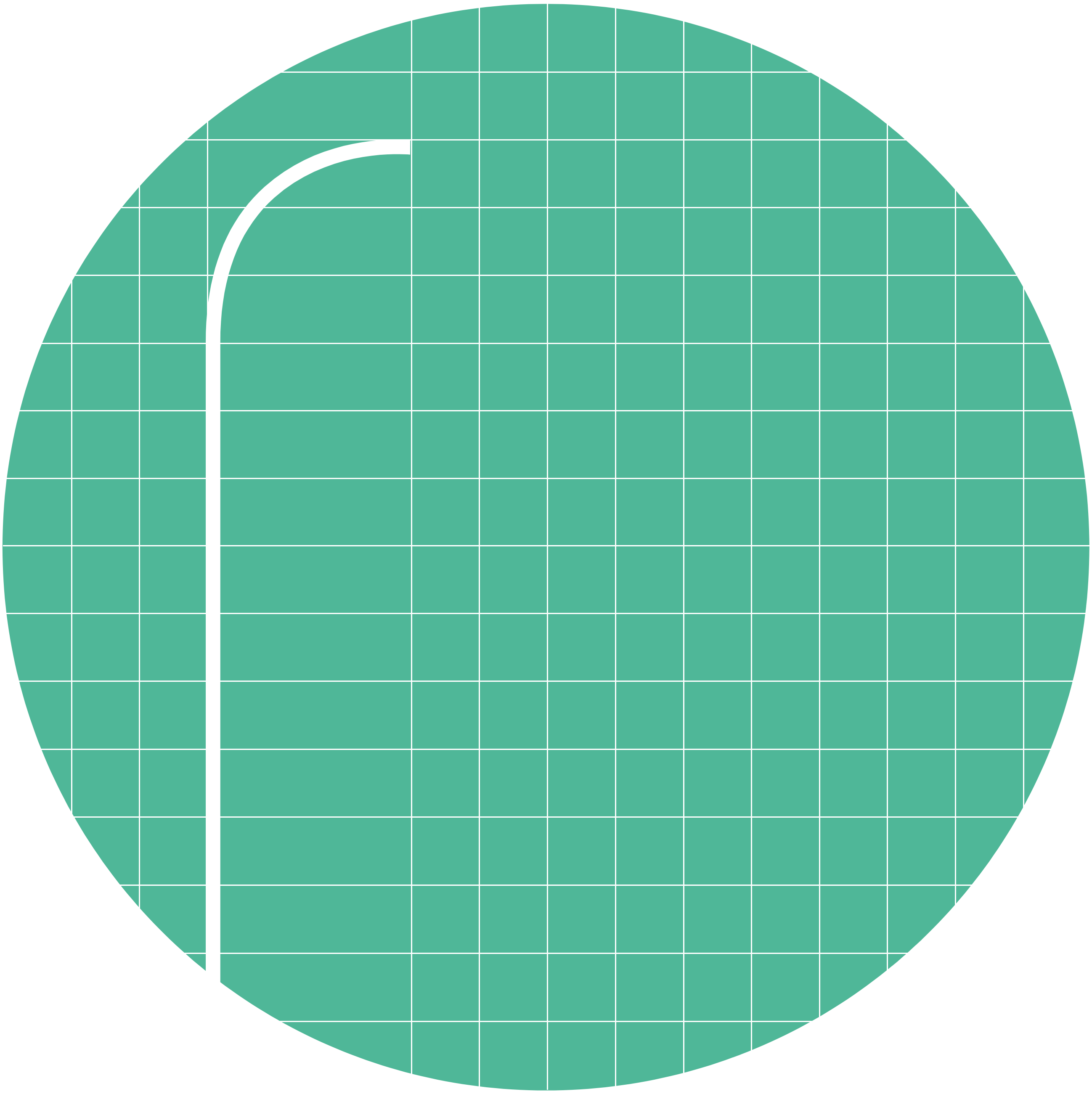
/02

Focus: Zootechnics of the future

Selection strategies and environment



