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Kindergarten Children's Perception about the Ecological Roles of Living Organisms

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Abstract: Young children will inherit the biosphere; therefore, it is crucial that they recognize the importance of all living organisms based on their intrinsic value and ecosystem function, not only on their "cuteness". However, children's knowledge about the interdependence among organisms has been little investigated. We interviewed 56 kindergarten children (5–6 years old) in Norway. The aim of the study was to investigate their perception of the importance for nature of six organisms, representing different trophic levels of food webs (producers, consumers, decomposers) and providing different ecosystem services (production, decomposition, and pollination). There was no difference in ranking between sexes or between ordinary and farm-based kindergartens. Bumblebees and earthworms were perceived as the most important organisms, followed by squirrel, trees, and wolf. None of the children recognized the ecological role of mushrooms. Our results show that, although upon completing kindergarten many children had gained an early understanding of the role of different organisms in nature, they missed the importance of plants and fungi. Kindergarten children's "fungi blindness" might reflect a neglect of the public for this extremely important, diverse, and dominating taxon. We should therefore put more emphasis in raising awareness about the interdependence among trophic levels in food webs.

Keywords: ecocentrism; education for sustainability; environmental education; food web; fungi blindness; plant blindness; pollinators

1. Introduction

1.1. Importance of Learning about How Ecosystems Work

Humans, through global climate change, pollution, habitat destruction, overexploitation, and spread of invasive species, are changing the composition of biological communities by directly or indirectly increasing the rate of species extinction [1,2]. According to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), up to 1 million plant and animal species could face extinction, many in the time span of few decades, because of human activities, unless action is taken to reduce the intensity of drivers of biodiversity loss [2]. These modifications in local and global biodiversity are also a consequence of the current socioeconomic model based on growth and the global shift of traditional diets towards diets richer in refined sugars, refined fats, oils, and meats [3,4]. All these human related factors, leading to biodiversity loss, alter the ecosystems and threaten ecosystem services, defined by the Millennium Ecosystem Assessment [5] as "the benefits people derive from ecosystems". These are divided in provisioning services (such as food, fiber, fuel), cultural services (such as recreational and aesthetic values), supporting services (such as nutrients and

water cycling), and regulating services (such as pollination, climate regulation, and pest control) [5]. Thus, biodiversity loss driven by human activities is not only unethical because it ignores the intrinsic value of species and ecosystems [6], but is also affecting ecosystem services and, in turn, human well-being [5].

The aim of environmental education (EE), in addition to fostering an understanding of the environment and environmental problems and motivation to deal with them, is to ensure that individuals understand that humans are part of the biosphere and have the capacity to change the interrelationships between organisms [7]. EE has in the last decades progressively shifted towards education for sustainable development (ESD), which relies on anthropocentric values and is less focused on the intrinsic value of nature and the moral obligation for caring about other species or ecosystems independently from the "benefits for people" e.g., [8,9].

According to EE, care for nature and knowledge about the natural environment should be fostered in humans from early childhood [10]. Learning about ecology and biodiversity is thus crucial for both the EE and ESD frameworks, since it is the first step to foster care and understand the environment and it is also necessary to motivate and empower citizens to take action for sustainable development [11,12]. Accordingly, it is essential for humanity to have a deep knowledge about the interdependence and ecological role of organisms, in order to effectively protect nature and conserve it for future generations [13].Therefore the question about children's knowledge of the ecological relations among living things is fundamental for practices in early science education [14].

1.2. What is the Role of Different Organisms in Food Webs?

Ranking the importance of a given species in an ecosystem should take into account extinction risks and potential cascade effects, where the first ranked species are the ones that trigger larger extinction cascades [15].

The fundamentals of all life on the planet are the "producers", which synthesize carbohydrates from inorganic matter. Producers are primarily plants, algae, and lichens that, through photosynthesis, make their own food and release oxygen by using sunlight, water, and carbon dioxide, and are therefore the first step of the food webs. The organisms that cannot produce their own food are the "consumers". Consumers can either feed exclusively on plants (herbivores or first grade consumers) or feed on other consumers (carnivores), or on both producers and consumers (omnivores). Consumers can also provide different ecosystem services, such as pollination, seeds dispersal, and population regulation. However, consumers cannot exist without producers. Finally, "decomposers", such as for example bacteria, earthworms, and fungi, make available again the nutrients in soil and water, after consumers' and producers' death (Figure 1).

