ASSESSING DAIRY CATTLE HEALTH WORLDWIDE

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1. INTRODUCTION

There is a large variation in the health status of dairy cattle worldwide. This variation on the one hand is partly due to differences in the occurrence or recurrence of diseases which are epidemic in nature. Examples are FMD, brucellosis, tuberculosis, and tick-borne diseases like anaplasmosis, cowdriosis, theileriosis (Preston & Jongejan, 1999). A lack of prevention and control programs for such diseases or failures in such programs contribute to these differences. Lack of control and control failures may be caused by e.g. political, geographical, wildlife-related, financial and socio-economic limitations. They may be further hampered by certain dairy cattle husbandry practices like transhumane, subsistence or community farming, while high cattle densities (sometimes in conjunction with high density of other livestock) will contribute to a potentially rapid spread of highly contagious diseases, once introduced into an area.

On the other hand, a large variation worldwide can also be observed in diseases which are endemic in nature. Examples are BVD, BHV-1, leptospirosis, salmonellosis, tick-borne diseases like babesiosis, but also mastitis, lameness, metabolic and nutritional disorders, reproductive disorders. Differences in prevalence of endemic diseases are largely caused by variations in geographical conditions, husbandry methods, level of intensification, specialization and technology, management skills, knowledge, socio-economic and sometimes political conditions.

This paper addresses the assessment of dairy cattle health in different regions of the world, predominantly focusing on endemic diseases.

2. DAIRY CATTLE HEALTH

Generally speaking, dairy cattle health can be expressed as the level of clinical and subclinical disorders on a farm or in a region. Both will affect productivity in terms of growth, milk yield, meat and economic value. Disease and health are components of an economic function (McInerney, 1988). This function can be presented as in Figure 1.

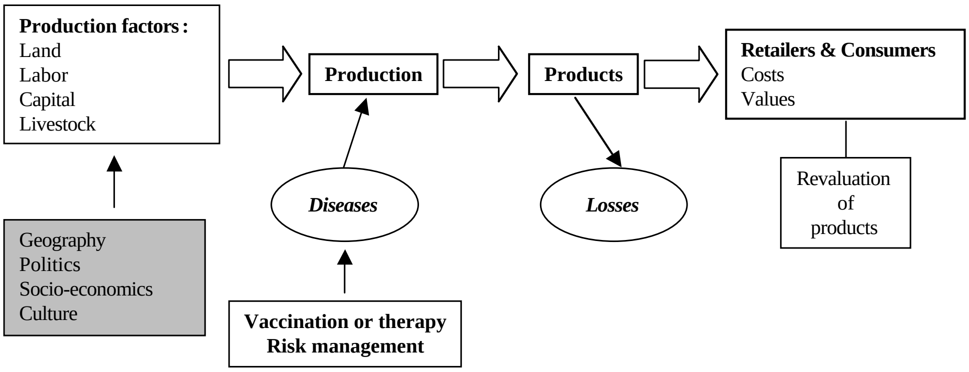

Figure 1. **Health and disease as components of an economic production function**

Disease causes loss of production and product loss, set aside the additional costs for extra labor, veterinary intervention, and product withdrawal time. In developing countries dairy production and cattle diseases are moreover related to geographical conditions, politics and socio-economic issues (Makuze & Wollny, 2005).

Consumers who ultimately pay for the product (costs), will at the same time value such products (public image) and (in case of overt disease) revalue the products. Especially in developed countries this function plays a paramount role in dairy production, not in the least because consumers have become very critical about animal production methods and husbandry, as well as the use of vaccines and medicines over the last decades. In developing countries, the prospects of cattle production largely depend on the extent limitations are prevailing in the area of geography, politics, infra-structure, culture, and socio-economics (the grey zone in Figure 1). Examples are available in literature (Zwart *et al.* 1998; Woods, 2001).

