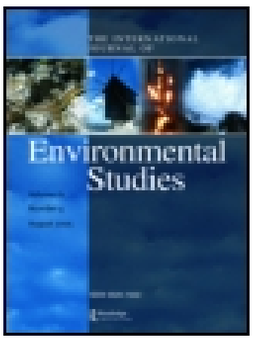

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Assessment of pre-service teachers' knowledge of the impact of livestock production on global warming: a comparative study between Portugal and Spain

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In this study we assess how higher education students (pre-service teachers) value and understand the impact of livestock production on global warming. We used a questionnaire with 91 students from a Portuguese institution and 111 from a Spanish one. The students had to mention measures to fight global warming, to explain the relationship between livestock production and global warming and to rank the impact of this cause compared to others. The Portuguese students showed a better understanding of this issue. Even so, the majority of the students do not recognize the high impact of livestock on global warming and consider other causes more relevant.

Keywords: Pre-service teachers; Livestock production; Global warming

Introduction

The earth is facing a global warming problem caused by the increase of greenhouse gases (GHG) emissions in the atmosphere since the beginning of the Industrial Revolution. For instance, carbon dioxide (CO_2) concentrations have increased from 280 to 400 ppm, nearly 40% higher [1]. Other gases are also implicated, such as methane (CH_4), chlorofluorocarbons (CFCs), hydroflurocarbons (HFCs), perflurocarbons (PFCs), sulphur hexafluoride, nitrous oxide, ozone at tropospheric altitudes, and water vapour [2]. All these have increased their concentrations over the last decades. The reason for the main focus on carbon dioxide may be related to the common association of this gas with the use of fossil fuels. But a broader understanding of global warming is needed, including the contribution of methane to this phenomenon. In fact, this gas in the atmosphere has increased from about 750 ppb in pre-industrial times to over 1750 ppb nowadays, and this concentration is the highest in the last 650,000 years [3].

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Although this concentration is much lower than that of carbon dioxide, methane is much more efficient at absorbing and re-emitting heat owing to its global warming potential (GWP), 25 times greater than that of carbon dioxide. In fact, the impact of the different GHG must be evaluated, not only according to their percentage in the atmosphere but also their lifetime in the atmosphere and their effective capacity to absorb infrared radiation. Methane has not received the attention it deserves, since it traps heat better than carbon dioxide, but resides for a lesser period in the atmosphere [4].

Methane comes from several natural sources like wetlands, because of their biotic and abiotic conditions, termites, through their digestive process, and ocean microbes. But large amounts of this gas that are still capped by arctic permafrost can be released into the atmosphere in the future as a result of ice melting. A significant impact on climate can result from a small increment [1]. It is the increase of anthropogenic sources which determines this hypothetical release. These sources are fossil fuel production (33%), intensive livestock farming (27%), landfills and waste (16%), biomass burning (11%), rice agriculture (9%) and biofuels (4%). Together, the first two sources are responsible for 60% of all human methane emissions [5]. Among these sources we highlight livestock production, since it is related to matters which we shall examine in this paper, such as the consumption of meat and animal welfare.

Ruminant livestock (cattle, sheep, goats) release methane, especially through belching, as a result of feed fermentation in their rumens and microbial decomposition in manure [3,6].

A comparative study of the environmental hazards caused by beef, dairy, poultry, pork and eggs also reinforces the negative role of ruminant animals holding them to account for 80% of the impacts and this study states that livestock-based food production accounts for one fifth of global greenhouse gas emissions [7]. But other authors consider that an even higher percentage of methane is released – 37% – through livestock production [8], an impact even greater than that from the transport sector, usually identified as the main culprit in global warming. Goodland and Anhang take a similar view [9], recalling the frequent emphasis on fossil fuels (oil, natural gas and especially coal) in causing climate change. Yet, methane produced by the manure and respiratory system of cattle alone has an effect on global warming equivalent to that of 33 million motor vehicles.