From an anthropocentric and utilitarian point of view, plants are some of the most important organisms on the planet, because they provide oxygen, food, water cycling, climate mitigation, medicines, fibers, and timber. On the other hand, the phenomenon of "plant blindness" i.e., the general lack of interest for plants, is a well-known challenge when teaching plant biology or trying to raise awareness towards the conservation of plant species [16]. In fact, the anthropocentric tendency to rank plants as inferior to animals also encompasses invertebrates, which constitutes 99% of animal terrestrial diversity [17]. Nevertheless, although plants can produce carbohydrates by using carbon dioxide, water, and solar light, they also need different nutrients, e.g., nitrogen, potassium, phosphorous, and therefore rely on decomposers to transfer nutrients back to soil and water.

Fungi are the main decomposers of biomass in terrestrial ecosystems, and without them waste would be prevalent. They can have several types of interactions with plants, from parasitic to mutualistic, such as in the mycorrhizae. Without fungi, it is unlikely that plants would have colonized terrestrial environments. Although research on fungi has traditionally focused on areas where they damage plants, and on their use in the food and brewing industry, recent studies have revealed their potential in helping humans addressing major environmental challenges. In fact, the decomposition of wood from plants by fungi is very important for the cycle of carbon. This is because in some types of

mycorrhizae, fungi compete with microbes in soil and reduce the amount of carbon dioxide that is released back to the atmosphere by decomposition after plants death [18]; thus, resulting in up to 67% more carbon sequestrated in soil [19]. Moreover, adding microbial fungi enzymes to detergents can allow washing laundry at lower temperatures, thus reducing carbon dioxide emissions [20], and fungi can be used to decompose persistent and highly toxic pollutant from the environment [21].

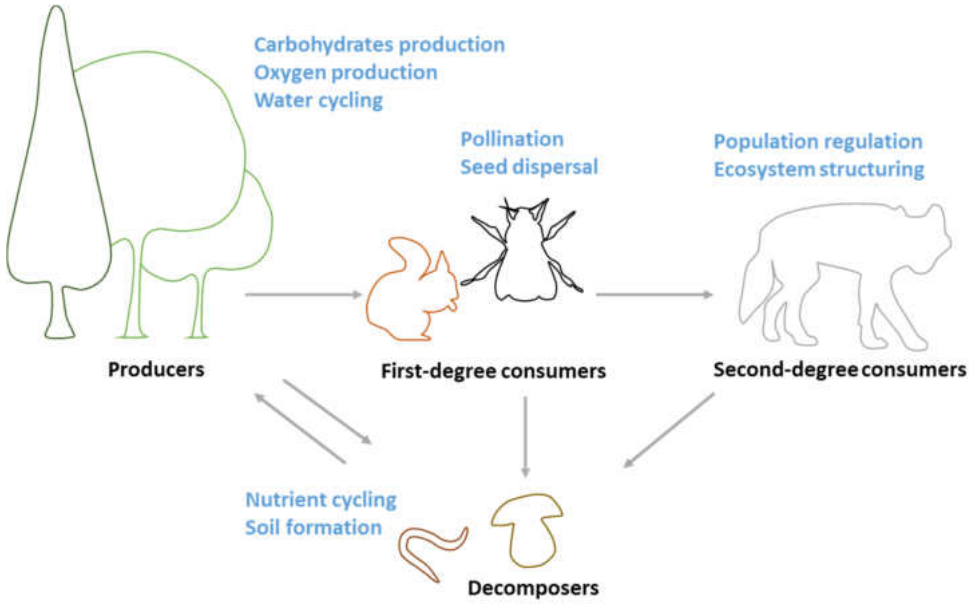

Figure 1. Simplified version of a food web (same examples as in children interviews). The grey arrows show the direction in which energy flows through the ecosystem. In blue, some of the ecosystem services provided by the different trophic levels are shown.

Earthworms also play a crucial role in nutrient cycling and have both direct effects on soil quality and indirect effects mediated through microorganisms in soil [22]. They build tunnels and burrows, changing soil structure, and thus making habitats for other organisms (ecosystem engineers) [23]. They enhance availability of soil nutrient, and therefore indirectly promote plant growth [22].

First-degree consumers or herbivores encompasses several taxa, both invertebrates and vertebrates. They are also exploited by humans as food and for other goods, such as fibers, and can therefore be perceived either as resources to protect, or as pests, when they damage the crops. In general, both television and school curricula over-emphasize herbivore vertebrates [17], especially, birds, rodents, and charismatic large ungulates. From an ecosystem perspective, herbivores are not the fundamentals of life, although many plants rely on herbivores for pollination and seed dispersal.

Almost ninety percent of cultivated plants pollinate with the help of insects [24]. Both wild and domestic pollinating insects are dramatically declining [25], due to several factors such as global warming [26], changes in land use [27], and pesticides used in agriculture [28]. Scientists have long tried to raise awareness about the importance of bees for the planet, and in general, the attitude of people towards the conservation of bees is more positive than it could be expected for an insect that can sting [29].

