The dilemma of dealing with complexity in animal breeding choice making

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Summary

Developments in animal breeding, genetic, genomic and data recording technologies in recent decades has allowed for the evaluation of larger numbers of animal traits than ever before. This should help make selection and breeding decision more informed. However, it also makes selection and breeding decisions far more complex, and this complexity has the potential to overwhelm end-users (farmers). This paper aims to review the theoretical principles of complex decisions, contextualize the findings to the field of animal breeding, analyse how farmers and the animal breeding industry is dealing with complexity, and provide research options to increase the level of knowledge on this issue. The four most important sources of complexity in breeding decision making are the number of breeding animals available to choose from, the amount of information (e.g. phenotypes, EBVs and indexes) used to describe those animals, the heterogeneity of weighting units across animal descriptors, and the format in which all this information is provided to farmers. The complexity of selection and breeding decisions can have two main negative consequences: a) farmers make non-optimal decisions, and b) farmers use (consciously or unconsciously) simplifying strategies (i.e. heuristics) to cope with such complexity. Finally, the methods to analyse the undesired effect of complexity in the selection of breeding animals are discussed.

Keywords: breeding, complexity, decision making, heuristics, choice inconsistencies.

Introduction

The scientific development of animal breeding, genetics, and in the last decade genomics, and the latest developments of individual data recording technology, has allowed for the evaluation of larger numbers of animals and animal traits with higher accuracy than ever before. This large amount of information makes farmer decisions regarding which animals to select and breed more informed, but also more complex. It is increasingly common for industry professionals to consider that the amount of information, its complexity, and the cognitive process required to interpret it might be overwhelming to farmers. Despite the acknowledgement of the complexity of choice making in animal breeding, to our knowledge, nobody has used this background knowledge to systematically analyse the sources of complexity in breeder and farmer breeding choices and how they cope with it. Conversely, the influence of complexity on people's choice making has been studied for decades in psychology, economics, and marketing fields.

In the classical approach to the analysis of decision making, people are believed to be

rational decision makers who logically assess all the options available and choose the one that gives them the highest utility (Uzawa, 1959). This approach is based on the assumption that people have all the information needed and the capacity required to analyse the information prior to making the decision (Todd & Gigerenzer, 2000). However, when decisions are complex, most people are unable to assess all the information available to inform their choices. Decision complexity can then lead people to make wrong or inconsistent decision or to use simplifying strategies (i.e. heuristics) when making decisions (Mazzota & Opaluch, 1995). These effects of complexity on decision making can be translated directly to animal breeding decisions. Theoretically, it is expected that all the information generated about animals informs farmers and enables them to make better animal breeding choices. However, it is quite unrealistic to think that farmers have clear relative weights of importance for all the animal information provided, which they use to somehow calculate an overall ranking of animals on which to base their selection on.

This review paper aims to bring attention to the fact that the animal breeding industry is facing the dilemma of how to balance to the need for more information (i.e. new technologies, genomics, phenotypes, major genes, BVs for functional traits) with the extra complexity this adds to already very complex decision-making processes.

Sources of complexity; what makes animal breeding choices complex

The sources or origins of decisions complexity are diverse. We summarize (Table 1) the four most important factors according to the theoretical principles of complex decision making and how they apply to animal breeding, along with examples.

Table 1. Key sources of decisions complexity applied to animal breeding choice making.

Theoretical principle	Applied to animal breeding	Example
Too many choice alternatives	Number of animals to choose from	The number of breeding animals available could be considered unlimited.
Too many attributes used to describe alternatives	Number of traits and other pieces of information used to describe breeding animals	Pedigree, phenotypes, traits EBVs and indexes, used to describe breeding animals
Heterogeneity of weighting units across criteria	Animal traits have different units and not all of them are easily translated into economic terms	Some traits are easily expressed in monetary term while in others the transformation is not so easy. Farmers have economic and non-economic motives to make breeding decisions.
Format in which information is provided	The format in which breeding animal characteristics are provided to farmers	Breeding animals' cards provided by breeding companies are designed to highlight animal features and include systems to simplify information provided.

Consequences of complexity and strategies to cope with it

The complexity of decision making in general and, the inherent complexity of breeding decisions in particular, have two main types of consequences: a) it leads to people (farmers) making sub-optimal decisions, and b) people use (consciously or unconsciously) strategies to cope with such complexity when choosing which animal to select and breed (Table 2). These simplifying strategies are called heuristics in the field of decision making analysis.