Several factors are often omitted from reports on livestock production, such as those from the Food and Agriculture Organization, because their focus is methane and nitrous oxide emissions [9]. (i) Carbon dioxide emissions resulting from the respiratory system of animals are considered equivalent to those that are absorbed in photosynthesis, which is not correct owing to the decrease in plant biomass in forest areas. (ii) Many agricultural crops (especially corn) and traditional pastures are intended to feed livestock, contributing to the decrease in forest area and biodiversity. (iii) The number of animals existing in the world is underestimated. (iv) The gases used in refrigeration systems associated with meat and meat products are equally potent in their contribution to global warming. (v) All wastes from animal husbandry, when placed in landfills, incinerators and waterways, emit GHG. (vi) The production, distribution and packaging of animal products are also responsible for emissions of these same gases. (vii) The production of medication aimed to treat and prevent cattle diseases has the same effect.

Yet this analysis is controversial, since it highlights the negative impacts of livestock production without presenting detailed methodologies or clear scientific evidence, as Herrero et al. have noted [10]. And they also refer to the discrepancy between several studies related to the impact of livestock on global warming with a range that can go from 10 to 51% of the total GHG emissions.

The impact of livestock production on global warming, irrespective of discrepancies in numbers, has to be an object of our concern.

The present study

This study has the following main purposes:

(1) To identify priority measures advocated by pre-service basic school teachers in social and individual terms, to minimize the problem of global warming;
(2) to test their capacity to explain the contribution of livestock on global warming;
(3) to check how pre-service teachers evaluate the impact of livestock production on global warming when compared with other causes.

This study is relevant in several respects. Firstly, it is always useful to identify the mindsets and ideas of students in higher education, since it is a way to evaluate the efficacy of the educational system and of science communication efforts [11]. Secondly, the students considered in this study will become teachers and will have to teach the global warming issue, which is now part of the basic school curriculum in several countries. They must understand the impact of the different causes that contribute to this problem. And finally, the many research studies, concerning students from higher and other education and people in general, have focused on their conceptions about global warming erroneously related to other environmental issues, such as ozone depletion [12–16]. The confusion between global warming and ozone depletion has persisted over time even in those who have taken science courses [17]. Therefore, it is possible that pre-service teachers can also have other gaps, such as the one related to the impact of livestock on global warming.

The results obtained by Leiserowitz et al. [18] are a good basis for this supposition. The study was conducted in 2010 with 2030 American adults and, among various results, only 25% recognize methane as an important gas in global warming. Even knowing that the study was not specifically directed at students, it is a relevant indicator of the devaluation of methane in the perception of global warming. Several other studies with students of other age groups produced similar conclusions. Students identify carbon dioxide as a greenhouse gas but other gases, such as methane, water vapour or nitrous oxides are rarely mentioned [19–23].

Even so, the media can be the main source of global warming information [23]. If that is so, perhaps access in many countries to the documentary film *Cowspiracy*: The Sustainability Secret, directed by Kip Andersen and Keegan Kuhn, has contributed to a better understanding of the animal production impact. Research on the Internet yielded several reports of people who changed their diet after watching this film. There is no known reliable study relating the movie to the improvement of knowledge about the impact of livestock on global warming, particularly in Portugal and Spain where the present study was carried out.

Methodology

This study sought to achieve the aims already outlined in the previous section. It has a predominantly quantitative methodological approach, although some data have been analysed using qualitative methods.

Participants

There were 202 pre-service teachers in the study; 91 (89 females) from a Portuguese higher education institution and 111 (74 females) from a Spanish university, during the academic year 2014/2015. The average age of the groups was, respectively, 24.4 and

22.7 years old. Both institutions are concerned with teacher education for the first six years of schooling (children aged from 6 to 12).

The institutions were chosen on the basis of their importance in teacher training courses in both countries, and because they are the workplaces of the research team. This proximity can help the dissemination of results and influence possible changes in teacher training courses.

