Cattle disease control programs in Spain

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Abstract

The status of control programs for cattle diseases in Spain is reviewed. For that purpose, the 17 Spanish autonomous communities with a cattle population were surveyed on 25 cattle diseases deemed important by the European Animal Health Law. There are two diseases (contagious bovine pleuropneumonia – CBP – and enzootic bovine leukosis – EBL –) of which Spain is officially free, four (anthrax, bluetongue, epizootic hemorrhagic disease and bovine genital campylobacteriosis – BGC –) that are sporadic, one (Aujeszky's disease) perceived free, fourteen endemic (infectious bovine rhinotracheitis – IBR –, bovine viral diarrhea – BVD –, neosporosis, paratuberculosis, Q fever, trichomonosis, salmonellosis, fasciolosis, *Staphylococcus aureus* infection, *Mycoplasma bovis* infection, *Trichophyton verrucosum* infection, bovine coronavirosis, bovine respiratory syncytial virosis and *Streptococcus agalactiae* infection) and two of unknown (leptospirosis and bovine digital dermatitis) status. Twelve diseases are under a national or regional control program and eleven are not. Anthrax, bluetongue, EBL, IBR and CBP are submitted to national programs. IBR is endemic and has been recently submitted to a national control program. Bluetongue appears occasionally and usually is quickly dealt with. In relationship with the others, Spain is officially or perceived free. BVD is submitted to control programs in 7 and 4 regions, respectively. Most programs have been developed during the first decade of the XXI century. At this point it is not possible to estimate the utility of the programs except for Galicia in IBR, BVD, neosporosis and paratuberculosis and the Basque Country in paratuberculosis. The involvement of farmers associations in the development of control programs by itself is probably a good system, but, except for Galicia, where clear reductions have been achieved, it seems to fail to make a good assessment of disease control progress or at least to make them readily available. It is noteworthy to point out the success with paratuberculosis control in the Basque Country. However, this might be due to the side effect of having a research center with a longtime focus on that disease. A lot of information that is collected at a substantial cost could be better exploited to monitor the programs themselves and to open the way for other regions or countries. An effort must be made to unify information collection systems and to keep them well maintained with periodical reports published either as scientific reports or, at least, in readily accessible internet sites. Another relevant issue that should be taken into account in the future that can prompt to rightly exploit the information is to analyze costs of the running programs in order to press program responsible administrators to elaborate and to share knowledge generated in the course of these programs.

1. Introduction:

1.1. Control programs overview and report objectives

Sustained efforts to control zoonotic endemic cattle diseases have allowed reaching eradication of brucellosis and a substantial progress against tuberculosis in Spain, of which two regions have recently been declared officially free. These advances have favored production and trade making the cattle industry safer, and more stable and profitable. However, there are other diseases that have less impact on production and are not zoonotic but that still cause substantial loses to farmers and have not yet been included in unified European regulated control programs until recently. Control of these diseases will increase animal health and welfare and reduce antibiotic use, as well as reduce direct (e.g. increase production, reduce morbidity and mortality rates, treatment expenses, etc.) and indirect losses (e.g. trade constrains, management changes, poor industry image, etc.) associated with the specific diseases. The relatively lower strength of these driving forces make difficult to handle control programs with classical strategies. On the other hand, the need of standardization of freedom of disease indicators, through the different European territorial policies has prompted to develop the COST Action (CA17110) "Standardizing OUtput-based surveillance to control Non-regulated Diseases in the EU" (SOUND control). This action aims to support output-based disease surveillance initiatives and to develop a framework that could be used to estimate the confidence of freedom from specific cattle infectious diseases (SCID)[1]. In order to achieve these objectives a first step is describing the situation of these cattle diseases control programs in Europe at different scales. An EU overview first reference document has been published[2] in addition to another more general on control program data availability[1]. In it, out the long list of diseases affecting cattle, 23 diseases susceptible of a control program were considered as of common or local interest and kept for further analysis at European and member state level. The present report intends to contribute to filling in a gap in the knowledge on the status of these SCID-CPs in Spain and thus to contribute to the building of a European picture by summarizing the Spanish scenario in a single depiction of the current situation of these SCIDs plus tuberculosis and brucellosis throughout its 17 main administrative divisions.