Humans often perceive large- and medium-sized predators as pests, competitors, or threats. However, they can also appreciate them for their aesthetic value and charisma [30]. For this reason, top predators are often used to promote the conservation of ecosystems (flagships species) [31]. However, carnivores have also an important role in structuring ecosystems and regulating populations of herbivores [32]. For example, in Norway, wolves, *Canis lupus*, occur in such low numbers that they are almost functionally extinct, and hunters try to replace, at least partially, large carnivores' role in regulating populations of large herbivores (https://rovdata.no).

Nevertheless, evaluating the importance of species from an anthropocentric perspective is challenging and will always remain incomplete, because of limited information on species interaction and unexpected benefits for humans [33].

1.3. Literature Review

Research on young children's knowledge about ecology has mainly focused on children's ability to identify species and classify taxa [12,34–37], on children's knowledge about the impact of human actions on the environment [38–44], and on traditional knowledge of ecology (local ecological knowledge) in different ethnic groups [45–47]. A number of studies have also investigated children's attitudes towards animals [48–51]. However, there has been little research investigating children's perception of the importance of organisms in ecosystems.

Leach et al. [52] investigated children's idea about the interdependency of organisms in northern England. They found that younger children were focusing more on individual organisms rather than populations during interviews. Moreover, many of them thought that organisms were dependent on human beings to supply them with their needs, suggesting that they were not familiar with natural environments. Palmer et al. [53] investigated children's knowledge about rainforest and polar environments in British, Slovenian, and Greek children. They found that four-year-old children could identify common vertebrates that inhabit these environments and a good proportion of them could predict the effects environmental changes such as cutting the trees or smelting of ice on these habitats. A study on French schoolchildren [54] found that their identifying skills for local species were worse than that for exotic species. Moreover, they considered exotic and charismatic large mammals, such as the giant panda, *Ailuropoda melanoleuca* and the polar bear, *Ursus maritimus*, as deserving priority protection with respect to local biodiversity. Similarly, children in Balearic Islands (Spain) revealed poor knowledge of the local fauna compared to exotic vertebrates [55]. A study on UK children's perceptions of biodiversity in rainforest environments based on children's drawings of an "ideal rainforest", found that children over-represented (relative to biomass) the importance of mammals, birds, and reptiles and under-represented social insects and earthworms [56].

1.4. Early Childhood Education in Norway

In Norway, more than 90% of children (age one to five years) are in kindergarten [57]. The Norwegian curriculum, named Framework Plan for Kindergartens [58], says, among the other aims, that kindergartens should through engagement with nature, the environment, and outdoor experiences, enable children to:

- Learn about nature and sustainable development;
- Gain an early understanding of nature conservation;
- Learn about animals and animal life.

As part of Norwegian tradition, all kindergartens spend a considerable amount of time outdoors, both in the kindergarten playground [59], and in the nearby nature [60]. Therefore, children have many occasions to experience the local biodiversity. Moreover, some kindergartens have specialized in areas such as farming, outdoor life, nature, and sports. There are no official guidelines for the formal content of such "profiles", and each kindergarten defines its own. Children in farm kindergartens are involved in cultivating vegetables and taking care of farm animals, whereas children in nature and outdoor kindergartens spend all or most of the day outdoors in a natural environment [60]. For more information on Norwegian kindergartens, see also [39].

1.5. Purpose of the Study

Given the vital role of ecological literacy for future generations and early childhood education, we investigated children's perception (meaning the way in which something is regarded, understood, or interpreted [61]) of the importance for nature of six organisms and their ideas about them. These were

chosen as being part of the local fauna, representing different trophic levels of the food web (producers, first- and second-order consumers, decomposers), and providing different ecosystem services (e.g., oxygen and carbohydrates production, decomposition, and pollination).

Our study attempted to answer the following research questions:

1. How do young children rank the (relative) importance of living organisms?
2. Are there differences in ranking between sexes?
3. Are there differences in ranking between kindergarten profiles (ordinary vs. farm)?
4. Do kindergarten children recognize the interdependence between living organisms?

2. Materials and Method

2.1. Ethical Considerations

The study was approved by the Norwegian Center for Research Data. The kindergartens and children's parents filled out a written informed consent upon participation. All data were anonymized; children's participation was voluntary and could be discontinued at any time without providing a reason. During the interview, we were careful not to give the children the impression that they had answered "wrongly" or that we expected them to know more, if they could not answer.