We considered that the formal approach to global warming could help the students' mastery of this issue. Therefore, the characterization of the participants of both countries also included the analysis of the content of all the syllabuses in their study plans. In the case of the Portuguese institution, the global warming issue is included in the curricular unit Earth Sciences, but only as a brief reference to the impact of livestock production on the phenomenon. In the Spanish institution, the participants have also studied the global warming issue in the curricular unit Natural Environment: Physics, Chemistry and their Didactics, but there are no links explicitly made to the subject under discussion. The syllabus information was also checked directly with the teachers of the above curricular units.

We did not ask about the non-formal or informal experiences of the students in regard to knowledge of global warming; but these could reasonably be inferred in some cases.

Procedure

A questionnaire in two parts was administered in both countries in March and September of 2015. The Portuguese and Spanish were closely similar, because the languages are very similar. The second part of each questionnaire was administered only after the first part had been. This avoided influence from the first seeping into the second. Some information was requested in the introduction to the questionnaire: institution, course, age, gender, and the indication of the curricular units where the formal approach to the global warming issue was included. This last request was a way to ascertain that the syllabus had this component.

Table 1 shows the items in the questionnaire.

Table 1 Items comprising the two parts of the questionnaire.

Part I
1-Give three measures that could be taken by society to mitigate global warming.
2 - Give three personal behaviours that you can adopt to mitigate global warming.
Part II
1-How does the use of fossil fuels contribute to global warming?
2-How does the emission of CFCs and other equivalent gases contribute to global warming?
3-How does intensive livestock production contribute to global warming?
4-How do landfills and other garbage deposits contribute to global warming?
5-How does deforestation contribute to global warming?
6-Considering the five global causes presented above, establish a ranking in descending order of importance for the problem of global warming.

Part I was intended to determine whether future teachers, spontaneously, would mention any measure related to livestock production and meat consumption, either in global or personal terms. Part II was intended to discover what influence the respondents would attribute to livestock production, compared to other causes, in regard to global warming; and

also their capacity to explain this relationship to climate change. The inclusion of a number of global warming causes was also a way to disguise the main aims of the study. This strategy was used to guarantee an unbiased ranking of the environmental causes, as proposed in question 6. But with this option, it was also possible to get important information about the ideas of the participants related to other causes of global warming. This rich information will be included in a future publication. The administration of the questionnaire took, on average, 45 min in both countries, and no difficulties were identified related to the questions presented. During the administration process oral comments were discouraged as well as conversation between pairs.

Treatment of the open questions

The questionnaire included three open questions. Two in Part I related to social measures and personal behaviours that would mitigate global warming, and one in Part II related to the explanation of the connection between livestock production and global warming. These answers were categorized using two different approaches. In the first two questions, the answers were analysed using an inductive approach, without pre-determined patterns. Therefore, the main categories emerged based on the content focus of students' answers. We coded each answer and reviewed the codes created at the same time as the main categories emerged as recommended by Cohen et al. [24]. It thus became clear that several answers expressed the same idea using different words.

In the third open question, the answers were coded according to their content focus. The categories were: A – Gases emission; B – Ecosystem alteration; C – Manure production; D – Production process and commercialization; E – Other reasons; F – Don't know. Secondly, the questions were classified according to their scientific accuracy and a score was also attributed. Thus, the following six categories were defined: Correct answer (4 points); Answer partially correct but without mentioning the main aspect (3 points); Answer with correct items but explaining little or nothing of the intended relationship (2 points); Answer with correct items but containing serious inaccuracies (1 point); Incorrect answers and absence of answer (0 points). We considered an answer correct when students mentioned that cattle and/or their manure released methane, thus contributing to global warming. In fact, manure also emits nitrous oxide as it decomposes in the soil [8]. But we decided not to be too demanding since the syllabus of the curricular units from both courses was not very detailed.

Descriptive statistics were used to calculate the frequency of each category.

Treatment of the closed questions

Inferential statistics, with SPSS, were also used to treat some data, with the level of significance set at $p < 0.05$. After rating the scientific accuracy of question 3 related to an explanation for the impact of livestock production on global warming, a mean was calculated for each group of participants from the two different institutions. We used the Kolmogorov–Smirnov test for testing the normality of the distribution of the data, since both groups consist of more than 50 subjects. For both subsamples, $D(91) = 0.226$, $p < 0.05$, and $D(111) = 0.203$, $p < 0.05$, the distribution was significantly non-normal, and, consequently, a Mann–Whitney U test was used.