1.2. Spain administrative organization

Administratively, Spain is divided into 17 regions or Autonomous Communities (AC) and two Autonomous Cities (no cattle population). Animal health is an autonomic competence and therefore the regional parliament and government are the primary territorial legislative and executive authorities comprising the design and deployment of cattle disease control programs. Livestock administrative services usually rank at the second level of the regional government below the

appointed head of department or counselor as a directorate. Then there is a Head of Animal Health Service generally selected by merits among the regional veterinary career civil servants.

The Spanish central government Ministry of Agriculture, Fisheries and Food (Ministerio de Agricultura, Pesca y Alimentación – MAPA) through the General Sub-Directorate of Animal Health and Hygiene and Traceability (Subdirección General de Sanidad e Higiene Animal y Trazabilidad) has the legally higher competence on animal health and coordinates the different regional activities, sets the framework for disease surveillance and control, and liaises with the European Commission and other international organizations like the OIE.

Taking into account the multiple autonomic scenarios, different control programs are applied both in dairy and beef cattle for NEURCD diseases, most of them based on regional legislation. These programs are carried out by general purpose or animal health defense (HD) farmers associations concurring to specific calls for subsidies from the corresponding AC administration. The former are more breeding and production oriented and the latter more territorially based. Both are voluntary, but given the economic and lobbying benefits they give access to, they are widely and solidly rooted in the Spanish livestock industry. The predominance of one or another varies throughout the country according to the province and the production system. In all cases, the funding is annual and submitted to approval of the action program by the regional government. Then, each association must report, at least annually, or at the end of each subsidizing period on the program activities to the subsidizing administration. Each association has its own history and was created at a different time, although most of them were founded in the late eighties of the last century. Additionally, for cattle mixing in summer communal pastures, the local pastures authority determines the rules to access these pastures which increasingly include testing for venereal diseases (trichomonosis and campylobacteriosis). Breeding livestock going to communal pastures are currently compulsorily tested only for tuberculosis and, depending on their origin, bluetongue. Brucellosis used to be also submitted to obligatory testing, but since Spanish provinces have been gradually declared officially free, since 2016, testing has ceased.

1.3. Overall description of the cattle population in Spain

The cattle production in Spain accounted to about 15% of the final agricultural product, in the first months of 2021[3]. This production was sustained by a population of 5,683,448 cattle, both beef, dairy and mixed located in 117,820 farms of an average size of 47 heads (Table 2). Its distribution throughout the territory is related to the different geo-climatic characteristics. According to these, Spain can be divided into two different big bioregions: the Atlantic and the Mediterranean. The humid and temperate Atlantic Spain is the north coast of Spain that includes, from west to east, the AC of Galicia, Asturias, Cantabria and the Basque Country (Figure 1). The dry

and continental Mediterranean habitats would be represented by the central and southern areas of the country, which include the remaining 13 AC. Those bioregions determine the management and type of cattle farms that can be found in each of them. In this regard, dairy herds concentrate in the north where there are abundant pastures that allow some grazing, while beef and bullfighting cattle are more abundant in central and southern regions. In the north is also common to find small herds mixed with goat or sheep, and throughout the rest of the country both extensive beef, mixed and dairy intensive systems can be found. Beef cattle is located both in the different mountainous areas throughout the country and in the extensive arid pastures in the rest of the country. Lidia (bullfighting) breed of cattle is a special breed and management system shared with Portugal and the South of France in the EU and it accounts up to 5% of beef cattle. It will not be included in this study because of its nearly complete separation from dairy and beef cattle management and trade circuits. According to this, cattle populations substantially vary from one region to another (Table 2, Figure 1).

Dairy farming [4,5] is constrained by high production costs, small farms and old age of the owners, although there is a trend to decrease the number of farms and increase its size. Beef farming has stabilized after several years of decrease[4]. Suckler cow farms are conditioned by the spread and remoteness of the pastures where the breeders are mainly kept. Feedlots seems to have switched to hired labor and facilities by big companies that own the animals and manage animal entrance and sale, but currently seem to enjoy a stable market because of export opportunities[3].