2.2. Participating Kindergartens

Between January and May 2019, we invited 33 kindergartens from the same county in Norway (Trøndelag) to participate in the study. Seven of these were 'nature', 6 were 'farm-based', and 20 were "ordinary" kindergartens. Of these 33 kindergartens, 9 accepted the invitation (27%), 7 declined (21%), and 17 did not respond (52%). Among the eight participating kindergartens (Table 1), three had a farm profile and five did not have any specific profile, but were eco-certified with a "Green Flag", which is a certification for schools and kindergartens showing that they prioritize the environment in teaching and daily activities (for more information see [39]).

Table 1. Overview of children and kindergartens participating in the study.

Category	Normal (Eco-Certified)	Farm	Total
Kindergartens	5	3	8
Children	37	19	56
Girls	19	9	28
Boys	18	10	28

Fifty-six children between five and six years old who were in their final year of kindergarten participated in this study. Of these, 28 were girls (19 in ordinary and 9 in farm kindergarten) and 28 were boys (18 in ordinary and 10 in farm kindergarten). The distance between the kindergartens and the nearest forested area was on average 200 m (range of 100–600 m).

2.3. Semi-Structured Interviews of the Children

Data were collected from children by means of a semi-structured interview based on open-ended questions and with the aid of pictures showing six different organisms, that we expected to be familiar to Norwegian children. These organisms (Figures 1 and 2) represent different stages of the food chain (producer, first-level and second-level consumers, decomposer) and provide different ecosystem services (e.g., oxygen production, decomposition, and pollination).

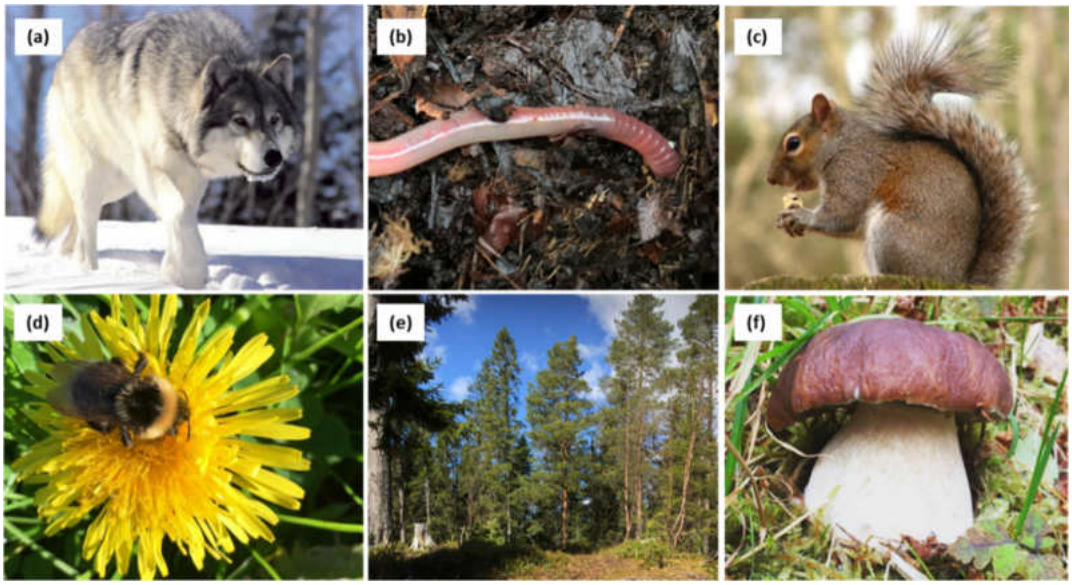

Figure 2. Set of six pictures shown to 56 kindergarten children (age 5–6 years old) in June 2019 in Norway in the context of semi-structured interviews to explore their ideas about the relative importance of different living organisms. (**a**) From Wikipedia: https://commons.wikimedia.org/wiki/File:Canis_lupus_265b.jpg, (**b**,**d**–**f**) author: Claudia Melis, (**c**) From the website Freestockphotos: http://www.freestockphotos.biz/stockphoto/10027.

We interviewed the children individually in June 2019. The interviews were audio recorded upon written permission obtained by the parents and consent obtained by the children before the interview took place. Four children were interviewed in the presence of their teacher upon request. Each interview took about 15 minutes, was conducted in Norwegian, and also included questions about the children's understanding of the environmental component of sustainability, which have been analyzed separately [39].

2.4. Semi-Structured Interviews with Six Photos—Which of These Living Organisms is Most Important for Nature?

The interview technique and duration were tested on four children, aged five to six years at an ordinary kindergarten, which was not included in the main dataset [39].