In the case of the ranking of animal production among the five different causes related to global warming, the same non-parametric test was also used.

Validity and reliability

The questionnaire was first evaluated by a panel of two specialists from the field of Science Education. They concluded that the questionnaire was well structured, easy to understand and apply, and that it comprised clearly defined elements. These assessors highlighted the way we had disguised the main focus on livestock production. They also found sound our strategy of administering the two parts of the questionnaire separately. The administration was done by the same researcher in each country.

The questionnaire was piloted previously with five students from similar courses in each country, not included in the final sample. No problems of comprehension were detected. In a second phase of preliminary testing, the questionnaire was applied to a sample of 50 subjects not included in the final sample (25 from Spain and 25 from Portugal). Again, no comprehension problems were detected.

The administration process was designed to ensure a similar attitude to the students' questions during the process of administration. The answers were categorized by each research team member separately. The concordance rate of the categorization process was 95%, and the discrepancies were analysed one by one until the final consensus. To validate the closed question 6, the correlation between the variables in this question (order given to fossil fuels, emissions of CFCs, intensive livestock production, landfill and other rubbish deposits and deforestation, according to the importance for the problem of global warming) was verified. The number of responses used for the validation (50 subjects; 10 subjects per item) is the one recommended by Thorndike [25]. As these are ordinal variables, the Kendall's Tau-b non-parametric statistical test has been used to determine their association [26]. Results of this test revealed correlations statistically significant ($p < 0.01$) between the order given to the different variables. These results confirm that it is a valid and reliable instrument.

Results

The presentation of the results is done separately for each of the two parts of the questionnaire.

Part 1

The answers to the first two questions were categorized according to content. Tables 2 and 3 include the frequencies of these categories. They include, respectively, the measures that

Table 2 Categorization of the answers of the participants of the two groups related with measures that should be taken by society to mitigate global warming.

Measures to be taken by society to mitigate global warming	Group 1 n1=91	Group 2 n2=111
To act at the level of mobility / transport	58	82
To act at the level of industrial processes	43	35
To act at the level of agriculture and livestock production	17	3
To act at the level of energy options	23	45
To act to raise consciousness of environmental problems	13	10
To encourage environmentally friendly behaviours	31	62
To preserve different ecosystems	17	22
To encourage regulatory guidelines	19	18
General answers or answers difficult to categorize	35	36
Unqualified answers	1	6
Total	257	319

the respondents considered relevant to be implemented by society or by them individually. Although the tables include the answers already categorized, the ideas expressed in several answers are also mentioned in the text. Each respondent could select up to three measures in each case. Only a few participants mentioned only one or two.

The measures mentioned by the participants from the two groups had a similar frequency in a number of categories, although the two samples do not have exactly the same number of subjects. There are a few notable differences. The first group had a little higher incidence in measures related to industrial processes, focusing on the need to eliminate CFCs production and other equivalent gases. In this category, the participants of both groups also mentioned the need for gases control, through the use of filters in industrial complexes. Group two highlighted more measures related to the following three categories: *mobility and transport,* emphasizing the use of public transport or less use of petrol cars; *energy options,* arguing for a greater investment in renewable energies or moderate use of energy; and the promotion of environmentally friendly behaviours, like the correct separation of rubbish or the refusal to buy products with CFCs.

But the difference between the two groups was more significant concerning measures in the domain of agriculture and livestock production (17 answers from the first group were included in this category against only 3 in the second); although, in global terms, the frequency of these measures had a low incidence. In this category, there is another important difference. More specifically, 12 participants from the first group emphasized the need to reduce livestock production. The other measures included in this category were related to a better control of the use of pesticides and fertilizers.