In general, farms raise only cattle and have become increasingly professionalized. However, there are still some small farms with a more diversified activity that are a significant part of the 48,873 farms smaller than 10 cattle[6].

1.4. Cattle health general considerations

The authors experienced opinion is that there is not so much biosecurity for cattle than for other species in more intensive systems. The use of pastures seriously limits the measures of biosecurity, being simple fencing the most common separation means in grazing animals. Biosecurity is higher for dairy farms that are kept within or close to the main property. In the most populated areas, the production system is very intensive and might entirely depend on an external daily ready-to-use mix input[7–10]. In the Cantabric coastal strip, where most of dairy cattle are located, heifers and dry cows are kept in fenced pastures, while lactating cows are kept indoors. In the mountainous areas, there is few fencing and many shared common pastures, with potential indirect interaction with other domestic animals or wildlife. This traditional way of using common seasonal marginal resources has prompted the development of some degree of control by farmers themselves because of the mixed interest of reducing grazing intensity and avoiding infectious diseases. Thus, it is

common the existence of local health clearance regulations for accessing these pastures preventing the entrance of lower health status individuals[11–13]. In the south-western half of the country the nearly climactic “dehesa” extensive system is widely used. It conforms a highly sustainable landscape of large, fenced properties with mixed grass and oak vegetal cover. Beef cattle herds in these dehesas are managed extensively with lower biosecurity and they are therefore at higher risk of infection due to contact with animals in other herds, as well as with other potentially infected domestic or wildlife species[14]. In those areas interspecies indirect contact is mainly observed in food and water resources, often scarce in the arid Spanish Mediterranean climate, which favor animal aggregation and therefore disease spread[15].

There is a relatively small volume of international trade of breeding animals, mostly imports for genetic improvement, while in the last years there has been a substantial export of beef animals towards Mediterranean countries[3,16]. In general, cattle replacements are raised in the same farm, but some trade allows to avoid inbreeding in beef cattle[8]. There are many local fairs and markets, but it is always a requirement to have an individual negative test, at least for regulated diseases (i.e., tuberculosis) immediately before transport.

For dairy cattle, artificial insemination fully dominates the breeding, with only some farms having a bull for backup[9,17]. However, beef cattle is mainly naturally bred with bulls, and therefore, there is some exchange of animals between farms to prevent inbreeding[18].

2. Material and Methods

2.1. Cattle diseases control programs assessment

In order to more precisely depict the overall Spanish picture, this study has focused on the primary sources and therefore has asked the regional animal health administrative services to report on the NEURCD control programs according to the questions formulated by a more general study at European level[2]. The data were collected and analyzed in two ways: a) a control program survey through a questionnaire sent to all AC animal health authorities to and b) an expert opinion discussion between the three senior authors (AB, JS, RAJ). The specifics are given below.

a) Control programs survey

Information was asked to the regional heads of the administrative animal health services in two rounds. In the first one, a blank spreadsheet with specific questions on cattle population structure was attached to an email briefly explaining the objective of the questionnaire (Table 1). In the second one, a draft table (Table 2) summarizing the information collected up to then was sent to the same veterinary officers for revision.

b) Control program expert opinion

Status of Spain regarding the 23 selected diseases was discussed by the three senior authors one by one in a videoconference, where control program status and factors affecting them in the Spanish production system were discussed. JS, a high-ranking officer in the Spanish Ministry of Agriculture in charge of Animal Health control programs coordination with the regional authorities and of reporting to the European Union, acted as the main expert given his close, continuous and legally mandated knowledge of the Spanish Animal diseases status and control measures[19]. This discussion implied a revision of the quality of the information.

Overall information on cattle population was extracted from the Integral Animal Traceability System (SITRAN) database from the Ministry of Agriculture, Fisheries and Food (MAPA)[20].

Summary tables were built with the information collected from the regions and the SITRAN data for population data of those that did not send information. One displayed cattle population structure (Table 3a) and the other on the frequency of the regional disease control programs (Table 3b). Information on the prevalence of each disease in Spain and in other European countries was searched in standard and grey scientific literature in order to set the local and general disease framework for the Spanish control programs and complemented with expert opinion on diseases without a Spanish control program (Table 4).

