



HappyMoo project - using milk mid-infrared spectrum to predict dairy cows' welfare status

J. Leblois¹, M. Calmels², L. Dale³, C. Grelet⁴, C. Lecomte⁵, M-N Tran¹, V. Wolf⁶, F. Dehareng⁴ and HappyMoo consortium

¹Elevéo asbl by awé groupe, ²Seenovia, ³LKV Baden-Württemberg, ⁴Walloon Agricultural Research Centre, ⁵France Conseil Elevages, ⁶CEL25-90

<http://www.happymoo.eu>



@HappyMooProject

Interreg



EUROPEAN UNION

North-West Europe

HappyMoo

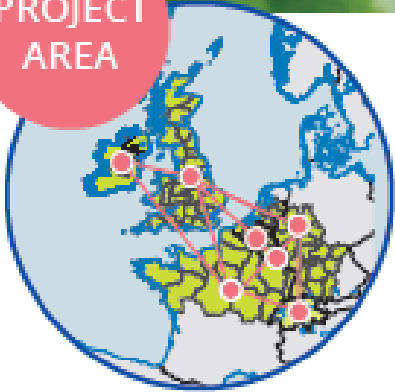
European Regional Development Fund



Qualitas



PROJECT
AREA



Precision milk analysis, an innovative
tool to improve cows' welfare



Project budget: 4.1 M €

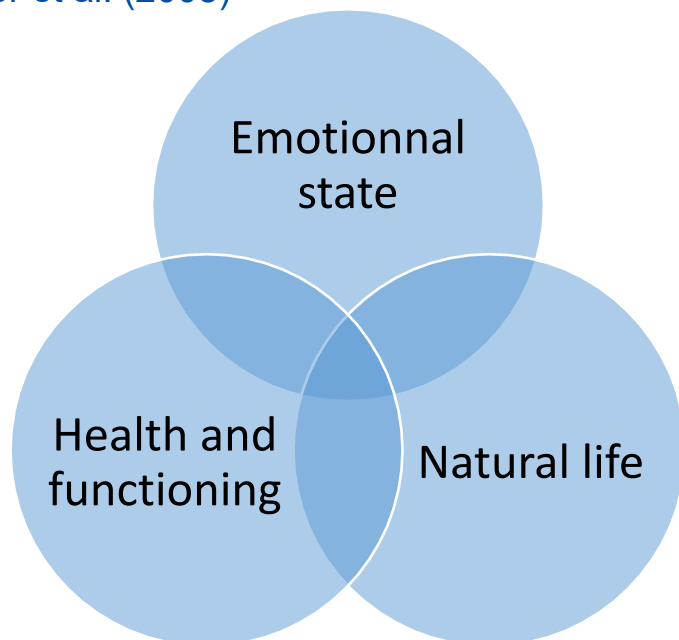
Project duration: 50 months (ended on 24/12/2022)

- 12 partners
- 7 countries
- 8 milk recording organisations
- 3 research centres
- 1 IT centre

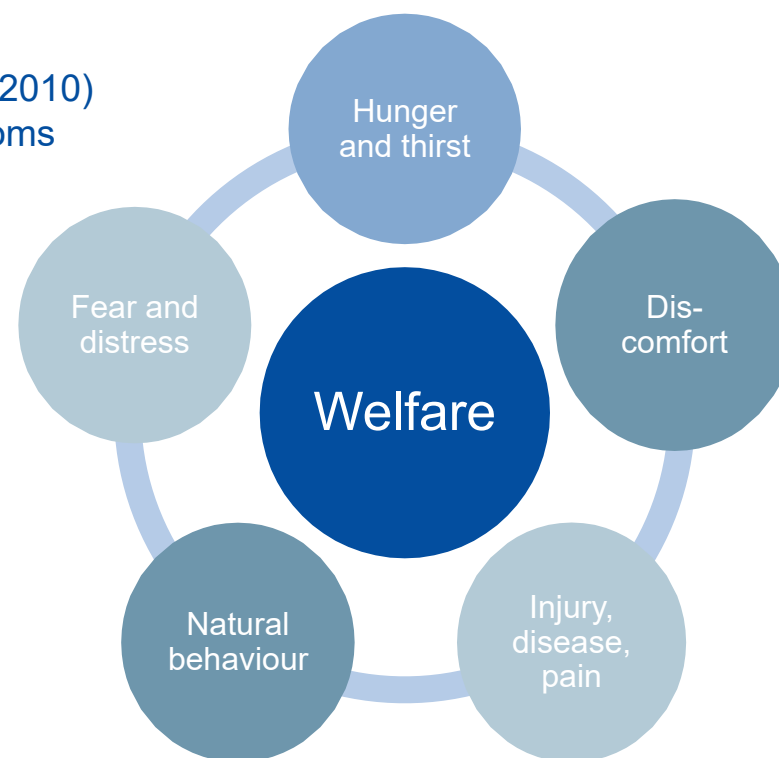
Animal welfare?