The incidence of the other categories was very similar. In the case of the category 'To preserve different ecosystems', the focus was on preventing fire destruction and on the need to avoid deforestation. In the category 'To encourage regulatory guidelines', the main measures proposed were related to better legislation and supervision. Finally, we considered general answers: i.e. such measures as 'to reduce carbon dioxide emissions' or 'not to pollute'. In the few 'Unqualified answers' were included very atypical measures like 'to introduce more ozone into the stratosphere' or 'to produce more carbon dioxide'.

Table 3 includes the categorization of the measures to be taken personally by the participants of both groups. These measures have some similarities with the previous ones, but several dissimilarities can also be identified. As in the previous question, each respondent could select up to three measures, and only a few participants mentioned one or two.

Table 3 Categorization of the answers of the participants from the two groups related with personal behaviours to mitigate global warming.

Personal behaviours to mitigate global warming	Group 1 n1=91	Group n2=111
To change mobility and transport options	89	101
To reduce energy and resource consumption	27	59
To adopt environmentally friendly behaviours	82	107
To be involved in dynamics of environmental citizenship	9	12
To change diet	12	4
To change behaviours in public spaces	4	12
General answers or answers difficult to categorize	5	15
Total	228	321

The behaviours proposed by the participants of both groups were very similar. This was reflected in the frequencies of the different categories. Most behavioural choices were again related to mobility and transport, and also the adoption of environmentally friendly behaviour. In the first case, the answers emphasized a more frequent use of public transport, but also included riding a bike or walking instead of using a car. In the second case, the main emphasis was on the adoption of a policy to Reduce, Reuse and Recycle – the 3Rs policy – and on not buying sprays containing CFCs. To reduce energy and resource consumption also had a high incidence, especially in the second group. These were related to the moderate use of energy, adoption of renewable energies (e.g. to install solar panels in the home), and water saving.

The other three categories had a low incidence of answers. Even so, both groups show a similar incidence of *being active as an environment-conscious citizen;* including participation in protest actions or environmental organizations. 'To change behaviours in public spaces' has a little higher incidence in the second group and was almost always related to the problem of litter. The category 'to change diet' included the following two types of answers: to eat less meat and more vegetables. This dietary choice had a little higher incidence in the first group. The general answers or answers difficult to categorize were, for instance, to avoid polluting or to respect environmental norms.

Part II

As previously stated, our focus in the second part of the questionnaire was questions related to global warming, including livestock production. Therefore, the connection between livestock production and global warming was required as well as a ranking of the different causes. Table 4 shows the main theme focus of the answers given by the participants.

Table 4 The categorization of the answers of the participants related with the main theme focus of their answers when explaining the connection between livestock production and global warming.

The main theme focus of the answers	Group 1 n=91	Group II n=111
A- Gases emission	59 (64,8%)	34 (30.7%)
B- Ecosystem alteration	2 (2.2)	21 (18.9%)
C- Manure production	7 (7.7)	15 (13.5%)
D- Production process and commercialization	4 (4.4)	12 (10.8%)
E- Other reasons	1 (1.1)	4 (3.6%)
F - Don´t know	18(19.7)	25 (22.5%)
Total	91	111

Most of the answers of respondents in the first group connect livestock production to global warming, especially through emissions. For the second group, this connection is also the main reason, but ecosystem alteration, manure production and the production process and commercialization of livestock were also mentioned by a few participants. Almost a fifth of the respondents from both groups were unable to explain the relationship.

Table 5 shows the assessment of the scientific accuracy of the relationship, using the categorization which is explained in the methodology section.

Table 5 The assessment of scientific accuracy of the answers from the respondents from the two groups in relation to the question: How does intensive livestock production contribute to global warming? The letters from A to E are related with the main theme focus content of the answers, as already presented in Table 4.

