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A GLOBAL META-ANALYSIS ABOUT ORGANIC VS CONVENTIONAL LIVESTOCK PRODUCTIVITY AND FEED-USE EFFICIENCY.

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Abstract: Livestock plays a key role in organic farming system to close nutrient cycles. Nevertheless, differences between organic and conventional livestock production have received little attention in the literature. Here, we provide a first quantification of differences in animal production and feed use efficiency between organic and conventional farming at the global scale using a meta-analytic approach. We focused on dairy cattle, pigs, poultry layers and broilers as the most represented species. We found (i) a 14% lower productivity for organic dairy cattle, (ii) an 11% and 89% lower feed use efficiency respectively for organic dairy cattle and poultry broilers, (iii) and a lower competition between feed and food use for organic cattle dairy. These results are key to accurately model global organic systems and to assess their potential contribution to global food security.

Introduction: Organic farming is often criticised for its low productivity. Several studies have compared organic to conventional crop production at the global scale, highlighting a 20% crop yield gap between organic and conventional farming (Seufert, Ramankutty, & Foley, 2012). While livestock production is a key component of organic farming systems (in particular to close nutrient cycles), its productivity remains understudied in organic systems at the global scale. Here we present a meta-analysis about animal productivity and feed use efficiency in organic *vs* conventional livestock production at the global scale. The feed use efficiency was evaluated based on three different feed categories (Ertl, Klocker, Hörtenhuber, Knaus, & Zollitsch, 2015; Laisse et al., 2018; Mottet et al., 2017; Wilkinson, 2011): (i) the entire feed ration, (ii) the concentrate feed (for its role in animal productivity) and (iii) the food-competing feed (for its impact on the feed-to-food competition). These results are key to estimate global food production in scenarios of large organic farming expansion.

Material and methods: A meta-analysis was conducted to quantify production and feed use efficiency differences between organic and conventional livestock production at the global scale. Through an exhaustive literature review, 31 articles comparing organic and conventional livestock production were selected, leading to 37 organic *vs* conventional comparisons. Dairy cattle, pigs, poultry layers and broilers were covered by these articles. For each study, production was expressed as the mean mass daily production (mean daily weight gain, dairy production or egg mass) and feed use efficiency was expressed as the amount of feed divided by the production level (Mottet et al., 2017; Wilkinson, 2011). As organic and conventional systems may differ in terms of concentrate or food-competing feed use, we estimated feed use efficiency based on (i) the entire feed ration, (ii) the concentrate feed and (iii) the food-competing feed. Although they are related to animal productivity and feed use efficiency, animal health and welfare were considered out of the scope of this study. In our meta-analytic approach, the organic systems were considered as the treatment and the conventional systems as the control. Two effect sizes were estimated (Makowski, Piraux, & Brun, 2017): the organic to conventional production ratio and the organic to conventional feed use efficiency ratio. These effect sizes were analysed through a linear mixed effect model with a random effect and a weight function based on the number of animals in each study. This analysis was conducted on the R software using the lme4 package.

Results: *Table 1: Ratio of organic to conventional feed use efficiency for the three different feed categories and each livestock type. A t-test test was realised to test whether values are significantly different to 1.*
(p-value<0.05, ** p-value<0.01, *** p-value<0.001)*

Livestock type		Feed use efficiency calculated based on the…					
		Total feed ration		Concentrate feed		Food-competing feed	
Dairy cattle	Org to Conv ratio	1.11	*	0.70	***	0.73	**
Pig meat	Org to Conv ratio	0.95		0.95		0.98	
Poultry layer	Org to Conv ratio	1.06		1.02		1.10	
Poultry broiler	Org to Conv ratio	1.89	***	1.89	**	2.30	***

We found that organic dairy cattle have a 14% (±3%) lower production compared to their conventional counterparts, whereas no significant differences in production levels were observed for the other livestock types. The observed differences may be explained by differences in feeding strategy (Röös et al., 2018; Van Wagenberg et al., 2017), as concentrate feed use is 15% lower for organic compared to conventional dairy cattle.
Our results also show that organic livestock have lower efficiency in using feed when calculated over the total feed ration (Table 1). For example, dairy cattle and poultry broilers exhibit an 11% and 89% lower efficiency, respectively, compared to their conventional counterparts. Differences in feeding strategy (for dairy cattle) and in animal lifetime (45% longer for organic poultry broilers) are key to explaining these results.
Interestingly, our result also show that organic dairy cattle were 30% and 27% more efficient than their conventional counterparts in using feed when accounting only for concentrate and food-competing feed, respectively. This makes organic dairy cattle less in competition with human nutrition.