While vaccination strategies may be substantial in one region (e.g. USA), they may be less applied in others (EU), e.g. due to restrictions in the latter. Vaccination may be a desired intervention in yet another region (e.g. Africa) but financial and political limitations may lead to a non-consistent and non-sustainable strategy.

While therapy may be sophisticated in one region, for example based on both microbiological culturing in well-equipped ISO-certified laboratories and on antibiotic sensitivity testing, it may be poor in other regions due to lacking equipment, scientific support and knowledge or strongly prevalent ethno-veterinary principles.

Zwart *et al.* (1998) have depicted the animal health constraints in different ecological zones (Table I). Part of the explanation for differences is in the fact that in developing countries the animal production is multifunctional: milk, meat, manure, draught power, social status, capital asset & insurance, fibres, and, sometimes, that (imported) cattle breeds are not well adapted to local climatic conditions and feedstuffs.

Table I. **Animal health constraints in different ecological zones**

Constraints	Arid	Semi-arid	Sub-humid	Humid	Highlands
Epidemics	+	+	+	+	+
Vector-borne diseases	+	+	+++	+++	+++
Parasitic diseases	--	+	+++	+++	+++
Production/management	--	++	+++	+	+++

= largely irrelevant
+ = some relevance
++ = moderate
+++ = high

Given the decreasing margins between costs and income in the western world, farm economics is becoming very critical. In the western world the veterinary costs associated with health and disease (curative and preventive) are somewhat around the 1 to 3 € per 100 kg milk. Part of this represents systems costs, most of it however refers to failure costs.

In both clinical and subclinical disease, individual cases and herd problems can be distinguished; often the discriminatory level is set at 15%. When there are less than 15% of the cows in a herd affected, one speaks about individual cases, while when more than 15% of the cows in a herd are affected one speaks about herd level problems. For small-holder dairy farms with between 1 and 5 cattle heads this level is not applicable. For health assessment purposes in the latter case the epidemiological unit is the herd, meaning that in a small-holder region many small-holders should be taken into consideration, while a small group of larger farms can be representative for the whole region with larger farms and hence a stepwise sampling procedure for disease detection would be appropriate. The perception of impact of health disorders can be different for small-holders vs larger dairy farms (Table II).

Table II. **Perceived impact of disease on health economics and product quality**

Impact of disease →	**Clinical disease on health economics**	**Subclinical disease on health economics**	**Impact of disease on product quality**
Individual cases			
Small-holders	xxxx	????	xxx
Larger farms	x	x	---
Herd level problems			
Small-holders	xxxx	????	xxx
Larger farms	xx	xxx	(xx)

One of the greatest drawbacks on perception of impact of subclinical disease on small-holder farms is the lack of knowledge among farmers: "What cannot be seen, will not be there". The latter further explains the public health hazard that raw milk may represent when directly sold to the consumer in the street without preceding checking for potentially harmful pathogens.

To position the respective farms in the disease-development pattern we can use Figure 2.