Table 2. Consequences of complexity and the use of heuristics to cope with it.

Consequences of complexity	Brief description applied to animal breeding decisions
Sub-optimal decisions	
Choice inconsistency	The relative importance farmers give to traits varies across consecutive selection events
Choice heterogeneity	Increase in the heterogeneity of estimates of relative trait weight at the farmer population level
Use of heuristics; simplifying rules or strategies used by people to make decisions in complex situations	
Elimination heuristics or attribute non-attendance	Animals are usually described with such a large number of trait EBVs and breeding indexes, in addition to other criteria that farmers have to focus on only some of them, sometimes using some other factor to refine their choice
One-reason decision making	Farmers make selection decision based on the one trait (or more likely a few traits) they believe to be the most relevant for their breeding programme, or the selection index value in which they trust to refine their choice
Recognition heuristic	Fidelity of farmers to their usual breeder, breed or sheep/cattle market. If farmers are satisfied with the animals they are buying from a breeder or the breed they are raising, they might not have a strong reason to look somewhere else for better animals.
Threshold elimination heuristic	Farmers might have lower bounds for some or every trait below which animals are rejected, or they might choose a subset of animals with the highest values for some important traits (or index) and then filter them according to a lower bound for other less important traits.
Social heuristic	The most straightforward social heuristic is do-what-the-majority-does; imitation generates harmonious social interactions and strengthens social relationships and it can also be connected to farmers social identity, which is strongly linked to their preferences and opinions

Methods to analyse the undesired effects of complexity in the selection of breeding animals

Due to the complexity of breeding decisions, it is very likely that farmers are not using the genetics selection tools available (EBV and breeding indexes), choosing breeding animals inconsistently, and/or using simplifying strategies –heuristics– to cope with all that complexity. All these actions lead to inefficient decisions, which in turn leads to the lack of realisation of potential genetic gain in breeding programmes.

In addition, there is increasing interest and research on farmers' preferences for animal traits (i.e. Nielsen & Amer, 2007; Martin-Collado *et al.,* 2015), where the main objective is to determine the relative importance that respondents give to specific animal traits. However, despite the fact that Tano *et al.* (2003) and Nielsen & Amer (2007) noted the potential influence of complexity on the outcomes of the experiments, little attention has been devoted to this topic.

Finally, the use of heuristics by farmers is acknowledged by breeding companies, who usually exploit it in their marketing strategies (i.e. the design of breeding animal cards, animal of the month, loyalty rewards) on which their success relies instead of relying on achieving genetic gain. This situation drives the need for independent industry driven comparison of gene stocks from different breeders and companies.

It is therefore of relevance to explore which strategies and heuristics farmers are using to deal with complexity when choosing breeding animals and how differences in complexity might affect those decisions. There are two primary methods to do so. Firstly, the most

straightforward and simple method involves asking farmers directly how they choose breeding animals and how they use all the available information to inform their decision. The second method is the use of discrete choice experiments (DCE). There is a clear parallel between how farmers are supposed to make decisions about breeding animals and three underlying concepts of consumer utility theory on which DCE is based (Phillips *et al.,* 2002): 1) Each good is a bundle of potential attributes, 2) Each individual has set of unique relative utility weights for attribute levels, and 3) Combining the utilities for different attributes provides an individual's overall relative utility. One of the strengths of DCEs is that they allow researchers to estimate the effect of the attributes of an alternative on people choices. Details on DCE statistical models and design can be found widely (i.e. Hensher *et al.,* 2005). The basic consumer utility model is an idealized form of how people make choices. However, it has been improved to account for the complexity of choices, and some of the potential heuristics used by choice makers. The two main effects of complexity for which DCE models have been developed are respondents attribute non-attendance (i.e. Campbell *et al.,* 2011), and the effects of complexity on the consistency of the estimates of the utility of alternatives (or the weights of the attributes) and/or the choice heterogeneity. Therefore, DCEs are a great tool to research the area of complexity in animal breeding. Not only to cope with the complexity of the experiment itself, which is of special interest for improving the experiments analysing farmers' preferences for animal traits, but to analyse if complexity is leading to farmers making inconsistent choices or to farmers not using all the information provided.

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