Assessment of the answers	**Group 1**	**Group 2**
-Correct answer	**33 (36.3%)**	**19 (17.12%)**
A1 – Cattle (or its manure) releases methane	33	16
C5- Manure releases methane	-	3
- Answer partially correct but without mention of the main aspect	**20(22%)**	**38 (34.23%)**
A3 – Cattle (or its manure) release gases into the atmosphere	17	15
A2 – Cattle release carbon dioxide	1	4
B2- Cattle need pastures, which contributes to deforestation	1	8
B4 – Cattle destroy habitats and contribute to desertification	-	4
D5 – Meat industries release contaminant gases	1	7
- Answer with correct items but explaining little or nothing of the intended relationship	**10(11%)**	**2623.43%)**
B1-Cattle eat vegetation, which reduces oxygen production	1	6
B3 – Cattle eat vegetation	-	3
C1 – Manure contaminates the environment	-	6
C2- Manure in excess harms soil fertility	1	1
C3 – Manure burns plants	-	1
C4 – Due to manure	-	1
C5 -Manure in excess is prejudicial	3	2
D4 - Industrial production releases contaminant gases	1	2
D8 - The problem is cattle	1	-
D9-Livestock production uses a lot of resources	1	-
D10-Livestock production uses a lot of chemicals	1	3
E2 – The energy used in rearing cattle		1
E3-Due to the smell it causes	1	-
- Answer with correct items but containing serious inaccuracies	**8(8.8%)**	**0(0%)**
A4-Cattle release methane, which destroys the ozone layer	4	
A6-Cattle (or manure) release methane, which destroys the ozone layer	4	
-Incorrect answers	**2(2.1%)**	**3(2,7%)**
A5-Cattle release sulphur dioxide	1	-
A7-Manure releases CFCs, which destroys the ozone layer	1	-
E4 – It is not a determining factor	-	2
E5 – Animals breathe a lot of oxygen	-	1
Don't know / No justification	**18 (19.7%)**	**25 (22.52%)**

The connection between livestock and global warming is only correctly explained by 36.3% of the respondents from the first group and 17.1% from the second, which is a significant difference. All the other participants respond in an incomplete way or introduced

inaccurate details. In the second group, however, one third of the respondents have an idea about the impact of livestock production, but without a direct reference to methane. Therefore, the highest incidence of the answers of this group is included in the category 'partially correct but without mentioning the main aspect'. The incorrect elements detected in the respondents' answers concern the gases released by cattle, and the consequences. A few other reasons also mentioned, like the use of chemicals in livestock production or the impact of the excess of manure on soil fertility, are not in fact related to global warming.

After scoring the answers, the result of the application of the Mann–Whitney test is $U = 4062{,}500$, $z = -2753$, $p = 0.093 > 0.05$. Therefore, the groups do not show significant differences in the scientific accuracy of their answers.

Finally, we wanted to record how the students from the two groups evaluate the contribution of livestock production to global warming, when compared to other causes, like the use of fossil fuels, the emission of CFCs and similar compounds, the impact of landfills and dumps and deforestation. Students established a ranking in descending order of importance. Table 6 includes the results related to livestock production.

Table 6 The impact of livestock production on global warming. Its position in the ranking when competing with the four other causes included.

Ranking attributed to livestock production in the context of global warming (from the 1st to the 5th position)					
	1th	2nd	3th	4th	5th
Group 1	7(7.7%)	5(5.5%)	10(11%)	22(24.2%)	47(51.6%)
Group 2	4(3.6%)	5(4.5%)	5(4.5%)	19(17.1%)	78(70.3%)
Total	11(5.4%)	10(5%)	15(7.4%)	41(20.3%)	125(61,9%)

As can be seen, most of the students from the two groups ranked livestock production in the fourth and fifth place. This selection occurred in 75.8% of the respondents from the first group and in 87.4% in the second group. These values show that the connection between livestock production and global warming is underestimated despite the views of several studies [7–9]. The statistical comparison of the two groups, also using the Mann–Whitney test is $U = 4377{,}500$, $Z = -1679$, $p = 0.006 < 0.05$.

The difference between the two groups is statistically significant. The underestimation of the impact of livestock production on global warming is not so pronounced in the first group, although in both groups a lower percentage of students put this cause in the first two places.

As stated earlier, the results for the other causes of global warming included in the questionnaire will be reserved for a separate publication.