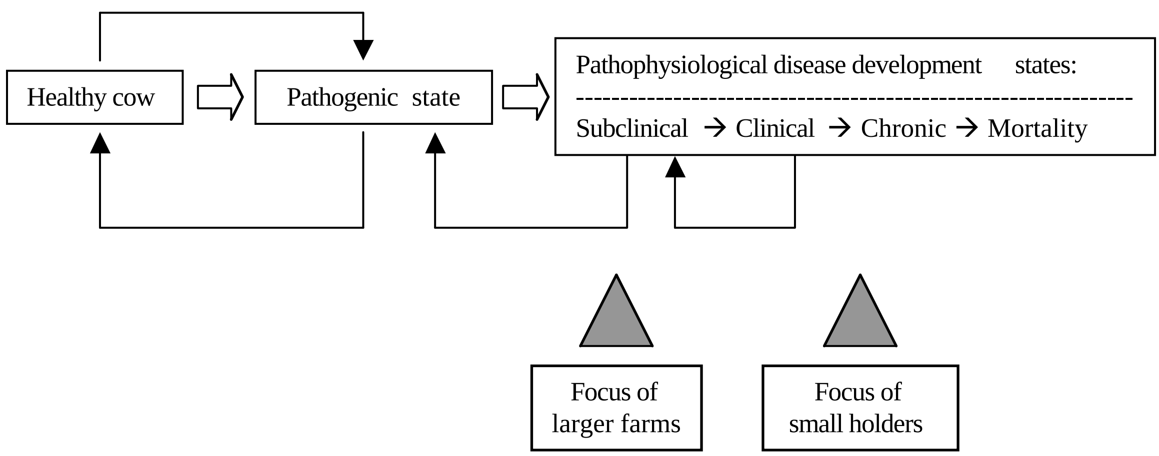

Figure 2. **Diagram representing different transition stages of disease development, and the positioning of larger farms and small-holders by means of their main focus**

Small-holders appear to be largely unaware of the pathogenic processes of disease. This will hamper efficient and effective disease eradication, control and prevention programs in the field. The most substantial elements for these farms are in teaching and training, rather than in obtaining, say, antibiotics for treating disease (antibiotics which may not be first veterinary choice fir that given disease anyway). When attention is given to this disease state, it appears that farmers more easily adopt control strategies (Kivaria *et al.* 2004a, 2005). The outcome of a longitudinal survey on clinical mastitis among small-holder dairy farmers in Tanzania largely pointed to the same udder pathogens as found elsewhere (Sol *et al.* 2002) (Table III).

Table III. **Results of a longitudinal survey into clinical mastitis pathogens in Tanzania as compared to those data from The Netherlands 1975/2000** (Kivaria *et al.* 2004a, 2005; Sol *et al.* 2002)

Micro-organisms detected in milk samples	**Tanzania**	**The Netherlands**	
		1975	***2000***
S. agalactiae	16%	12%	0.4%
S. dysgalactiae	5%	16%	8%
S. uberis	4%	15%	17%
S. aureus	26%	39%	23%
Coagulase-neg staph.	--	--	7%
E. coli	14%	2%	26%
Klebsiella spp	14%	--	0.5%
Pseudomonas spp	8%	--	--
Culture-negative	10%	47%	30

Many endemic diseases in dairy cattle throughout the world are to a large extent characterized by management failures. Examples are presented in Tables IV and V.

Table IV. **Example of risk factors associated with subclinical mastitis due to *S. aureus* in small-holder dairy cattle in Tanzania** (Kivaria *et al.* 2004a)

Risk factors for *S. aureus* subclinical mastitis in Tanzania	**Odds Ratio**
Low frequency of water availability	2.9 **
Number of handmilkers > 2	2.3 *
No single udder towel used	9.3 **
Residual suckling by calf	0.2 *
Poor housing a/o hygiene	9.9 **
Teat lesions present	7.4 ***
No dry cow therapy applied	5.1 ***
Poor water microbiological quality	5.9 **

* = $p < 0.10$
** = $p < 0.05$
*** = $p < 0.01$

Table V. **Findings during routine checks of the milking machine** (GD, 1981)

Findings at milking machine checks	**On 5417 observations**
Too high vacuum	14%
Too low reserve	14%
Air leaking regulator	34%
Air leaking tubes	44%
Dirty regulator	10%

The relevance of management issues in relation to the occurrence of health disorders in dairy cattle appears.

Therefore, it is paramount that regarding health of dairy cattle much attention has to be given to the monitoring of animal- and management- related issues on the dairy farms, irrespective whether these are small-holders or larger farms.