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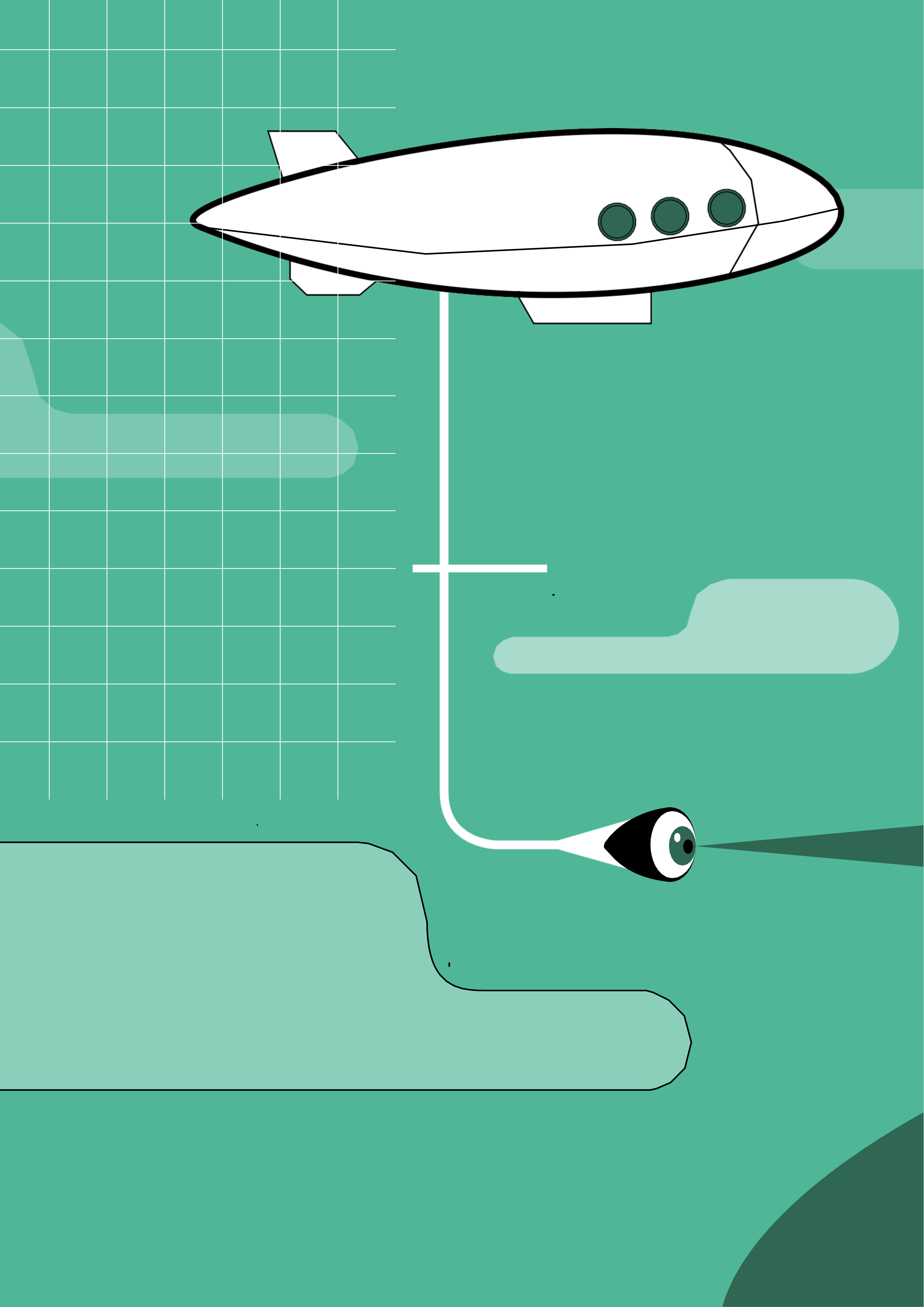