Several definitions

Fraser et al. (2008)

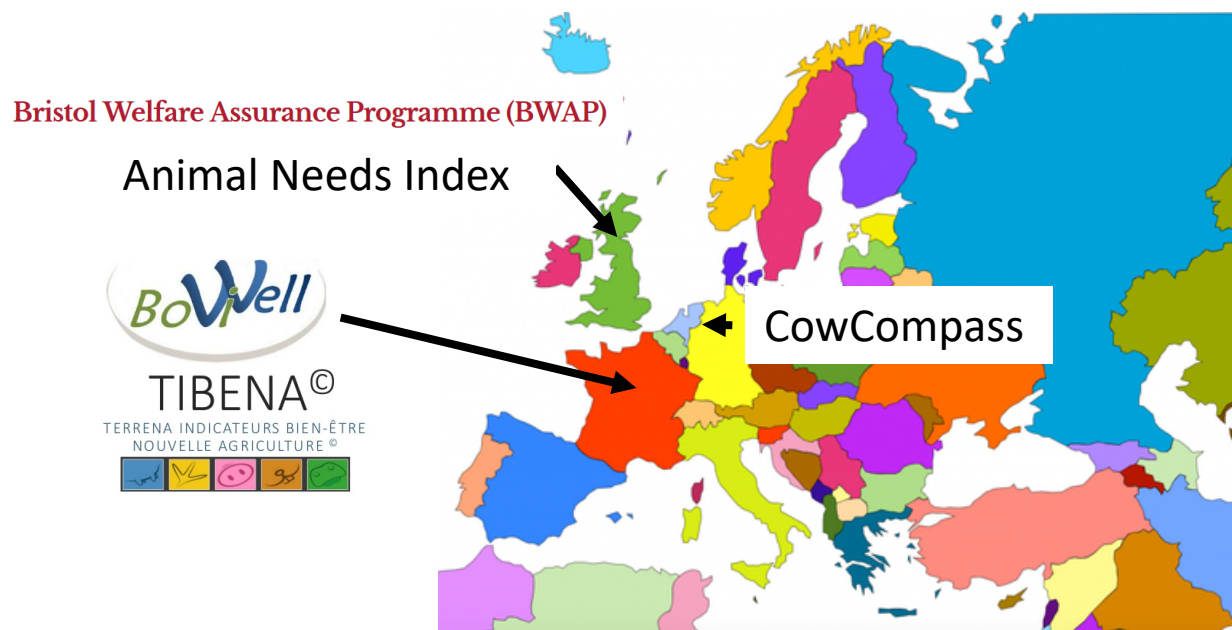


FAWC (2010)
5 freedoms



Animal welfare – state of art

- Objective indicators to assess the animal welfare are scarce
- Existing: protocols to assess welfare on-farm



Animal welfare – state of art

Existing protocols

- Need a farm visit
 - Not regular (once/year maximum)
 - Costly
- Can assess herd welfare level but not individual problems