Discussion

The main findings

The study found that most of the respondents from both countries, Portugal and Spain, tended to underrate the impact of livestock production on global warming, despite the slightly better result of the first survey group. The participants showed a remarkable

consistency between their answers in both parts of the questionnaire. Firstly, very few students mentioned global warming *mitigation measures* related to livestock production or food options. The need to reduce animal production as a social measure only emerged among the participants from the first group, and the same happened in relation to the need to change our eating habits and the consumption of less red meat. Most students prefer to highlight measures related to mobility and transport, energy choices and environmentally friendly behaviours, mainly associated with the 3Rs policy. This preference reflects the issues commonly discussed in the school systems of Spain and Portugal, but it can as well be affected by the perception that livestock production has a minor impact in global warming if we take into consideration the figures for livestock production in both countries.

Nevertheless, the results are similar to those in other studies. For instance, a study of students from a university in the United Kingdom concluded that the 'green' personal actions most often quoted were those related to changing purchasing habits and forms of transport, recycling and saving energy and water [27]. Another study with a group of invited teachers participating in a climate change course, found that the most popular environmental behaviours were reductions in the consumption of electricity, water and paper, and in the use of cars and over-packaged products [28]. A study with Greek university students found that they considered industrial activity, deforestation, chemical products and CFCs and power stations as the main factors of global warming, but agriculture and cattle raising activity were considered to be of minor importance [29].

Further, there is similarity among studies with participants from different ages, levels of schooling and countries. For instance, a study with English students from 11 to 16 years old found that the best ways of decreasing GHG are to reduce vehicle emissions and factory production, and to use renewable energy sources [2]. A similar study of Chinese students also highlights the same measures. Only the need to plant more trees had a higher incidence, a result that the authors relate to the awareness of students of the Chinese policy in this field [30]. A study comparing secondary students and pre-service teachers also found a very low level of scientific understanding about global warming in both groups. The pre-service teachers were better able to identify the main GHG, but no direct questions concerning livestock production were included in this survey [31].

In our study, students from both institutions also performed badly in their scientific justifications concerning the impact of livestock production on global warming. The tendency which was more pronounced in the second group, even though we accepted as correct an over simplified answer. This is an important result, independent of the real weight of this cause in global warming.

The differences between the two groups can be explained by the fact that the participants of the first group covered the impact of livestock production on global warming in one curricular unit of their course. Since this approach was not particularly developed, it may also justify the underestimation of this cause of global warming when compared with the others included in the questionnaire. It also appears that the knowledge of the participants had not been influenced significantly by non-formal and informal education. In the media, the subject of animal production is often absent despite the fortuitous broadcasting of the film *Cowspiracy* in both countries just a few weeks before our survey.

It was also possible to identify several incorrect answers (partially or totally) related to the gases released by cattle, and also answers that do not explain the connection required, like those about the use of many resources or chemicals during livestock production. Furthermore, several other answers from both groups mentioned the need to reduce the manufacture and use of CFCs. This type of answer shows that most respondents are unaware of

the changes already made at this level, and that the confusion between global warming and ozone depletion still persists in different cultures. In fact, despite scientific advances in the study of climate change in recent decades, the average level of knowledge has not increased significantly as other authors also highlight [11].

Implications for formal education

The results suggest that the importance of livestock production has been underestimated in formal education, certainly in pre-service teachers' courses. Livestock production's negative impacts should be recognized. They include its contribution to deforestation, desertification, high water consumption, different kinds of pollution, energy waste and the use of agricultural land to feed animals instead of crops for direct consumption [32].

The question of society's eating habits is also generally omitted from teaching about environmentally friendly behaviours. Pre-service teachers seem to lack awareness of the environmental impact of these choices, especially when associated with meat consumption. Cultural and economic differences among continents and countries explain the large differences in the average of meat consumption per person per day or year (e.g. Bangladesh compared to Spain), but rising affluence, growing population size and urbanization have increased the demand for livestock products [33–35]. The general state of the economy affects meat consumption. For instance, there was a sharp fall in meat consumption in Argentina, one of the biggest beef consumers, during the financial crisis of 2001 when Argentine consumers lost buying power [36].