During the interview, we showed children six pictures representing different living organisms (Figure 2). These were a wolf (Figure 2a), an earthworm, *Lumbricus terrestris* (Figure 2b), a squirrel, *Sciurus* sp. (Figure 2c), a bumblebee, *Bombus* sp., feeding on a dandelion, *Taraxacum* sp. (Figure 2d), some trees (Figure 2e), and a (comestible) mushroom, *Boletus edulis* (Figure 2f). We asked the name of the organisms when we presented them (in a random order) to the children and then asked which of the organisms they thought was most important for nature. If the children were insecure about the meaning of the question, we reformulated it, asking which of these organisms they though would cause most damage if it disappeared from nature. We also specified that there was no right answer, but we were interested in their ideas and they could rank them as they wished. They could give the same rank to several, or rank all of them from one to six. After they had ranked the organisms, we asked why they had ranked them as they did.

2.5. Data and Statistical Analyses

For each of the six pictures, we first noted whether the children recognized the organism on the picture. We then wrote down the ranking and the explanations that the children provided for their ranking. After removing two children who answered, "I don't know", we had 54 interviews left. These interviews were used in the qualitative analyses. To obtain a measure of the overall perceived

importance of an organism, we calculated its average ranking. To avoid overestimating the rank, we removed the cases where the children ranked more than three organisms as equally important. This process left us with 46 rankings, were the six organisms were ranked from one to six (1,2,3,4,5,6), from one to five (1,2,3,4,5,5), or from one to four (1,2,3,4,4,4).

To provide a general picture of the ranking data, descriptive statistics were calculated using the Probability Models for Ranking Data package *pmr* [62] in R [63]. We used a multidimensional preference analysis (*mdpref*) to display in a 2D plot the relationship between individual children and their ranking for each organism. The organisms were labeled with consecutive numbers 1–6, while the children were presented as vectors pointing from the origin to their most preferred items. Finally, we tested for differences in ranking between males and females and between farm and ordinary kindergartens by means of Chi-square tests, where the significance value was set at $p < 0.05$.

3. Results

3.1. Ranking of the Organisms

Most of the children ranked all the six living organisms in order of perceived importance. Only 1 child of 54 (2%) said that all the six organisms were equally important for nature, whereas six children ranked only one or two organisms. Overall, bumblebee was ranked at the first place, followed by earthworm, squirrel, trees, wolf, and mushroom. The number of times that each organism was ranked at the first three places and its average ranking are shown in Figure 3.

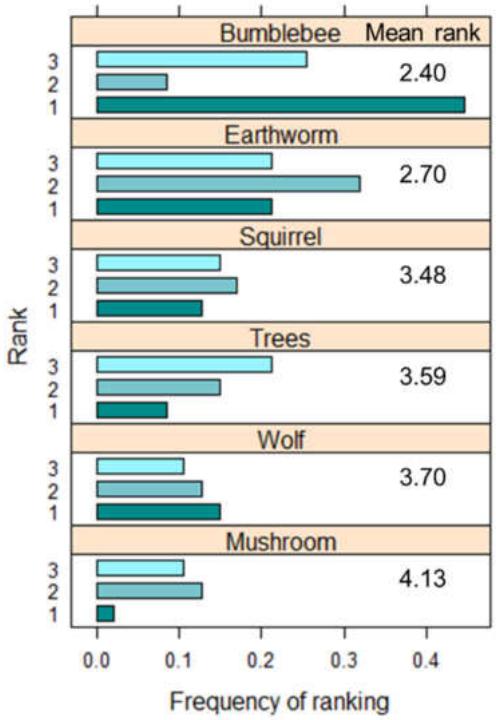

Figure 3. Frequency of six living organisms being ranked as first, second, or third for importance by 47 kindergarten children (age 5–6 years old) in June 2019 in Norway.

A multidimensional ranking of importance given by the 47 kindergarten children is presented in Figure 4. The 2-D plot explained almost 50% of the variance. There was no significant difference in ranking between males and females (Chi-squared = 16.029, df = 35, $p = 0.997$) and between farm-based and ordinary kindergartens (Chi-squared = 42.114, df = 35, $p = 0.190$).