➔ Need a fast, recurrent and cheap alternative

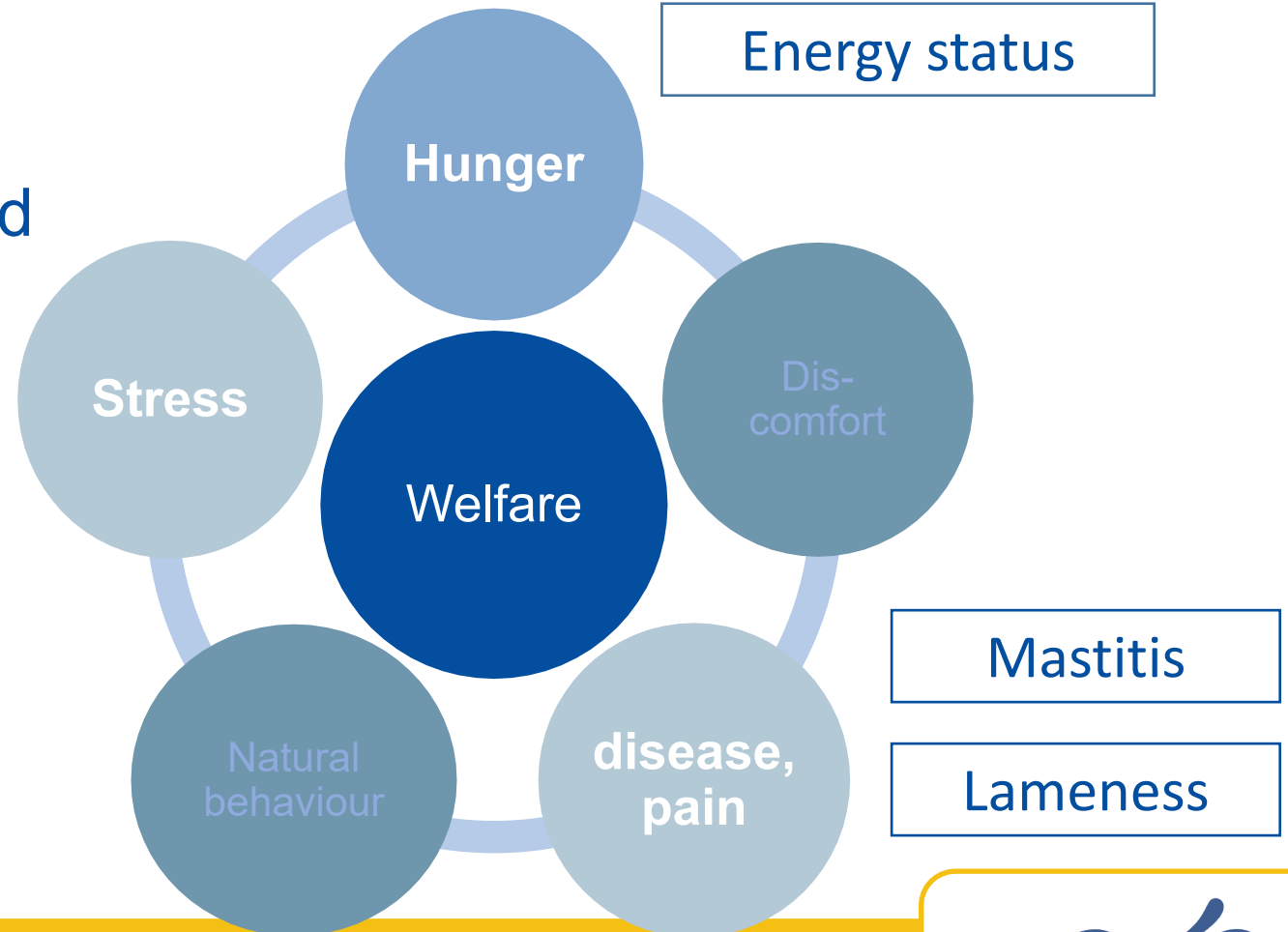
➔ **Milk recording samples**

HappyMoo – objective

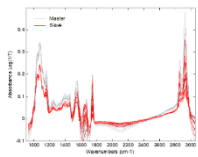
Use milk mid-infrared spectral analysis to **predict** welfare-related traits (molecules, phenotypes)

In particular:

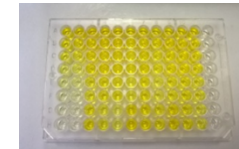
→ **Roll-out monitoring tools for the farmers, vets and extension workers**



HappyMoo – how to predict?

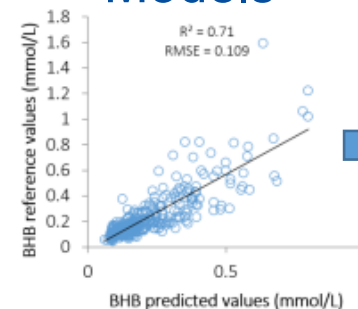


Mid-infrared (MIR)
spectroscopy



Reference values (lab
analysis, phenotype)

Models



Prediction of new biomarkers

- Stress
- Mastitis
- Lameness
- Energy balance

HappyMoo – building models



Construction of models through **European collaboration** is essential:

Building robust models requires a lot of variability in the dataset:

- Breeds
- Feeding systems
- Climate
- Management etc.