3. DAIRY CATTLE HEALTH MONITORING

Monitoring of health refers to a practical methodology to routinely, rapidly, cheaply and effectively gather sufficiently reliable information about certain issues in both dairy cattle and their direct environment. The ultimate goal is to interpret monitoring findings properly and make inferences about the question whether there are (pending or prevalent) health problems in the herd. This will subsequently be the basis to design a plan of actions for the shorter and the longer term. Examples of monitoring issues can be found in Table VI.

Table VI. **Examples of animal, environment (including management) and information related issues for routine monitoring**

Animal-related	Environment-related	Data/information-related
Body condition score	Farm hygiene	Milk quality parameters
Rumen fill score	Milking hygiene	Somatic cell counts tank
Faeces consistency	Milking machine function	Milk bacteria counts
Undigested fraction	Ration formulation	AI and choice of sires
Teat end callosity	Feeding management	Water quality test report
Locomotion score	Pasture management	Roughage analysis reports
Reproductive tract exam	Housing conditions	Concentrates contents
Clinical cases = indicators	Barn climatic conditions	Milk recording data

For many dairy cattle-related issues scoring methods and charts have been developed. Some examples are body condition scoring (Mulvany, 1977); rumen fill, feces consistency and undigested fraction in feces (Zaaijer & Noordhuizen, 2003), teat end callosity scoring (Neijenhuijs *et al.* 2000). These scoring charts appear to be extremely relevant for creating or improving their awareness in dairy farmers about different processes and functions of their cattle.

Strictly speaking, the sensitivity of each of such monitoring issues can be very low. For example, Heuer (2000) has calculated the sensitivity of body condition scoring with respect to predicting negative energy balance and ketosis to be as low as around 25%; the same can be stated for milk fat to milk protein ratio as predictor for subacute rumen acidosis.

In the field not always an exact sample size needs to be calculated to detect pending or prevalent herd health problems related to productivity or management; not the last affected cow needs always to be detected to start action. Monitoring on the other hand must be executed in a broad sense, covering different areas of the farm and looking for cross-relationships, e.g. between nutrition, fertility and lameness. That is exactly why veterinary herd health programmes must be executed in a multi-factorial and multidisciplinary way.

There are 4 different dimensions in monitoring, as is depicted in Figure 3.

Within each country, region within country, and on each farm a selection has to be made from the 4 dimensions in Figure 3 what to do, why, when, how often and how. This selection must be based on the chosen goals. Such selection will depend on the disease(s) of concern, priorities of the farmer, the feasibility on the farm, and the relevance given the health situation on that farm.

Health monitoring as indicated above is valid in every situation on every farm, when it is properly executed according to the forenamed guidelines.