Details on the control programs for each one of the 23 cattle diseases were summarized in Table 5. Prevalence and control program implementation disease by disease was discussed in relation with the situation in other European countries.

3. Results

3.2 Control programs survey and sources

Six AC answered the questionnaire at the first round regarding cattle population and HD associations that making up to a 35% success (Table 2). In this round Lidia cattle was included, but then it was decided that given its very specific and contained management system it should not be included in the final results. After this, in the second round, four more regions joined up reaching to a 59% participation rate. Of these, seven reported having at least one control program (Table 3b).

Indexed journal literature was the main source of information on cattle disease prevalence (Table 4). This was associated with a substantial bias on four diseases (paratuberculosis, Q fever, neosporosis and trichomonosis) for which this source provided restricted territorial or sample characteristics not representative of the whole country by themselves. The second source was expert opinion related to dealing with diseases that have drawn less scientific or epidemiological

attention. However, the experience on managing diseases and reporting had made MAPA officials aware of them at one moment or another. Official sources as the MAPA and EFSA were the other main source. The quality of these sources could be considered good or very good.

3.2.1. Specific regional programs (Table 5)

a. Infectious Bovine Rhinotracheitis (IBR)

Seven autonomous communities reported having a control program for IBR. Galicia started an IBR control program in 2004 and the other 6 communities began much later (Tables 4 and 5). Only Galicia reported initial (34.9%) and current prevalence (4.4%), thus having achieved an 87% reduction. The Basque Country started a limited experimental IBR program in a few farms in 2006, but it was later discontinued. Currently, the provincial Basque administrations run independent monitoring programs including IBR, BVD, paratuberculosis and neosporosis whose results are not formally published. There is a voluntary Spanish national control program that is starting to be implemented during the current year 2021[21].

b. Bovine Viral Diarrhea (BVD)

Only four regions reported a control program on BVD. Galicia was the first to start its control program on BVD in 2004 with an estimated prevalence of 26.4% that currently has been reduced to 15.6%, that is a 41% reduction (Table 5). Control programs are voluntary and based on testing for antibodies and antigen in negative ones. Vaccination at farmer cost is also an option.

c. Neosporosis

At least three regions have adopted a voluntary control program based on testing of adults and culling the positives offspring. Galicia started its program in 2004 and Asturias followed suit in 2013. Galicia estimates sets prevalence at 23.7% at the beginning of the program and now reports a 6.9% seroprevalence, which means a 71% prevalence reduction (Table 5).

d. Paratuberculosis

There were three ACs reporting a control program on paratuberculosis. The first region to apply a program was Galicia in 2004, closely followed by the Basque Country in 2005. Asturias joined in 2013. Galicia reported an initial prevalence of 2.25%, while the Basque Country observed 10.7%. The main strategy is test and cull based on antibody detection confirmed by fecal isolation or PCR. Current situation has improved in both regions to 2.1% and 1.11% prevalence representing a 7% and a 90% reduction, respectively. In the Basque Country, the control program has an experimental vaccination branch aimed to compare with the standard test and cull. Overall shedders prevalence has decreased from 10.68% to 0.49% after 13 years of program, which represents 95% reduction.

However, vaccination achieved a stable 0% shedding by 10 years of control, while testing and culling still had some residual shedding by the 13th year of control (Table 5).

e. Q-fever

Coxiella burnetii infection in cattle is subjected to a control program in three regions: Asturias, Balearics and Basque Country. In all three the disease is considered sporadic and the control program is aimed at outbreak control in those associated with human cases or abortion storms (Table 5) and a national program has been recently published by the MAPA[22].

f. Bovine Genital Campylobacteriosis (BGC)

Two regions (Asturias and Basque Country) report a program for control of BGC at a local level (Table 5). It is applied to bulls going to common summer pastures. The pastures local councils establish the usage rules and include a negative control of BGC to grant access[23]. A national control program regulates control of BGC for semen collection centers[24].

g. Trichomonosis

In the current study, two regions (Asturias and Basque Country) reported a program for control of trichomonosis at a local level based on preputial scraping detection and culling of positives[25]. It is the same as for BGC applied to bulls going to common summer pastures. Likewise, it is aimed at keeping free of the *Tritrichomona foetus* the pastures where animals from different origins mix and bred. Only bulls with a *Trichomonas* pre-movement negative control are granted access. Implementation of a control program of those characteristics in Asturias increased the calving rate by 17.7%[25] (Table 5). There is also a national control program for *Bos*, *Bison* and *Bubalus* species bulls specific for semen collection centers that mandates preputial scraping testing and killing of positives[26].