➔ Necessity to share data

HappyMoo – building models

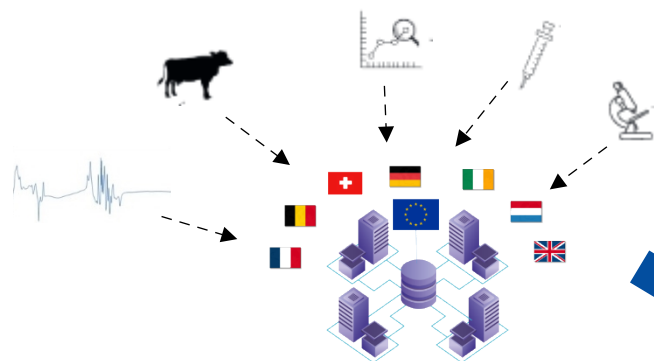


European collaboration dependent on data harmonization

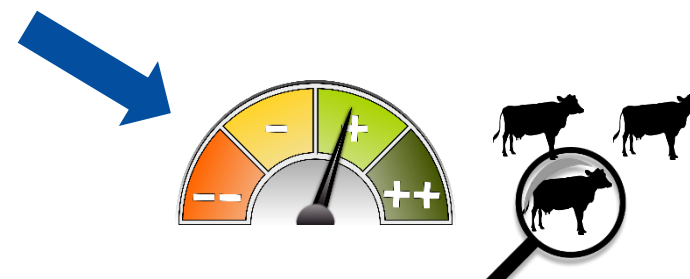
- Reference data
 - Phenotypes: ICAR codes
- Spectral data
 - Dependent on the analyzer brand, model etc
 - OptiMIR project allowed to create a method to standardize the spectra (Grelet et al., 2015)

Working plan

WP T1 – Data acquisition

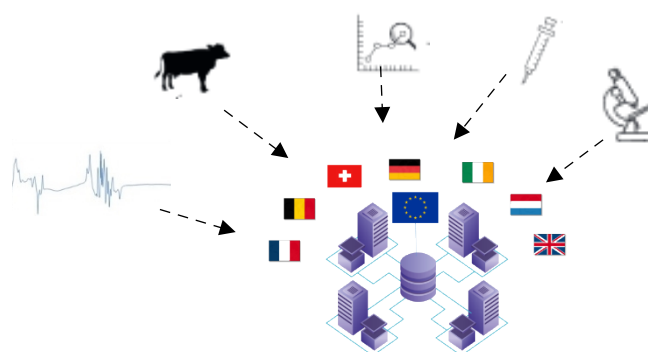


WP T2 – Processing of data through machine learning approaches



WP T3 – Production of screening index and dashboard (welfare and €)

Working plan



WP T1 – Data acquisition

Transnational database

- Milk recording data
- Phenotypes (lameness, BCS, diseases, trimming animal data etc)

Lab reference values

- Blood samples → fructosamin
- Hair samples → cortisol
- Milk samples → NAGase, LDH, haptoglobin

Working plan



WP T2 – Processing of data through machine learning approaches

Prediction models

Welfare related
molecules

Phenotypes

PLS-DA

GLMNET

Neural
networks

Random
Forest

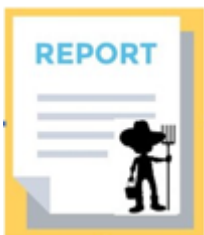
Working plan



WP T3 – Production of
screening index and dashboard
(welfare and €)



Implementation of these new equations into
milk recording organizations' platforms



Good practices manuals

NEGATIVE ENERGY BALANCE IN DAIRY COWS

Limiting its consequences through
vigilance at key periods!

Negative energy balance: several causes are possible

A dairy cow is in negative energy balance (NEB) when her diet does not cover her energy needs (energy deficit). To meet her needs, the dairy cow mobilises its body reserves, which are used as a new source of energy to ensure vital functions and milk production. This state can be observed:

- During the weeks following calving. In this case it is related to the onset of lactation which requires a lot of energy at a time when intake is limited. If NEB is physiologically normal in dairy cows at the beginning of lactation, limiting its intensity and duration will avoid reaching a state of ketosis and its deleterious consequences.

- When dairy cows are undernourished. This may be due to overly severe rationing, a shortage of feed stock or poor grass growth.
- As a result of a health problem (e.g., lameness, acidosis...) or stress causing a drop in feed intake.

The intensity of NEB varies according to the milk potential of the dairy cows, the ration offered (in quantity and quality) and the body condition of the dairy cows. Furthermore, the factors leading to NEB can occur at the same time and aggravate the energy deficit of the dairy cow and its consequences.

Short- and long-term consequences that lead to economic losses

- On the health of the animals: more frequent occurrence of diseases (digestive disorders, locomotor problems, uterine diseases, which can also be the cause of NEB), especially ketosis, increase in somatic cell counts, loss of condition or even weight loss.
 - On milk production: decreases in milk yield that can be very sharp, increase in the fat content (FC) and decrease in the protein content (PC) and lactose concentration.
 - On the reproduction of cows: reduced fertility, anoestrus, delayed fecundation.
- When NEB appears following a drop in intake or a feed restriction, the effects are temporary, the condition of the animals and their production returning to normal when the cows are re-fed ad libitum. In contrast, a high energy deficit in early lactation can lead to long-lasting consequences, from a persistent drop in production throughout the lactation to possible culling.