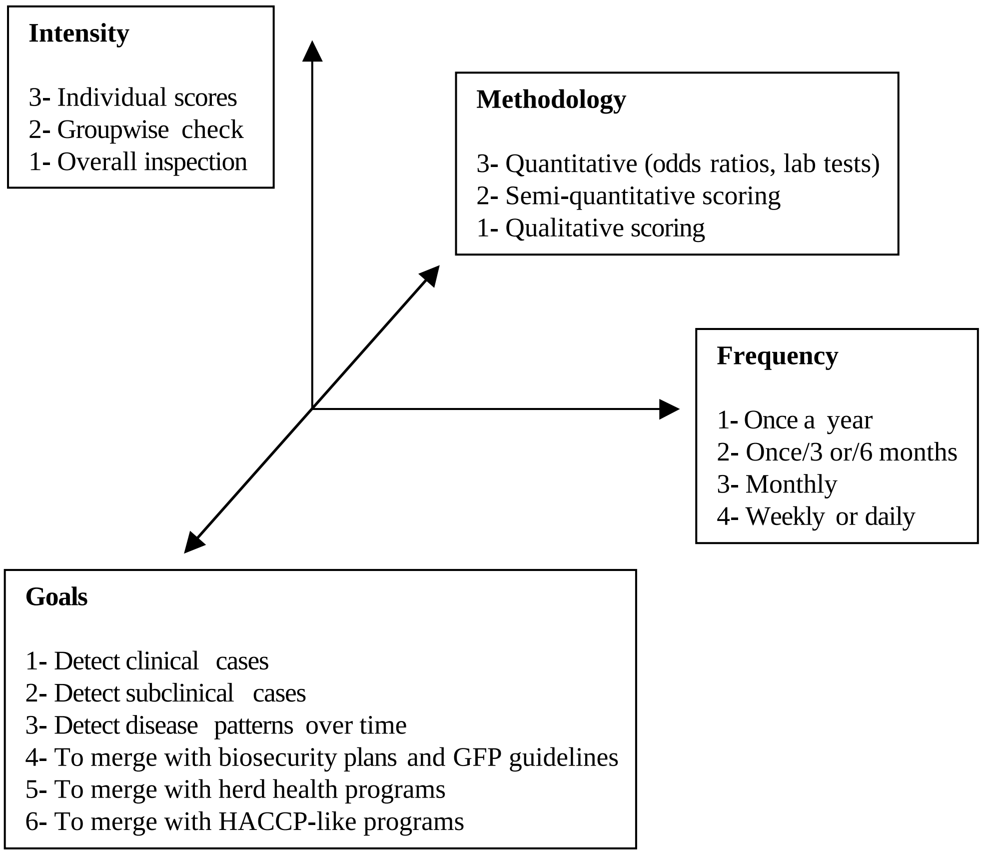

Figure 3. **The 4 different dimensions of monitoring cattle health on dairy farms**

Note: GFP, Herd Health and HACCP are addressed in the text below

In addition to cattle health *per se* it has appeared economically worthwhile to consider elements of cow comfort as prerequisites for optimal health (Noordhuizen & Lievaart, 2005). Cow comfort comprises 4 main components:

- feed and feeding-associated issues,
- barn and barn climate,
- housing,
- specific cattle behavior.

These 4 components refer to basic measurements and requirements of cattle with regard to their biological needs (Bracke *et al.* 2001). For assessing cow comfort different scoring or monitoring parameters can be defined in addition to measuring the various elements of housing, climate and feeding. These parameters can be considered as potential risk factors which might hamper health, reproduction, production and welfare, and are, hence, closely related to the issues addressed above. The interaction between floor design and maintenance on the one hand and locomotion and lameness of cattle on the other hand, shows that cow comfort issues and cattle health are very closely related (Somers *et al.* 2003). It is obvious from the elements of cow comfort that this issue is highly relevant for dairy farms in the developed world with respect to health, production and welfare; on dairy farms in the developing world it is equally relevant for better health and production, while welfare may come as secondary.

4. FORMAL SAMPLING FOR DISEASE DETECTION

There are next to health problems associated with productivity and management, however, also diseases for which formal sampling is warranted, either for disease detection, eradication campaign purposes or for establishing freedom of a certain disease, e.g. a zoonosis or a notifiable, highly contagious disease. In those cases veterinary epidemiological methods involving formal sampling procedures and biostatistical techniques apply. Below are just a few crude examples of sampling formulae (Noordhuizen *et al.* 2000).

Sample size to estimate a disease prevalence in a cattle population:

$$n = [(t \times SD)L]^2$$

n = sample size

t = value of the normal distribution of observations at a certain confidence level, e.g. at 95% (1.96) or at 99% (2.58)

SD = standard deviation (which is fixed because we deal with proportions)

L = absolute error that is accepted, e.g. 5%

Sample size to detect a disease in a cattle population:

$$n = [1 - (1 - a)^{1/d}] \times [N - (d - 1)/2]$$

n = sample size
a = confidence level, e.g. 95% (0.95) or 99% (0.99)
d = minimally expected number of diseased animals
N = size of total population

The latter formula can also be used for determining the maximum number (d) of animals testing positive in a diagnostic test, when all samples taken have tested negative. The formula has simply to be elaborated in another way.