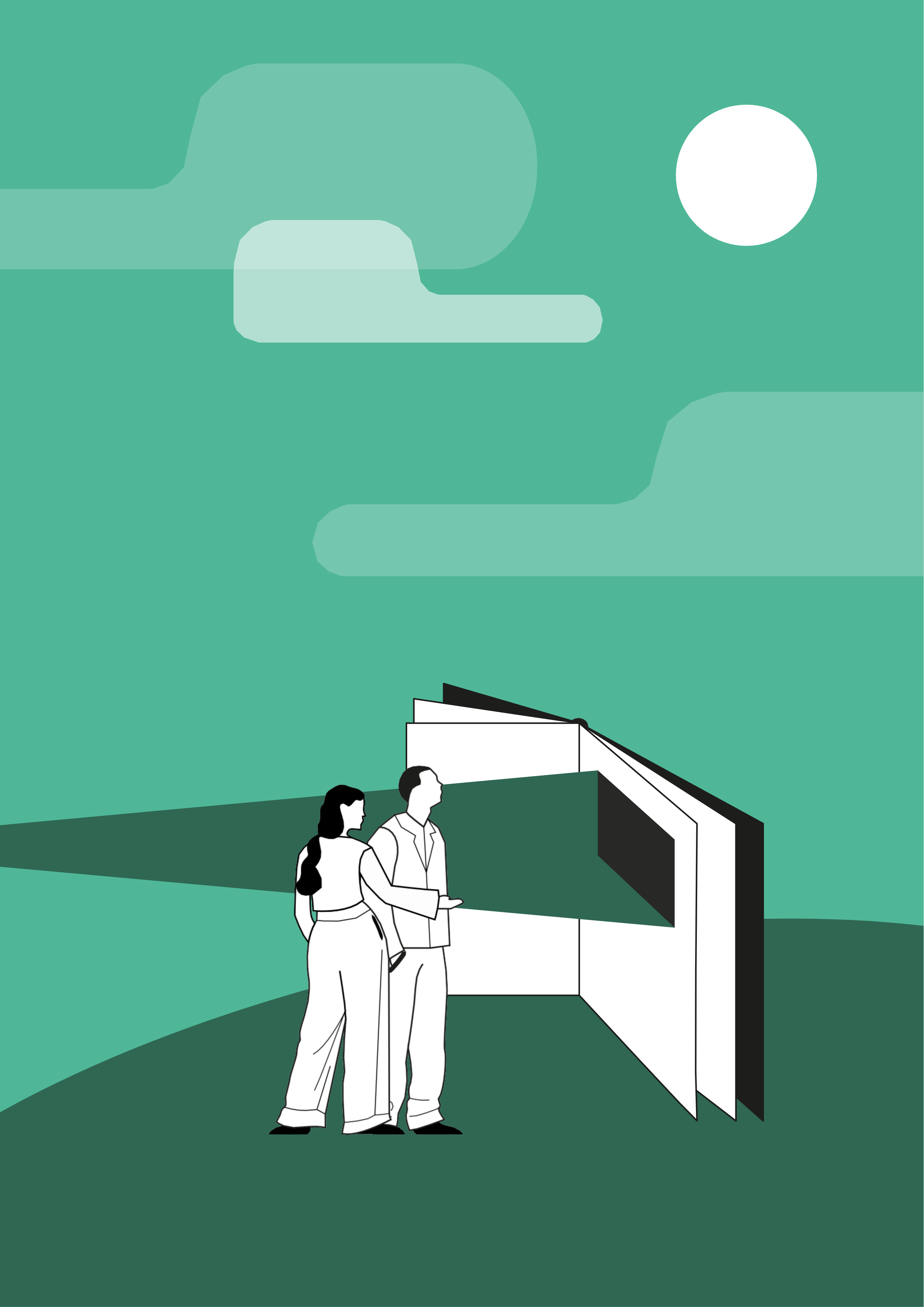

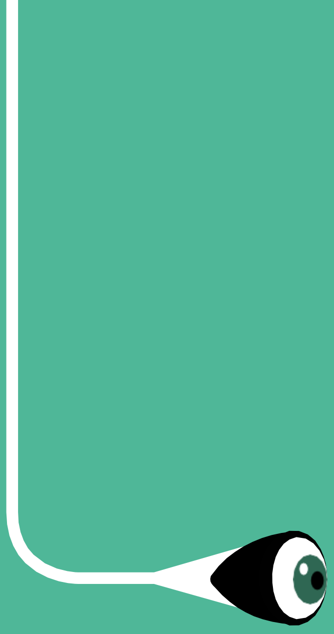

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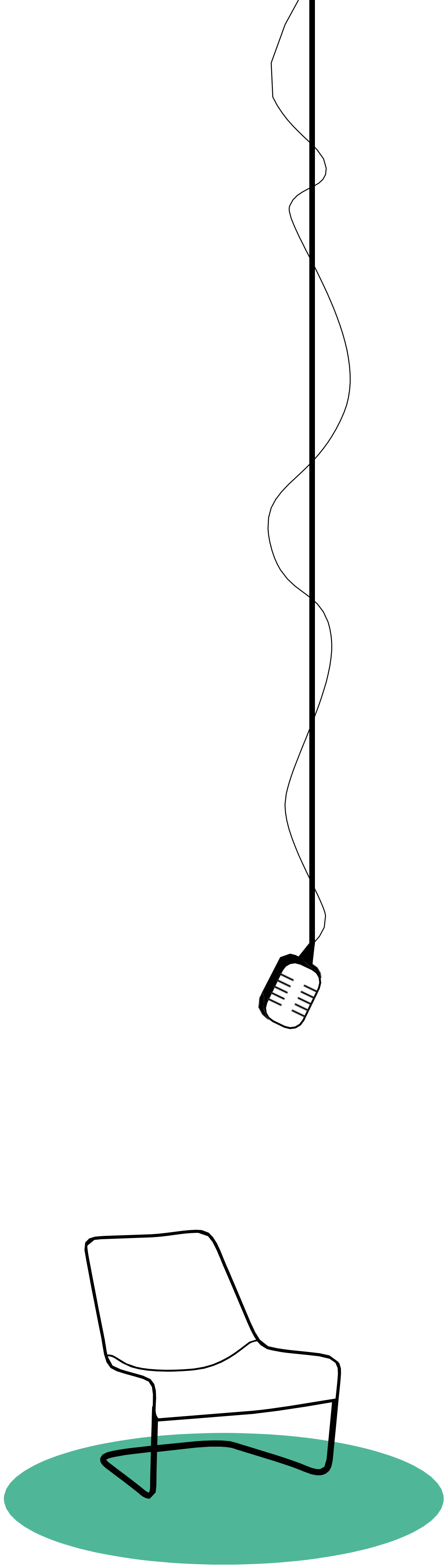


Introduction

The "livestock farming of the future" series aims to focus on the stable of tomorrow from multiple points of view. In particular, it focuses on the strategies that the cattle breeding sector will adopt to respond to the challenge of "*improving production performance, reducing the impact on the environment*".

The first focus dealt with the topic by delving into the contribution of animal nutrition to the environment, and in particular the precision feeding strategies that can be implemented to reduce methane production in cattle farming. However, while the study of animal nutrition has the potential to offer solutions in the very short term, it is the study of animal genetics that produces permanent changes in a population of animals subject to selection.