MASTITIS : THE FIRST HEALTH PROBLEM IN DAIRY FARMING

Integrated management for
sustainable improvement

Mastitis : various pathogens and multifactorial risk factors

Mastitis, udder infections affecting one or more quarters, are of two types:

- clinical (change in the milk appearance, even impact on the general condition of the animal),
- sub-clinical without associated clinical signs: we talk about «cell», which is a payment indicator for milk quality.

These infections are caused by bacteria living in the environment or the udder. Bacteria originating predominantly from the environment (e.g., coliform bacteria, fecal streptococci, etc.) generally lead to clinical mastitis, which is sometimes severe and often short-lived. Contamination occurs via a soiled environment (damp litter, etc.). Bacteria that are predominantly found in the mammary gland (e.g., *Staphylococcus aureus*, *Streptococcus agalactiae* and *Streptococcus dysgalactiae*)

generally result in sub-clinical mastitis (= cells), which may persist over time (e.g., encystment of *Staphylococcus aureus* in the mammary gland). Animals often get contaminated during milking, for example by non-disinfected teat cup liners between each cow, especially if there are teat lesions. Other bacteria may be involved such as *Streptococcus uberis*, coagulase-negative *Staphylococci*, but there are still debates about the degree and modalities of their involvement in mammary infections.

However, the origin of mastitis remains multifactorial. The main risk factors are housing, milking, and husbandry, including care during mastitis. Let's not forget about feeding which has an indirect impact on mammary health.

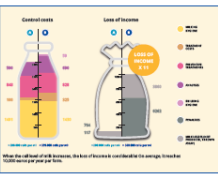
Clinical and sub-clinical mastitis : substantial impacts at all levels

The economic impact depends on many aspects (duration, severity, production level of the animal, days in milk, prevention and control measures implemented, etc.). The average economic impact of mastitis can range from 50 to over 350 euros per cow per year. The loss of income for a producer can be up to 30 euros per 1000 L.

Clinical mastitis and subclinical mastitis (= cells) have a negative impact on the production level in primiparous and multiparous cows. These losses vary considerably depending on multiple criteria (days in milk, lactation number, severity, production level...). Simulators that take into account the specific characteristics of each farm allow a more accurate economic estimation.

The inhibitor risk (such as antibiotic residues) is also increased. The impact in terms of welfare is very important for the farmer (stress, time

lost...) but also for the animal (pain, possible loss in ingestion, etc.).



Source: ONEL «Mastitis, l'anticipation»

LAMENESS : ANYTHING BUT FATALITY !

Solutions at all levels

Lameness : a profound economic and welfare impact, often of multifactorial origin

Lameness is a symptom of a locomotor system failure. It is the second most important disease in dairy farming. The average economic impact of a lameness ranges from 69€ to 483€ per lameness (Dolecheck, 2018), with the impact varying greatly depending on the nature and severity of the injury or disease present. The economic impact must take into account:

- economic losses due to lameness, i.e. the loss of income resulting from the effect of diseases on affected animals (e.g. reduced intake, production, increased risk of mastitis, reduced overlapping, fertility...),
- health costs or expenses related to lameness (e.g. trimming, treatment, etc.).

Longevity is also affected, not to mention the significant repercussions in terms of animal welfare (pain, restriction of natural behaviours such as heat, difficulties in moving around and therefore in feeding and drinking, bedsores, etc.). Lameness is also detrimental because of the extra workload, the need to restrain the animal in order to examine it when it is in pain...

This impact is worsening as the number of cases increases. So what can be done to stop or prevent this disease?

The 1st step in combating this health problem is to identify the lame animals and then the affected limbs. Lifting the feet will be essential to diagnose the origin of the lameness and adapt the care. The identification of biomarkers in milk would also be an interesting avenue to provide a complementary tool for screening for lameness. This is what has been explored in the HAPPYMOO project. The results of these 4 years of research are available on the HappyMoo website (link at the end of this document) although linking the composition of milk and its spectrum to lameness does not seem so simple.

90% of lameness involve the foot, and in 80% of cases the hindquarters. When the lameness does not affect the foot, there are many possible causes (bone, joint, muscle, nerve damage, etc.). Lameness of podal origin may be due to infectious or non-infectious lesions. The table below lists the main foot diseases, their causes and associated risk factors.

	Milk production	Reproduction	Longevity
Average impact of lameness	From - 0.5 kg to - 1.8 kg/day From - 100 kg to - 350 kg per lactation So, 32 euros to 112 euros	+ 40 days on calving interval	Number of cullings x 3 So - 2 100 euros (3 x 700 euros)

Source: CASDAR Lameness, 2017

Duration of lameness	< 15 days	1 month	> 1 month
Average impact of lameness	Ingestion : - 3% Milk production : - 5% Low losses : 5 euros	Ingestion : - 7% Milk production : - 17% Medium losses : - 40 to - 60 euros + 25 days on calving and 1 st insemination interval	Ingestion : - 16% Milk production : - 36% High losses : 250 euros to 350 euros Number of cullings x 5

Source: CASDAR Lameness, 2017

STRESS IN THE DAIRY HERD : WHAT IMPACTS AND WHAT SOLUTIONS?