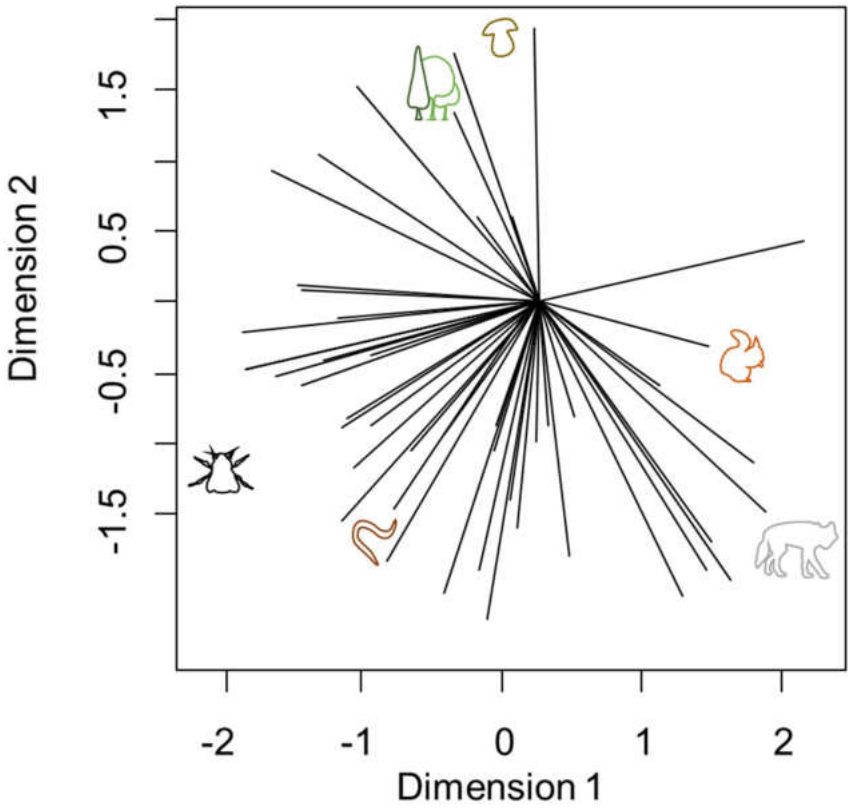

Figure 4. Multidimensional ranking of importance given by 47 kindergarten children (age 5–6 years old) to six living organisms in June 2019, in Norway. The 2D plot explains around 49% of the total variance. The children are represented by vectors pointing from the origin to their highest-ranked organisms. The first dimension can be interpreted as the overall importance of the six organisms. The leftmost (bumblebee) is the most important and the rightmost (wolf) is the least important organism. The second dimension can be interpreted as the overall variance of the six items. The bottommost item (wolf) has the largest variance, and the topmost item (mushroom) has the second largest variance among the six organisms.

3.2. Children Ideas about the Importance of the Six Organisms for Nature

In about one-third of the cases, either the children could not explain why they had ranked an organism as they did (18%), or they provided explanations only for the first ranked organisms (11%).

The bumblebee was correctly identified by 42% of the children, whereas it was identified as "bee" by 28% and as "wasp" by 4% of the children. In 37% of the cases, the explanation for the importance of bumblebees was that they help with plant pollination. The children said for example, "The bumblebee helps with pollination; they put the pollen from one flower to another". Alternatively, they could give a less detailed explanation, such as for example "The bumblebee helps the flowers and then we get food". In 28% of the cases, the explanation for the importance of bumblebee (often identified as "bee") was that they produce honey. A child said for example, "The bees make honey for us, so we don't get a sore throat". Only one child (2%) negatively depicted bumblebees, because they can sting.

All the children identified the earthworm correctly. In 54% of the cases, the children explained the importance of earthworms for nature because they improve soil quality for plants. For example, they said, "The earthworm makes the soil good and nice for plants", or "It is good to have earthworms in your flowerbed because they make tunnels and the air can get in". The children also showed a quite detailed level of knowledge by saying that the earthworms eat the soil, and their litter is good for the plants. Three children (6%) said that earthworms are sweet and cute. Only one child (2%) said that the earthworms are not important, whereas 9% stated earthworms' importance, but could not remember why they were important for nature.

All the children correctly identified the squirrel. Two children explained the importance of squirrels because of their kindness and cuteness and the rest mentioned the fact that squirrels collect nuts, have many nuts, or even "can make nuts for humans". A child said, "It is nice to see the squirrel in nature".

Although trees were generally not ranked amongst the most important organisms for nature, 33% of the children gave a correct description of the ecological role of trees. They for examples said that "The forest is important, because is there that the animals live; wolves are found in the forest.", "The forest is part of nature and therefore there are so many trees, because then we have energy and air", and "The tree makes it possible for us to breathe". One child said, "The forest collects the water". Nine percent of the children mentioned the provisioning value of the forest in providing wood and food for humans; one child said, for example "I like trees because is fun to make a bow and arrow".

All the children recognized the picture of the wolf. In nine percent of the cases, the explanation for the importance of the wolf was that it is "cool" or that the child "loved wolves". In four percent of the cases, the children negatively depicted the wolf, because it can eat humans. For example, a child said, "It is not very clever if you go for a walk in the forest and can be eaten by a wolf". Whereas in four percent of the cases, the children explained the ecological role of the wolf, such as "The wolf is a predator which eats its prey" or "Wolves can be good for nature".