3.2.2. National programs

a. Enzootic bovine leukosis (EBL)

A surveillance program for the 2021-2025 period is in place based on slaughterhouse surveillance and ELISA testing of a defined number of herds[27] (Table 5).

b. Contagious bovine pleuropneumonia (CBP)

The current surveillance program was issued for years 2021-2025 and consists of slaughterhouse passive surveillance and active surveillance on a defined number of herds with the complement fixation[28] (Table 5).

c. Bluetongue

There is an annual national control program based on different measures applied to all susceptible species according to season and serotype risk zone, active serologic and virologic surveillance, passive clinical surveillance, vector and tracer herd monitoring, and vaccination that allows quick eradication of the disease in the affected areas[29] (Table 5).

d. Anthrax

Anthrax is a hyperacute infectious disease caused by *Bacillus anthracis* that in Spain is submitted to a national compulsory surveillance and control program aimed at complete eradication based in biosecurity and vaccination for prevention and passive clinical surveillance for detection. No cases have been reported in Spain since the late 2000's[30] (Tables 4 and 5). Thus, no new information on its control has been obtained in the current study.

3.2.3. Other diseases without control programs

Salmonellosis, staphylococcosis, *Streptococcus agalactiae* infection, *Mycoplasma bovis* infection, fasciolosis, tricophytosis, coronavirosis and bovine respiratory syncytial virosis are endemic diseases that have no specific control programs for cattle in Spain and for which no prevalence estimates have been reported.

Leptospirosis and bovine digital dermatitis are diseases of unknown prevalence, while epizootic hemorrhagic disease and Aujeszky's disease are diseases from which Spain is perceived to be free.

3.2.4 Summary

There are two diseases of which Spain is officially free, three are sporadic, two perceived free, thirteen endemic and two unknown. Eleven diseases are under a national or regional control program and twelve are not.

4. Discussion

The method to collect field information used did not work as well as expected. Not only nearly half of the subjects did not answer but the information was substantially incomplete regarding the specific aspects of control programs. Lack of a more direct personal approach possibly was the reason of a failure to get a 100% answer rate. The authors intended result was to leave time and freedom to answer to the territorial officers in charge of animal health control programs trusting that a simple email requirement via the central government would be enough to stimulate them to share the regional information. This might be due in part to the daily work overload, but also to lack of implementation of control programs on top of those for the regulated diseases or efficient record

keeping. Even though this lack of first-hand information reduced the fidelity of the NEURCD control programs Spanish representation, the good knowledge of the authors on the situation in their territory as well as similarities and difference with the neighboring ones or the overall view from the central Government Ministry of Agriculture, granted that the picture would not be substantially different from reality. Actually, the information obtained and the specific points of interest defined in the procedure would be a solid base and a stimulus to improve the completeness and quality of the information in a near future. Anyway, these results show that the information on control programs is scattered and still difficult to extract to build up a common picture. Therefore, an important conclusion of this study would be that, in addition to expanding the control programs, an effort must be made to standardize the recording and availability of information related to NEURCD control programs.

Spain is in line with the rest of European countries and has a similar number of diseases on control programs as the other countries (Table 6). The country structure reproduces quite well the European situation at a regional scale since there are 17 different governments that are autonomous in making their animal health decisions if basic national rules for an animal disease do not exist. Therefore the information on its workings and results is dispersed and, although available, it is not always at reach at any given time. Here we have tried to summarize this information, but we have not been able to get enough feedback from all the regions. Therefore the view is focused on those more willing to collaborate and share their data, although some regions did not send additional information because they run no other programs than the national ones on regulated diseases. This is a limitation of this report. Even with this shortcoming, this paper represents an effort in line with the spirit of the SOUND control COST action as it is a compilation of information that had never been previously put together. An important control program driver would be to include benefit/cost analysis that could show to all stakeholders the long term positive balance of developing such programs, or, at least, where the resources use should be prioritized.