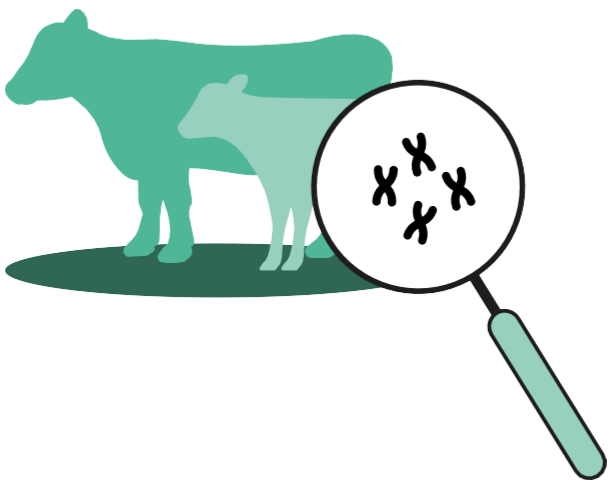
Genetic improvement is considered the tool par excellence to guarantee the sustainability of farms over time. It has been defined in many studies as a green engine as it is capable of offering permanent and cumulative effects in the activities of subsequent generations.

This second work will therefore deepen the study of the potential of genetic improvement in cattle farming to explore future strategies to mitigate the impact on the environment.

This will be one of the variables to be considered more carefullyto encourage an ecological transition that is also sustainable from an economic point of view.

This work, like the others that will follow, is based on the contribution of authoritative experts who were asked to provide their vision of the future of animal husbandry and in particular of the different aspects covered in the series.

1.



1. Genetic improvement for the environment

Interview with Prof. Giulio Visentin

Associate Professor of the Department of Veterinary Medical Sciences - University of Bologna

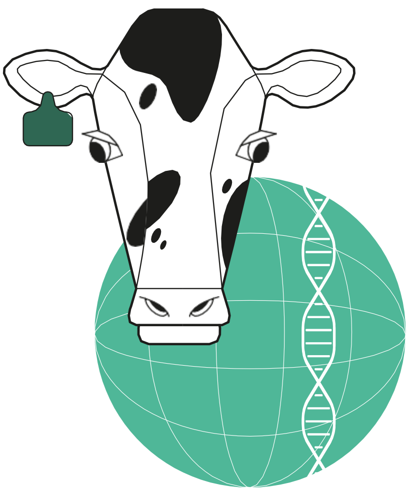
Research area: animal genetic improvement

What is genetic improvement and what is the contribution to the sustainability of livestock production?

Before focusing on the focus of the question, it is useful to make a premise and remember what genetic improvement is and how it works. Firstly, genetic improvement does NOT consist of creating genetically modified animals or introducing genes into a population that are NOT currently present in nature! Genetic improvement is a practical discipline and represents a branch of population genetics which has the objective of predicting the value of the genetic heritage of an animal in the event that this subject is used as a breeder. This value is called reproductive value, or breeding value, and represents the portion of an animal's genetic heritage that can be transmitted to the next generation, i.e. to its offspring. The choice of the best reproducers on the breeding value and not on its phenotype value (which represents the measurement of a specific character, for example Kg of milk) is fundamental because: i) the phenotype is also influenced by natural non-genetic factors (e.g. order of calving of an animal, husbandry conditions), and ii) by certain traits that are not observable in all individuals. These two sources of information, nowadays, are joined by a third and fundamental source of information which is represented by genomic information, i.e. DNA markers present in the genetic make-up of an individual and appropriately identified using cutting-edge technologies. The use of elite breeders allows for genetic progress, i.e. improved performance in the next generation of animals compared to their parental generation. This process requires a careful choice of breeders from the breeder and the centres that distribute semen material upstream. Finally, it is useful to remember that genetic improvement brings permanent changes in a population of animals subject to selection and that these changes are cumulative over time, therefore acting in an additive manner. On the other hand, selective choices do not bring an immediate benefit but are observed gradually as the breeder pursues their selection strategy. Nowadays, there are increasingly detailed selection objectives that take into consideration not only production parameters (e.g. kg of protein and milk quality), but also functional parameters (e.g. fertility, duration of the productive career, health) accompanied by a correct morphology of the animal. Normally the interest of a breeder is to improve several characteristics immediately. Consequently the choice of the best reproducers takes place based on the selection objective, which represents an index in which the reproductive values estimated for different characters and for each animal are weighted and then combined together in order to obtain a single parameter according to which the national ranking (i.e. the classification) of the best breeders is created.