The mushroom was mainly described as edible (24%) or as not important, because they are not edible (7%). Several children underlined the risk of eating poisonous mushrooms, for example, they said, "It is not good to pick mushrooms if you find one that is not edible". Several children stated that mushrooms "do nothing, they are just there" (7%). None of the children recognized the ecological role of mushrooms in nutrients cycling.

4. Discussion

Most of the children in our sample were able to rank the six organisms in order of perceived importance for nature and provided relevant explanations for their ranking choices. Given the young age of the respondents, we would have expected them to rank the organisms mainly according to their popularity and "cute effect" [64]. Instead, children ranked two invertebrates (bumblebees and earthworms) as the most important organisms for nature. This result confirms our impression that the children understood well the question and did not rank the organisms based on their "preference", but tried to rank them according to their knowledge on the role these organisms have in nature.

For example, an American survey study from 1993 on attitude towards invertebrates found that adults mostly expressed feelings of aversion, or fear, toward invertebrates, particularly insects [65]. Moreover, in the American study, although the public was more positive towards taxa with aesthetic value (such as butterflies) or practical value (such as bees), almost 70% of adults agreed with the statement "Insects visiting flowers are unnecessary in modern fruit farming" [65]. Conversely, the children interviewed in our study, when providing explanations for the importance of invertebrates, addressed crucial ecosystem services such as pollination (37%) and soil formation (54%).

It is also interesting that more than 40% of the children correctly identified the bumblebee and not only the insect group "bees", which are generally well known due to their association with a utilitarian value (honey production) [29]. The awareness of bumblebees as pollinator insects was much higher than previously reported for children. For example, in a German study on attitudes towards bees, almost 60% of primary school students mentioned products like honey and wax as reason for protecting bees and only 8% talked about pollination [29]. Several of our interviewed children were also able to link pollination with food production for human consumption. This rather deep knowledge about ecosystem services provided by bumblebees is probably consequence of increased focus on pollinators decline worldwide [25]. Moreover, in Norway, a National Pollinator Strategy has been implemented since 2014 [66], with, amongst others, the aim to inform kindergartens and schools about pollinator-friendly actions and pollination as an ecosystem service. This supports the finding of Kellert [51] of a positive association between education and appreciation, concern, and knowledge of

biological diversity, suggesting that educational programs may help recognizing the positive values of invertebrates.

The earthworm was also ranked amongst the most important organisms, although "worms" have been previously associated with negative attitudes and little protection concern [67]. For example, in a study conducted on kindergarten children in Italy, earthworms were ranked as the least preferred, in the same cluster as spiders, mosquitos, and bees [48]. The children interviewed in our study not only addressed the effect of earthworms on soil quality, but also mentioned the fact that they make tunnels, thus increasing aeration of the soil.

The squirrel was rather highly ranked (at third place) for importance. However, the children explained its importance mostly in connection to its aesthetic value. When we asked children what the squirrel did, they did not bring up ecosystem services provided by squirrels or their role in ecosystem as, for example, prey for carnivores. They, however, said that squirrels "collect nuts" and "have many nuts". This connection between squirrels and nuts might arise from the fact that all kindergarten children in Norway have heard the song "Nøtteliten" [68], which is about a young squirrel called "Little nut" who "collects many nice nuts and has his own nutcracker". Moreover, in a popular media franchise for children named "Ice Age" [69], the character named "Scrat" is a Paleolithic squirrel obsessed by nuts and always represented in the act to trying to bury or fetch one. On the other hand, we cannot exclude that some of the children were thinking about the fact that squirrels scatterhoard, i.e., bury nuts at dispersed sites in their home ranges to consume them during winter, and in this way, they contribute to seed dispersal [70]. In a Norwegian study about children and adolescent species preferences, the squirrel was ranked at third place after dog and cat [67], so it is not surprising that it was highly ranked for importance, given its popularity and cuteness. This suggests that the ecosystem service provided by squirrels is not so obvious to children as its aesthetic value.

Trees, although not ranked as the most important organisms, were recognized by one-third of the children for their role in producing oxygen, timber, and for providing a habitat for many animal species. One child even addressed the ecosystem service provided by the forest in recycling the water.

The phenomenon of "plant blindness", i.e., not noticing plants despite their crucial role in ecosystems, has been addressed by several studies, e.g., [16,17,71]. The perceived lack of interest by children (and adults) for plants is mainly due to their absence of detectable movements [72], and it is reinforced by teachers, who have a tendency to focus on animals rather than plants [73,74]. For example, in an American study, 21% of the children did not consider trees as being part of nature [75]. In a study conducted in Greece, one-third of the school children did not mention plants when asked to list five living things [74].