These and other formulae can be found in the public domain (training) software WinEpiscope which can be downloaded from several websites (see references list).

More about veterinary epidemiological concepts, principles, methods and techniques can be found in standard text books and other software (Martin *et al.* 1987; Thrusfield, 1995; Noordhuizen *et al.* 2000).

It is highly warranted that (quantitative) veterinary epidemiology is fully integrated in the veterinary curricula over the world, and largely applied both at organizations like the EFSA, the European Food Safety Authority, and in national animal health institutes and diagnostic laboratories. For field practitioners it is worthwhile to consider participation in epidemiological networks.

5. MONITORING CATTLE HEALTH IN THE FIELD AND VETERINARY SERVICES

5.1 Small-holder dairy farms (tropics and non-tropics)

In addition to diseases for which control programs are or could be in place such as FMD, brucellosis, tuberculosis, tick-borne diseases, management diseases are very important for farm-economic reasons.

The rapid and early detection of both clinical and subclinical production diseases as well as their appropriate treatment can reduce the losses that already occur. This relates to mastitis, claw disorders, reproductive disorders, endo/ecto-parasites, and nutritional disorders (ketosis; acidosis), which may, moreover, lower the general disease resistance. Management skills and knowledge are pivotal here-in. Farmers must be thoroughly trained and educated before control and prevention programs can be designed, implemented and adopted (Kivaria *et al.* 2004a, 2004b; Klopcic & Osterc, 2005). Parts of such education and training must be dedicated to hygiene practices and risk identification and management.

Substantial improvement of cattle health status on these farms cannot be achieved than after strongly improving nutritional status of cattle. The phenomenon of ketosis is well-known on these farms, but (contrary to large farms in the western hemisphere where it is due to severe negative energy balance at high milk yields) it is associated with poor nutrition and deficiencies in developing countries, like in Africa (Murondoti, 2002). Next to improvement of nutritional status, the monitoring and control of subclinical diseases is a must for these farms (Kivaria *et al.* 2004a, b). The application of appropriate and cheap cow-side tests (Rollin, 2006) may be supportive; the CMT/T-pol test is an example. Simple, instructive protocols in the format of wall charts with pictures can be highly supportive too. The execution of monitoring cattle health itself is not different from that on other farm types. In spite of the forenamed, a major drawback in improving animal health status on small-holder farms is the lack of veterinary infrastructure. The local availability and accessibility of veterinary livestock technicians are very often a limitation to offering proper veterinary services, while on the other hand the veterinarians are too expensive, too far away or too few in number to provide such services (Woods, 2001). Finally, imported non-endogenous cattle breeds do often not very well adapt to local climatic conditions, feedstuffs, pathogens or management.

5.2 Larger dairy farms

Items named in Table V will be monitored more often and more broadly on larger dairy farms than on small-holder farms. Moreover, they will show more fine-tuning with regard to the respective items (see dimensions in Figure 3). In addition to clinical disease detection, these farms will much more focus on disease risk identification and risk management to prevent diseases from occurring and avoid economic losses. Some of the risk management features will appear in Good Dairy Farming Practice, GFP, guidelines. Examples of such guidelines are:

- Good Medicine Application Code of Practice,
- Good Milking Hygiene Code of Practice,
- Good Feeding Management Code of Practice,
- Good Footbath Management Code of Practice.

GFP guidelines comprise protocols and work instructions regarding the activities on a farm, the way animals and different farm conditions can be best dealt with, and how to best handle equipment and utensils. They are meant to reduce or eliminate the general health risks associated with dairy farming and farming activities.

When the monitoring of health and disease is combined with proper risk identification and risk management, one could consider the design of GFP-guidelines, as well as of Biosecurity Plans for controlling introduction and spread of infectious diseases in/on the farm. BAMN has issued several guidelines for designing Biosecurity Plans for dairy farms (BAMN, 2000). It is foreseen that, for example, in the European Union GFP guidelines, and possibly HACCP, may become compulsory in the era 2010-2015.