Stress is a natural phenomenon allowing animals to adapt to an unusual situation disrupting their organism's balance. This stress increases energy expenditures of the animal in order to restore its equilibrium, which can lead to reduced performance and aggravated health risks. When the animal fails to adapt, the consequences can be dramatic, even leading to mortality. Stress results in increased heart and respiration rates. An animal that is regularly stressed, especially because of competition with other animals, may end up isolated from the herd. Stress can also be objectified by different measures: behavioral observations, measurements of biological or biochemical parameters...

Stress : solutions to be adapted according to the origin of the stress

The sources of stress are multiple and can be classified into 4 categories:

- Relationships between animals: nervousness, introduction of new conspecifics, etc.
- Diseases : mastitis, lameness, etc.
- Environmental conditions: overcrowding and competition in watering and feeding areas, heat waves, cold and wet weather, etc.
- Breeding management: handling, transport, weaning, milking (e.g. switch to automatic milking systems), etc.

A distinction is made between acute stress, the consequences of which are directly noticeable,

and chronic stress (e.g. overcrowding), which has an indirect negative impact on longevity and resistance to disease.

The overall management of stress involves zootechnical and sanitary prevention of diseases, compliance with recommendations regarding housing and controlled interventions (adapted restraint, calm environment, etc.).

As the origins of stress are multiple, we will focus on 2 examples of chronic stress: heat stress which dairy cows are increasingly confronted with and stress induced by overcrowding.

Heat stress: impacts, detection, prevention and control measures

Multiple short and medium term impacts for the animal and the farm

Heat stress affects animal welfare, performance and health. The attached diagram summarises these main effects. The impact of heat stress is particularly high in lactating cows, especially in high-producing cows (> 9,000 kg of milk), in the middle of lactation. Heat stress has a major impact on animal welfare : increased competition for shade, watering and feeding areas, increased risk of injury and accidents, fatigue... Heat stress therefore not only has a lasting negative effect on the metabolism and health risk for the cow, but also on her offspring. In

deed, the heat stress suffered by cows, particularly at the end of gestation, has a negative impact on the survival and production capacity of the calves born from these pregnancies : lower birth weight, potentially poorer immunity due to a maternal colostrum less rich in antibodies, lower milk production during their first lactation. Dry cows exposed to heat stress also have lower milk production in the following lactation.