The question of livestock production should be re-considered. In fact, 'the higher you eat on a food chain, the greater your carbon footprint' [4, p. 75]. An increase in meat consumption reduces the energy efficiency of the food chain. Beef production is notably inefficient; each kilogram of cattle body mass needs seven kilograms of animal ration [37]. Thus, a higher incidence of vegetables, fruit and cereals would feed more people. This is a matter both of ecology and social justice, as the world population continues to grow.

Industrial livestock production also raises ethical questions. These industrial farms can have hundreds or even thousands of animals, confined in limited spaces, with minimal adherence to animal welfare, and great reliance on antibiotics to limit the spread of diseases. The only 'guarantee' of health in these factory farms is the use of antibiotics [38]. But, the lack of new developments in antibiotics and the mounting evidence of resistance raise a significant risk of disease in the human population and an end to the trend to longevity.

Increased meat consumption is related to obesity worldwide. If this trend continues, obesity will remain a global public health problem [39]. Obesity affects the increase of several non-communicable diseases, such as cancer, cardiovascular and liver diseases, hypertension and diabetes [40].

Education to reduce meat consumption and obesity goes further than the question of reducing global warming. Improvement of public health begins with eating habits in childhood and adolescence. A study by Assunção et al. [41] with Brazilian adolescents is of particular concern: red meat was much more consumed than white meat, and processed meats were eaten weekly.

The ethical questions have prompted many to increase their intake of non-meat products, to become vegetarian or to follow a vegan way of life. Many animals entering the market as meat products have had miserable lives in factory farms, without even swift and pre-stunned death. Human preference for meat reflects the fact that healthy development needs protein, but that does not need livestock production in factory farms [42].

This issue should also be discussed in relation to the benefits associated with cattle production, which can be done in a sustainable way. These benefits are, at least, the following: (i) cattle help to maintain rural areas, which are important in economic, social and ecological terms; (ii) rural areas respond to care for the countryside, which is an important source of income from tourism; (iii) cattle eat a kind of vegetation that is not edible by people, and convert it into human food; (iv) animals provide a natural fertilizer for the soil, providing essential nutrients such as nitrogen, phosphorus and potassium; (v) animals' hooves press the seeds and bury dead matter on which the decomposers can act;(vi) soil becomes more aggregated, with more organic matter, allowing for better water retention and the activation of biological activity; (vii) cattle contribute to the elimination of invasive plant species, maintaining biodiversity; (viii) meadows are not ploughed, which reduces the erosion of their soils when compared with agricultural soils; (ix) meadows are mainly composed of multi-annual plants, whose roots have greater penetration in the soil compared to the annual plants, thus also helping to reduce soil erosion [32,43]. Improvements in livestock production to mitigate the release of methane are also important. Studies in Brazil indicate that mitigation can be achieved through cattle diets of better quality, a more appropriate management of pastures and with the choice of livestock breeds [44].

Finally, it is important to note that the recent United Nations Climate Change Conference held in Paris (2015) can only succeed if, in addition to the implementation of ambitious measures that depend on the political and economic powers, there is also a general social commitment to use energy resources better and to adopt environmentally friendly behaviours, including changes in our way of mobility and food choices [45]. Consequently, the research team have already proposed including livestock production questions in their departments' curricula, to provide a better understanding of global warming questions. Also important has been the design of some educational resources to approach this issue with children from 6 to 12 years, taking advantage of ideas and texts of other authors, e.g. Murphy [46].

Conclusions

The results show that it is desirable to enrich the understanding of pre-service teachers in regard to global warming issues. Livestock production is a big and complex question. The work reported here began with the assessment of knowledge about the impact of livestock on global warming in pre-service teachers for basic school level in Portugal and Spain. It is recommended that there should be a more consistent – and enriched - approach to the impact of livestock production on global warming in future teacher training. The children of today and tomorrow will have to face the problems produced now.

Disclosure statement

No potential conflict of interest was reported by the authors.

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