A further step in the expansion process regards the merger with veterinary Herd Health & Production Management, HHPM, programs (Brand *et al.* 2001), where operational (health) farm goals are taken into consideration to avoid economic losses and increase income by the routine application of farm visits, monitoring activities and advisory/intervention plans. Monitoring of both animals, their direct environment and information is an essential component in such HHPM programs.

A final step in the expansion process is the merger of the preceding with Quality Risk Management, QRM, programs, in which hazards and risks are formally identified, and where formal critical control points, CCP, and points of particular attention, POPA, throughout the production process are monitored according to a formal and structured approach (Noordhuizen & Welpelo, 1996; Lievaart *et al.* 2005). The application of the HACCP, hazard analysis critical control points, concept with its 7 principles and 12 steps appears to be the best way to deal with this approach, especially when both animal health, food safety and animal welfare are involved.

A workshop on HACCP-like applications on cattle farms is part of this WBC 2006 congress.

The development of the forenamed mergers can be described as is presented in Figure 4.

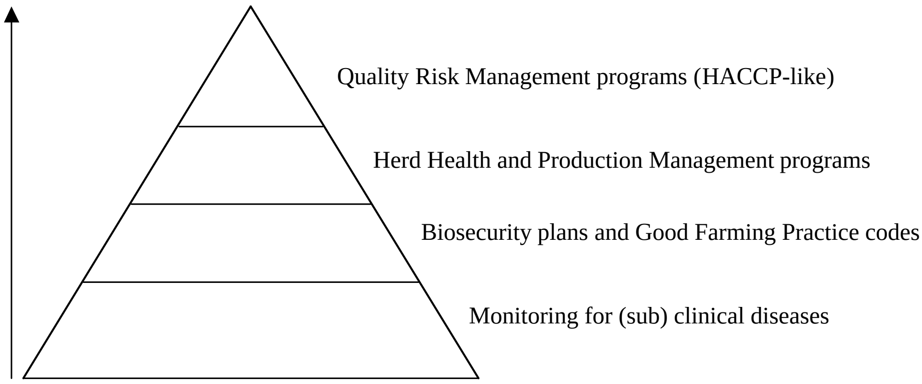

Figure 4. **The various developmental steps for assessing dairy cattle health according to different goals, formats and needs**

6. CONCLUSIONS

Although the dairy cattle health situation throughout the world may be different with regard to the diseases prevalent, it is obvious that all dairy farms form part of a certain developmental process in time and each has a position on that time-line. Associated with that position is the need for training, skills and knowledge development (small-holders) or the demand form society and industry to link up with the dairy food chain and quality assurance programs (larger farms).

Many, often simple and cheap, management instruments are currently available to assess cattle health, both qualitatively and quantitatively. Monitoring instruments have been proven valid and applicable in every condition and should be more widely applied for early detecting pending or prevalent health problems. We have trained our veterinary students in complex disease matters and modeling, but often we have forgotten to teach them the basic issues of health observations; the latter (to a large extent) also applies to our dairy farmers.

With regard to dairy cattle health the main issues regard knowledge about disease development, risk conditions potentially involved, and the hazards that are associated with animal health status. In developing countries moreover constraints for treatment and diagnostics do exist. Attitude building and enhancing the proper mentality regarding both cattle health improvement, and product and process quality improvement, are elementary issues.

Finally, when we are able to integrate the different health and disease approaches into one program, the dairy farmers can largely benefit from its advantages without the burden of an overload of documentation and extra labour. Imposing quality assurance including cattle health in a top-down manner will create resistance in farmers; adoption of such programmes is enhanced by including operational herd health management issues.

