less functional. In Porto Caleri, a natural area, there were fewer taxonomic units among the soil microorganisms than in an equivalent near anthropized ecosystem, but which recorded a higher phylogenetic signal. The important thing in biodiversity lies in the functional aspect, not just in the number. Even if necessarily provisional finality (which may be behind a stronger phylogeny), few but coordinated living beings is better than many uncoordinated and running in bulk each on their own. These aspects recall the very important precursor works of Lovelock and Margulis (Lovelock 1990,Lovelock and Margulis 1974,Margulis 1998), certainly.

We arrived at the site of the Castelporziano estate where the forest changed from ash wood with laurel (*Laurus nobilis*) with fresh soil, to oak wood with Turkey (*Quercus cerris*) and Frainetto (*Quercus frainetto*) oaks with drier and filtering soil. The passage materialized along a band that meandered between the two types of forest. We dug holes: the ash wood grew on a Mull (without OH horizon) resting on an impermeable clay layer (Bt horizon); in the oak wood we found an Amphi (with OH horizon above an A horizon), in contact with a sandy and filtering horizon (BC). The ecosystem changed altogether, in just a few meters.

While we were eating a sandwich at the end of the excursion, I also asked him 'How did you manage to put together all the Flora of Italy (Guarino et al. 2017a, 2019, 2017b, 2018)?'

‘My house was full of lists of plants’, he answered frankly. ‘In small notebooks, on the bedside table, at the edge of the stairs, on each library, everywhere. Census years. And a network of collaborators. It amused me, it has been my life. A struggle that I don't tell you to order everything, monstrous, and we're not done yet’.

Smiling, like a hero.

Author Contributions

The author only added references to the dialogue he remembers, to simulate the style of a scientific communication.

Conflict of Interest:

There is no conflict of interest.

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