The challenge to which animal husbandry is also called upon is to produce healthy, quality food for a growing world population, creating and guaranteeing income for the national production system but pursuing a clear path of sustainability. The path therefore towards true sustainable development (in economic, social and environmental terms) is currently feasible and achievable by combining the potential of genetic improvement with the technologies that livestock farming is equipping itself with through substantial investments of both a private and public nature, in particular through the stimuli of the National Recovery and Resilience Plan and the National Rural Development Plans. By way of example, the National Breeders' Associations, which represent the associative bodies of breeders who pursue the objectives of selecting a specific breed in livestock production, are equipping themselves with cutting-edge technologies for the individual measurement of enteric methane emissions of breeders, but also for the measurement of food and water ingestion.This is allowing the development of selection indices that are useful for identifying those animals which, from a genetic point of view, are characterised by lower emissions of enteric gases and lower food consumption (environmental sustainability) while maintaining the high production and quality standards of animals in livestock production (economic sustainability).At this point it is legitimate to ask: in the absence of these selection indices, can genetics do its part? Surprisingly the answer is YES! Extremely interesting studies (such as Berry, 2013; Cole and VanRaden, 2018) which help us understand how current selection objectives are already contributing to the reduction of the environmental impact of livestock farming. By way of example, to date, fertility and longevity are traits on which strong genetic selection is taking place, dictated by the importance that these characteristics have on the profitability of the livestock farm. More fertile animals in the herd can lead to a reduction in the replacement rate, i.e. it is necessary to raise fewer young animals to keep the size of the herd unchanged. In a production quota scenario, selection towards more fertile animals can lead to reductions in annual enteric gas emissions ranging between 10 and 11%, and a reduction in nitrogen emissions of 9%.These results represent an aspect that deserves its own quantification also in the national context.

2.



2. New selection strategies in dairy cattle

Interview with Prof. Miglior Filippo and with Dr. Angela Costa

Miglior Filippo, Adjunct Professor of the Department of Animal Biosciences - University of Guelph, Canada.

Dr. Costa Angela, Researcher of the Department of Veterinary Medical Sciences - University of Bologna

Research area: Animal genetic improvement

What will be the future challenges of genetic improvement for emissions mitigation in dairy cattle farming?

There are ever more efforts both in terms of scientific research and investment of resources, aimed at improving feed efficiency and identifying nutritional strategies that reduce emissions from ruminants. Genetics can complement nutritional strategies and together significantly reduce methane emissions. At present, geneticists around the world are developing, with the help of zootechnicians, animal nutritionists, veterinarians and breeders, indices of feed efficiency and/or methane emissions. In dairy cattle, for example, it has been shown that improving feed efficiency, more easily measurable in practice than the "daily methane emissions" character, indirectly leads to a favourable response in selected generations regarding greenhouse gas emissions into the environment.