Discussion: To our knowledge, this meta-analysis is the first attempt to quantify differences between organic *vs* conventional livestock production levels and feed use efficiency at the global scale. This works highlights (i) a production gap between organic and conventional farming for all livestock types (though, it is only significant for dairy cattle) as well as (ii) differences in feed use efficiency between organic and conventional for both dairy cattle and poultry broilers. Muller et al. (2017) highlighted a lack of data on livestock production between organic and conventional to properly set their model on global organic production. Therefore, this first quantification is key to model global food production under scenarios of large organic farming development (Erb et al., 2016; Muller et al., 2017). However, these results must be used carefully as they face limitations. These limitations are related to (i) the low number of articles included in our database (livestock production and feed efficiency being an understudied field of research in organic agriculture) and (ii) the lack of data on several animal types such as suckler cows and small ruminants. More unified procedures are needed to collect and report data on organic *vs* conventional animal feed for future meta-analyses on this subject, with a better attention paid to small ruminants.

References: Erb, K. H., Lauk, C., Kastner, T., Mayer, A., Theurl, M. C., & Haberl, H. (2016). Exploring the biophysical option space for feeding the world without deforestation. Nature Communications, 7. https://doi.org/10.1038/ncomms11382

Ertl, P., Klocker, H., Hörtenhuber, S., Knaus, W., & Zollitsch, W. (2015). The net contribution of dairy production to human food supply: The case of austrian dairy farms. Agricultural Systems, 137, 119–125. https://doi.org/10.1016/j.agsy.2015.04.004

Laisse, S., Baumont, R., Dusart, L., Gaudré, D., Rouillé, B., Benoit, M., … Peyraud, J.-L. (2018). L'efficience nette de conversion des aliments par les animaux d'élevage□: une nouvelle approche pour évaluer la contribution de l'élevage à l'alimentation humaine. INRA Productions Animales, 31(3), 269–288.https://doi.org/10.20870/productions-animales.2018.31.3.2355

Makowski, D., Piraux, F., & Brun, F. (2017). De l'analyse des réseaux expérimentaux à la méta-analyse (pp. 107–161).

Mottet, A., de Haan, C., Falcucci, A., Tempio, G., Opio, C., & Gerber, P. (2017). Livestock: On our plates or eating at our table? A new analysis of the feed/food debate. Global Food Security, 14, 1–8. https://doi.org/10.1016/j.gfs.2017.01.001

Muller, A., Schader, C., El-Hage Scialabba, N., Brüggemann, J., Isensee, A., Erb, K. H., … Niggli, U. (2017). Strategies for feeding the world more sustainably with organic agriculture. Nature Communications, 8(1), 1–13. https://doi.org/10.1038/s41467-017-01410-w

Röös, E., Mie, A., Salomon, E., Johansson, B., Gunnarsson, S., Wallenbeck, A., … A. Watson, C. (2018). Risks and opportunities of increasin yields in organic farming. A review. Agronomy for Sustainable Development, 38, 1-21. https://doi.org/10.1007/S13593-018-0489-3

Seufert, V., Ramankutty, N., & Foley, J. A. (2012). Comparing the yields of organic and conventional agriculture. Nature, 485(7397), 229–232. https://doi.org/10.1038/nature11069

Van Wagenberg, C. P. A., De Haas, Y., Hogeveen, H., Van Krimpen, M. M., Meuwissen, M. P. M., Van Middelaar, C. E., & Rodenburg, T. B. (2017). Animal Board Invited Review: Comparing conventional and organic livestock production systems on different aspects of sustainability. Animal, 11(10), 1839–1851. https://doi.org/10.1017/S175173111700115X

Wilkinson, J. M. (2011). Re-defining efficiency of feed use by livestock. Animal, 5(7), 1014–1022. https://doi.org/10.1017/S175173111100005X

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