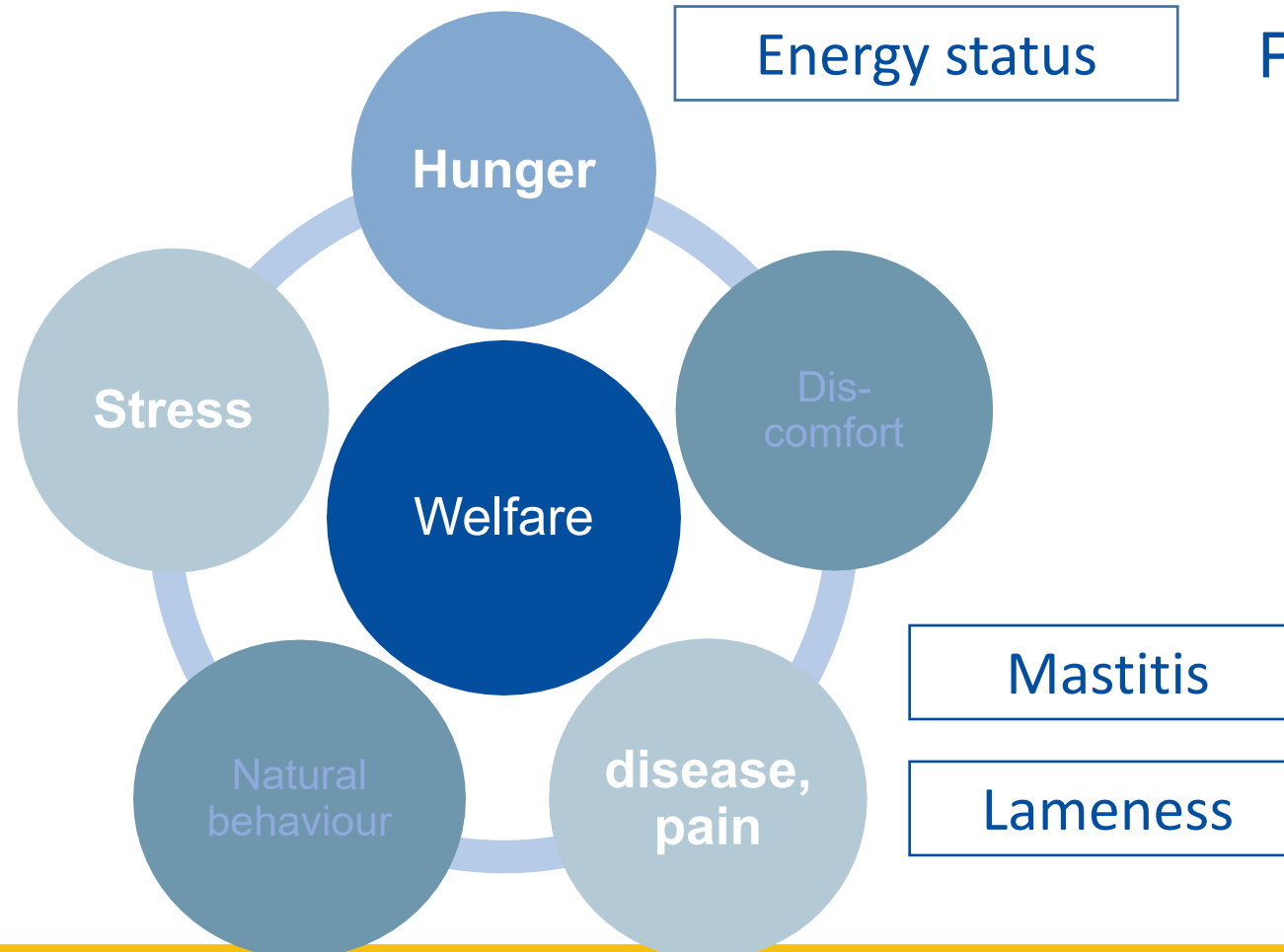
English, French, German and Dutch



Details

Presentations:

- Grelet
- Simon
- Dale
- Lemal



Presentations:

- Calmels
- Wolf

Presentations:

- Dale
- Jattiot

Next steps

Interreg



Co-funded by
the European Union

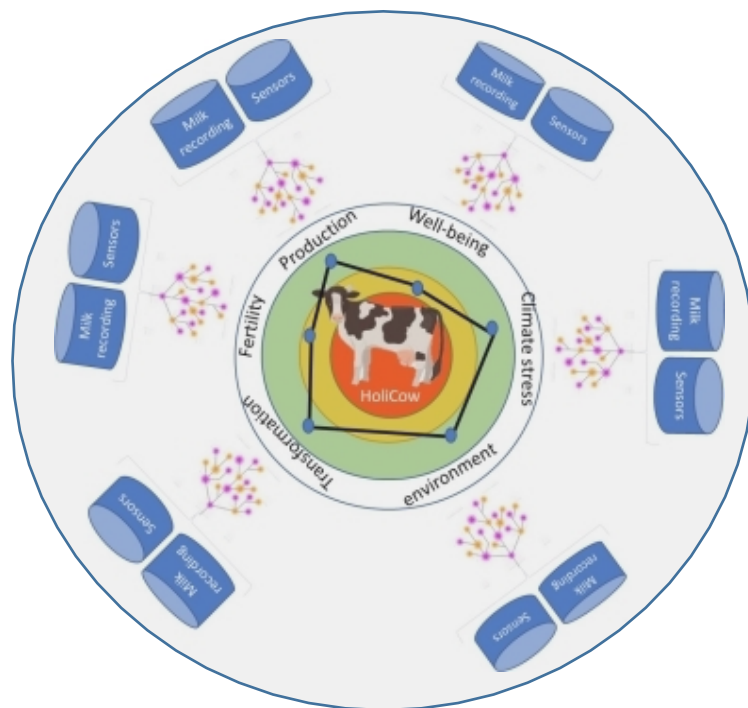
North-West Europe

HoliCow

Start date 01/07/2023

End date: 30/06/2026

Objective



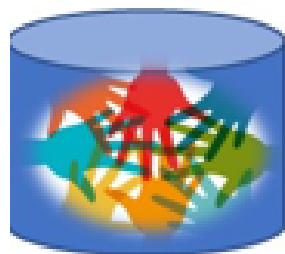
Use

- Results from previous projects (prediction equations)
- Other routinely collected data (sensors, diagnoses)

➔ Production of an easy-to-understand single indicator to assess the cows and herd health