To date, it is possible to work from a genetic point of view on bovine food efficiency using improved breeding animals. These subjects are identified thanks to the presence of specific data that are collected within the population on a large scale; these data, in the case of the feed efficiency index, are daily intake, body weight (daily or weekly) and milk production (measured weekly or every two weeks with percentages of fat and protein). Through these three characteristics it is possible to determine which animals feed in quantities appropriate to their daily needs and which are less efficient, as food ingestion is higher than the actual needs for milk production and body weight. The possibility of choosing breeding animals according to the level of feed efficiency is in the hands of farmers, whose sensitivity towards environmental sustainability must not conflict with the breeding objectives: milk production, animal health and welfare and profit. For this reason, the need has emerged in recent years to evaluate the correlation between food efficiency and traditional characters of interest. On this aspect, the Canadian experience demonstrates that the genetic indices for feed efficiency are not correlated with any other trait; therefore, selection for this character would not impact on other characters under selection. The same indications emerge for the genetic evaluation for the reduction of enteric methane emissions.

An indirect index of food efficiency is calculated for the Italian Friesian population taking advantage of a limited number of machineries for experimental use installed in dedicated stables scattered across the national territory. These devices are capable of individually detecting daily food consumption, a key phenotype for geneticists. In practice, the breeder who uses genetics in their herd to improve their feeding efficiency observes direct economic benefits which translate into a reduction in feeding costs at the same production level. In the Italian Friesian, as in other dairy breeds present in the area, much study is still needed before being able to develop a specific genetic (or genomic) index for methane emissions into the environment. In this regard, the world of research and breed associations are working to develop systems to detect emissions at an individual level. Ideally, it would be sufficient to exploit data deriving from a limited number of contexts if subjected to experimental control (university experimental stables, progeny testing bull calf centres, bull centres, etc.).Having access to innovative tools to detect daily ingestion, feed efficiency and greenhouse gas emissions at individual animal level remains the priority for the Italian dairy cattle sector, together with the study of the impact of climate change on animal husbandry.

Interview with Prof. Martino Cassandro

Tenured professor

Department of Agronomy, Animals, Food, Natural Resources and Environment - University of Padua

Research area: Animal genetic improvement

What will be the selection strategies that farms will have to implement to reduce emissions?

There are multiple selection strategies that farms are implementing and will need to implement. In dairy cow farms, the first important way is to improve the efficiency of the breeding cycle, continuing to work on the fertility of the animals. Studies, such as Garnsworthy, (2004) have demonstrated the effectiveness of this strategy with reductions in methane emissions of 10-11%. The second possible path is to reduce methane production by directly selecting the "best" animals, i.e. those that are more efficient and capable of producing fewer emissions (Gonzales-Recio et al., 2020).

At the individual animal level, there are numerous parameters that are capable of producing an effect on the production of enteric emissions. Firstly, there is certainly the ability to influence it with specific feeding strategies, while other contributions come from the study of the genetics of the rumen microbiota (Benson et al., 2010). Studies increasingly propose integrating these strategies, in the shorter term, with new genetic selection objectives, which should be understood as an investment to improve one's herd of the future, as its effects are visible not before the next generation of animals. This path requires many measurements on a very large population, as well as the adoption of technologies capable of capturing the influence that each factor has on the production of emissions over time. The consideration of new phenotypes and new traits in selection indices will be essential to reduce emissions from livestock farming in the future. These represent some of the strategies on which it will be important to concentrate genetic improvement efforts. To make these strategies effective, it will be increasingly necessary to encourage the use of new technologies that are capable of providing accurate measurements of greenhouse gas emissions both at the individual animal and production system level, also taking advantage of the current system of functional controls.

The first step is to exploit modern technologies to measure enteric emissions. This will be functional to evaluating the individual animals on the farm over time for a direct selection of the best animals in terms of reduced emissions of enteric gases, as reproducers for the future generation. Many breeders' associations have already equipped their Genetic Centres with modern systems for the detection of enteric methane emissions. With such measurements it will be possible to create innovative databases over time which will soon allow the production of genetic indices aimed at identifying the most efficient subjects. The contribution provided by new technologies will be fundamental. Tools such as Greenfeed and *Crowcon Detection Instruments* are already available for the measurement of methane produced by cattle. In the first case, the cattle are identified through the electronic ear tag and, while they are feeding, the Greenfeed system quantifies the amount of enteric methane and carbon dioxide that escapes through the snout. Instead, the Laser Methane Detector (*Crowcon Detection Instruments, ltd*) is a portable methane detector. By pointing the laser beam emitted by the device in the direction of the bovine's snout, this instrument is used to determine the quantity of enteric methane emitted. The ease of use, the speed of recording and the reliability of the data open up the possibility of recording methane emissions on a large scale, even involving farms distributed throughout the national territory. The phenotypes collected with both of these devices are creating a large critical mass of data, essential for genetic and genomic evaluations, with the aim of developing an index for methane emissions.