7. SUMMARY

This paper addresses the different levels of cattle health throughout the world under different husbandry systems and constraints, and the various methods to assess cattle health. There is a difference in focus on health between intensive large cattle operations in the developed world as compared to small-holders in developing countries. Next to formal sampling procedures, attention should be given to cattle monitoring according to easy techniques and distinguishing four dimensions. Once the basis of health monitoring is laid, one may expand to other levels of health improvement like through herd health programmes, good farming practice guidelines and biosecurity plans and quality risk management programmes.

8. KEY WORDS

Dairy cattle, health management, health monitoring, biosecurity, quality risk management.

9. RESUME

Cet article traite des différents niveaux de santé des vaches laitières, à travers le monde, dans des systèmes de production différents et parfois contraignants, ainsi que des méthodes pour évaluer cette santé. Des écarts peuvent être relevés entre les grandes exploitations intensives dans les pays développés et les petites fermes dans les pays en voie de développement, en ce qui concerne leur focalisation sur la santé animale. A côté de procédures formalisées pour prélever des échantillons, les éleveurs et vétérinaires devraient accorder plus d’attention à l’observation clinique du troupeau par des techniques simples. Pour cette étape, 4 axes sont à distinguer : objectifs, méthodologie, intensité et fréquence. Une fois cette étape prise en compte, d’autres niveaux de maîtrise de la santé pourront être inclus : gestion-suivis intégrés de troupeau, guides de bonnes pratiques d’élevage, bio-sécurité et programmes de gestion des risques de qualité.

10. MOTS CLES

Vache laitière, gestion de la santé, observation clinique, bio-sécurité, gestion de la qualité.

11. ZUSAMMENFASSUNG

Diese Arbeit beschreibt die unterschiedlichen Niveaus der Rindergesundheit in der ganzen Welt in verschiedenen Haltungssystemen mit deren Beschrankungen und die verschiedenen Methoden, um die Rindergesundheit zu erfassen. Es besteht ein Unterschied in der Konzentration auf die Gesundheit zwisschen den intensiven Rinderbetrieben in entwickelten Ländern im Vergleich zu kleinen Haltungen in Entwicklungsländern. Abgesehen von den formellen Methoden zur Stichprobenauswahl sollte darauf geachtet werden, dass fur die Beobachtung der Rinder einfache Techniken gewahlt und vier Dimensionen unterschieden werden: Ziele, Methoden, Intensität und Haufigkeit. Nachdem die Basis fur das Monitoren der Herde festgelegt ist, sollte man ein hohere Niveau der Herdengesundheit anstreben mit Hilfe von Herdengesundheits Programmen, Richtlinien zum "Good Farming Practice", Planen zur biologischen Sicherheit, und Qualität-Risiko-Management Programmen.

12. SCHLÜSSELWÖRTER

Milchkühe, Gesundheitsmanagement, Gesundheitsuberwachung, biologische Sicherheit, Qualitat-Risiko-Management.

13. RESÚMEN

Este articulo describe los diferentes grados de salud animal a nivel mundial bajo diferentes sistemas de manejo y dificultades, asi como distintos metodos para evaluar la salud animal. Existen diferencias sanitarias entre las grandes explotaciones de los paises desarrollados en comparaciaon con las pequenas explotaciones de los paises en via de desarrollo. Junto a los habituales procedimientos de muestreo, se debe prestar atencion a la monitorizacion del Ganado de acuerdo con tecnicas simples y distinguiendo cuatro dimensiones: objetivos, metodologia, intensidad, frecuencia. Una vez que se han establecido las bases para la monitorizacion de la salud, uno puede extenderse a otros niveles de mejora de la salud animal como los programas de salud des rebano, recomendaciones sobre buenas practices ganaderas y planes de biosguridad, y programasde manejo de riesgos de calidad.

14. PALABRAS CLAVES

Ganado lechero, manejo sanitario, monitorizacion de la salud, bioseguridad, manejo de riesgos de calidad.

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Public domain software on veterinary epidemiology applications, including training

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