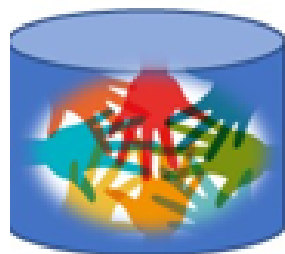
Objective



Community
database

- Possibility for a farmer to
- Provide feedback and improve the tool
 - Provide information on the solutions taken up at his farm to improve his results
- ➔ « Forum » for farmers

Objective



Community
database

Possibility for a farmer to

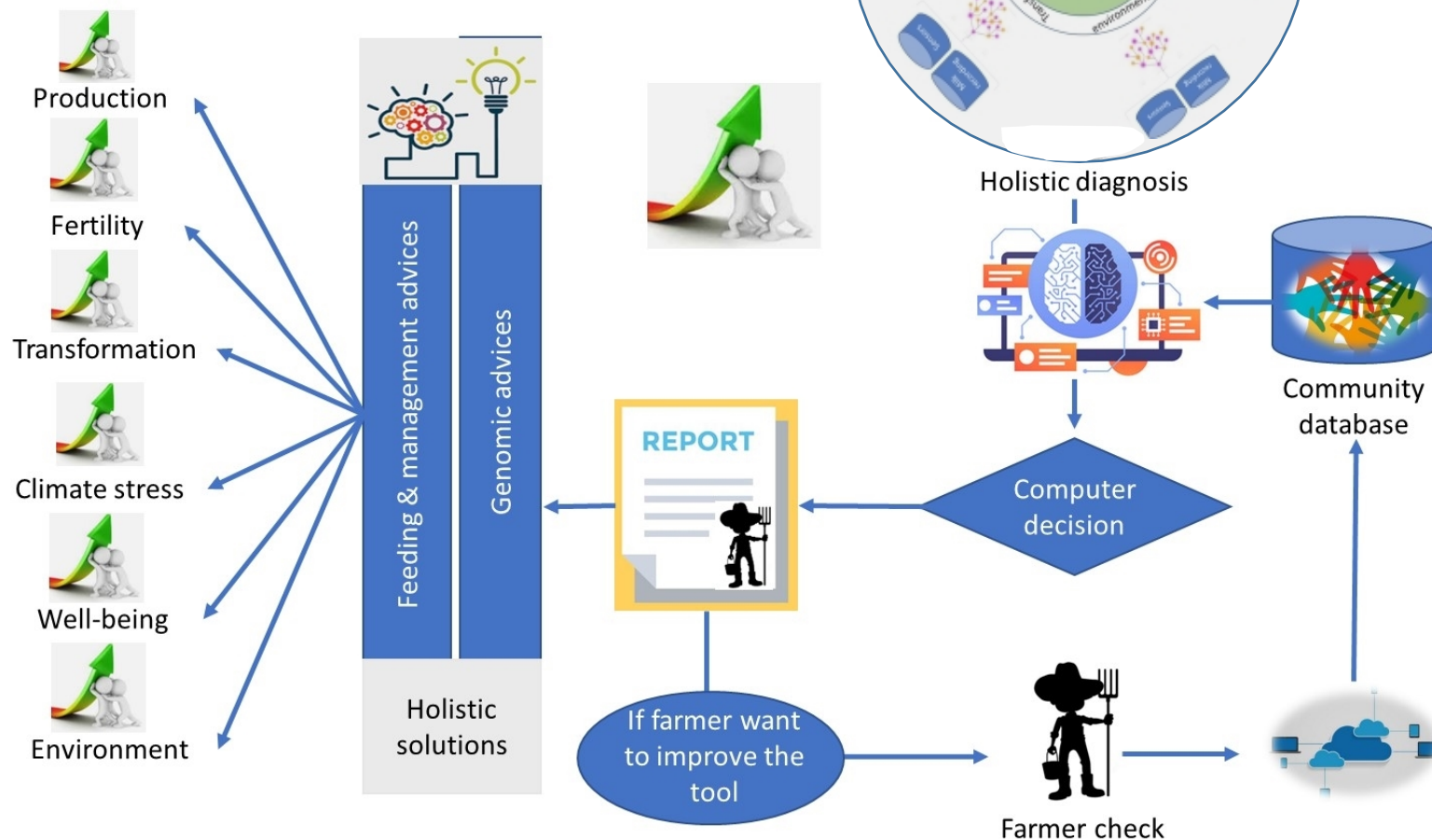
- Provide feedback and improve the tool
- Provide information on the solutions taken up at his farm to improve his results

→ Forum for farmers



- Anchoring the farmer in its community
- Image development of small farms in rural areas

Objective



Thank you!

Contact:

Julie LEBLOIS (jleblois@awegroupe.be)

<http://www.happymoo.eu>

 **@HappyMooProject**