ANAFIBJ and FEDANA promptly accepted the challenge of sustainability with the awareness that to reduce the problem, a shared contribution from all the actors in the production system is necessary. The first evaluations are undoubtedly positive and affirm that selection for environmental sustainability is now possible! The objective is to provide breeders with a selective tool that concretely responds to market and consumer demands from an environmental and economic sustainability perspective.

Conclusion

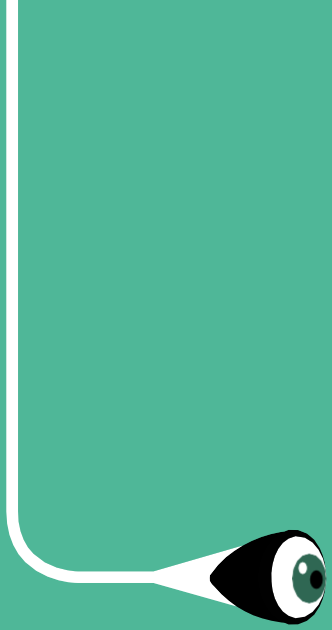
- Genetic selection is the key to guaranteeing food and income to the livestock system, as it is capable of offering permanent and cumulative effects in the performance of subsequent generations.

- Sustainability, in all its meanings, is the main driver of future selective strategies pursued by the world of breeders.

- Genetic selection is already, indirectly, contributing to the reduction of the environmental impact of livestock farming: selection towards more fertile animals can lead to reductions in annual emissions of enteric gases of between 10 and 11%, and a reduction in nitrogen emissions by 9%

- New breeding strategies are required to directly select for useful phenotypes and new traits in breeding indices to reduce emissions from livestock farming.

- Having access to innovative tools to detect daily ingestion, feed efficiency and greenhouse gas emissions at individual animal level remains the priority for the Italian dairy cattle sector, together with the study of the impact of climate change on animal husbandry



Bibliography

- Benson, A.K., Kelly, S.A., Legge, R., Ma, F., Low, S.J., Kim, J., Zhang, M., Oh, P.L., Nehrenberg, D., Hua, K., Kachman, S.D., Moriyama, E.N., Walter, J., Peterson, D.A., Pomp, D., 2010.Individuality in gut microbiota composition is a complex polygenic trait shaped by multiple environmental and host genetic factors. P. Natl.Acad.Sci.USA 107:18933- 18938.

- Berry, D. P. (2013) .Breeding strategies to reduce environmental footprint in dairy cattle. *Advances in Animal Biosciences*, *4*(s1), 28-36.

- Cole, J. B., & VanRaden, P. M. (2018). Symposium review: Possibilities in an age of genomics: The future of selection indices. *Journal of dairy science*, *101*(4), 3686-3701.

- Garnsworthy, P. C., 2004.The environmental impact of fertility in dairy cows: a modelling approach to predict methane and ammonia emissions.Anim.Feed Sci.Tech.112:211- 223.

- González-Recio, O., López-Paredes, J., Ouatahar, L., Charfeddine, N., Ugarte, E., Alenda, R., & Jiménez-Montero, J. A. (2020). Mitigation of greenhouse gases in dairy cattle via genetic selection:2.Incorporating methane emissions into the breeding goal. *Journal of dairy science*, *103*(8), 7210-7221.

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