The wolf was, on average, given a rather low rank, mostly due to being perceived as a threat for other animals and humans. On the other hand, 15% of the children ranked it at first place according to a sort of "Darth Vader effect", because it is scary and stronger than the other organisms. Some of the children also said that wolves are similar to dogs and meant that dogs were the most important. Nevertheless, wolves are charismatic animals that have entered our families disguised as "dogs". Dogs occupy a very special place in our human–animal relationships, and in a Norwegian study about children and adolescent species preferences, the dog was ranked at first place [67]. Thus, it is likely that the children who ranked the wolf at first place were thinking mostly about "importance" in term of "hierarchy" and "strength", or in terms of affection value, rather than ecosystem role. A few children seemed to be aware of the ecological role of wolf in population regulation and structuring [76] and meant that wolves have a positive role in nature as predators.

The mushroom was ranked lowest and its role was only described in terms of potential edibility or as a threat (if poisonous). None of the children addressed the ecological role of fungi in decomposition of organic matter and nutrients cycling. This "fungi blindness" might reflect a general neglect of the public for this extremely diverse and dominating taxonomic group. Nevertheless, adults also largely ignore fungi and see them as interesting only in function of the palatability of some of their fruit bodies. In fact, wild edible mushrooms are collected for food in more than 80 countries [77]. Commercial

harvesting of mushrooms is especially important in developing countries and wild mushrooms can also have medicinal proprieties [77]. In Norway, although nobody has died of mushroom poisoning in the last 25 years, ca. 200 people are hospitalized each year with serious symptoms after they consumed poisonous mushrooms [78]. As consequence, children are familiar with the potential threat coming from mushrooms, and it is not surprising that kindergartens' staff does not normally encourage them in exploring the diversity of this taxon.

An unexpected result of our study is that we did not find any difference in ranking between males and females. A considerable number of studies on attitudes towards animals found differences between genders, which might suggest that gender influences the way we perceive animals. For example, a Norwegian study found that adult females expressed greater fear towards large carnivores than males [79]. An Italian study on kindergarten children found that boys appreciated dangerous animals and invertebrates more than girls [48]. Conversely, a Czech study on kindergarten children did not find gender difference in fear towards animals [49], suggesting that these differences might arise later in life.

The fact that we could not detect any differences in ranking between farm and "ordinary" kindergartens suggests that both kindergarten types have a similar focus and put similar emphasis in teaching ecology, which is consistent both with the directions given in the Framework Plan for Kindergartens in Norway [58] and with the Scandinavian tradition for outdoor life [80]. Moreover, all the kindergartens included in our study are located nearby nature and took trips to nature at least once a week [39].

One child said that all the organisms were equally important in nature. Our research questions focused on the instrumental view of nature and we did not investigate whether the children recognized the intrinsic value of nature. In addition, our question was leading them in the opposite direction, by asking to rank living organisms. Nevertheless, this answer is very interesting, because it reflects an "ecocentric" view of nature, where all living organisms have intrinsic value and are necessary for the well-functioning and stability of ecosystems [81]. It is true that nature would collapse without mushroom or plants, whereas life could continue to exist without consumers. However, human thriving depends on the stability of renewable resources and on the predictability of seasons and weather, which can occur only in healthy and complex ecosystems with a rich biodiversity [81,82].

Limitations of the Study

It is important to bear in mind that the children who could not rank the organisms or did not provide an explanation for their ranking might have not felt confident in presence of strangers, or might have been afraid of giving a "wrong" answer. Besides, our set of pictures might have influenced the answers given by the children. For example, the picture of the bumblebee showed it in the process of feeding on a dandelion and might have suggested the ecosystem function provided by these insects. Moreover, in our food web, there were some inconsistencies, because we tried to select organisms that were familiar to the children. For example, squirrels or bumblebee represented first-grade consumers, but wolves do not (normally) eat these species. The wolf itself is not a widespread predator in Norway, although it is often present in fairytales and movies. Finally, we showed a picture of an edible mushroom, which might have suggested a reason for the importance of mushrooms.

5. Conclusions

The kindergarten children interviewed in our study showed an early understanding of the role of different organisms in nature and were able of rather sophisticated thinking about ecosystem functioning. This suggests that even children at this young age can appreciate the complexity of interrelationships of organisms in nature. The finding that the ecological roles of plants and fungi are under-recognized by the kindergarten children of our study raises the question of whether we should adjust education programs and put more emphasis on these neglected, yet fundamental, organisms. Moreover, as ecosystems' stability is threatened by humans activities, we could adopt a more ecocentric

approach when talking about ecology in kindergartens and schools, and we should try to communicate that all organisms have intrinsic value, beside the fact that they are necessary for the well-functioning of ecosystems, and, in turn, human well-being.

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