Regarding the specific diseases:

a) IBR

IBR is endemic in Spain and there are voluntary control programs based on both testing and vaccination. The farm estimated prevalence in 2018 was 33.7% in dairy, 63.5% in beef and 38,4% in feedlots with a 19% vaccination overall coverage[21]. Individual prevalence estimates fall around 30% (Table 5). In Spain this disease has been recognized since the 70s of the past century, however, its clinical impact seems to be mainly restricted to feedlots, with few if any reports of abortions in dairy cattle and some in beef cattle. Reported prevalence in Spain is within the range of other European countries before running their control programs. Availability of vaccines, and specially

marker vaccines, has made this an individually controllable production disease whose costs are assumed by the farmer. Therefore, a drive to collectively fight the infection has not been enough strong until now to carry out a control program in each region. The recent drawing of a Spanish IBR program[21] is expected to provide better information on IBR impact and hopefully to control or even to eradicate the virus like as other member states have already done.

b) BVD

BVD was first detected in Spain in the early 70s of the last century and in the first study on seroprevalence, 47.8% of animals were positive[31]. Subsequent studies found herd prevalence over 84% and currently is considered to be endemic. Different regional reports set the herd seroprevalence estimates between 70.9% and 94.2% [32–35] and 25.5% regarding persistently infected individuals[36] (Table 5). BVD virus infection is one of the first causes of abortion in dairy cattle and therefore its control is a priority in the cattle industry. Vaccination and an efficient strategy to deal with persistently infected animals has allowed a certain degree of control that seems to be enough to maintain reasonable production levels without incurring in the costs of a collective action. Like IBR, the prevalence falls within the range reported other European countries (Table 5). However, Spain is behind countries like Germany, Netherlands and Denmark in the implementation of control programs against BVD which are the second most reported. Decrease of bovine tuberculosis prevalence is likely to free resources to approach BVD control.

c) Neosporosis

Neospora caninum is endemic in both dairy and beef cattle and constitutes a serious threat for farms. Different farm prevalence estimates in Spain range from 30.6% to 87.7% in dairy cattle and from 41.0% to 76.7% in beef[37–39]. Together with BVD it is the leading cause of abortions in dairy cattle (Table 5). Although it was a major concern during many years, detection and culling of carriers has allowed maintaining production at individual farm level and, therefore, not being a zoonotic risk, it has not driven implementation of control programs in all the ACs. Prevalence in Spain falls within the range reported in other countries (Table 5). Farm control practices allow maintaining acceptable production levels and therefore no control program seem necessary, like in other European countries.

d) Paratuberculosis

Paratuberculosis was first detected in Spanish beef cattle in 1983[40] and since then it has been recognized as an endemic infection affecting mostly dairy farms. Farm prevalence was estimated to be 8% to 10% in a bulk tank survey in the North of Spain[41]. Other studies have reported prevalence of 28.4% to 44,4% in Asturias[42] and 2.78% to 27.77% in Galicia[43]. However in a slaughterhouse study of Friesian cattle in the northern half of Spain[44] between 2007 and

2010, parallel interpretation of histopathology, serology, PCR and isolation yielded a 60.0% individual prevalence, representing 72.4% farm prevalence (Table 5). Paratuberculosis is a big problem for the dairy industry and less to the beef sector. No efficient control programs do exist and running those that have been implemented in some regions is very expensive and difficult to be implemented by the Spanish cattle industry even though clinical disease creates totally untenable situations in some severely affected farms that become unable to raise to adulthood and production their own replacers. Vaccination, is a highly efficient alternative, but cannot be implemented until tuberculosis programs have reached the maturity enough to objectively deal with the limited number of cross-reactions induced by paratuberculosis vaccine. Its use would allay any funded or unfunded fears of a zoonotic impact, that everyday seems to lose ground. The Spanish situation is similar to that in the rest of Europe, although a higher upper range prevalence limit (Table 5) is reported because the survey used the much more sensitive histopathological detection.

e) Q fever

Q fever has been recognized as a relevant zoonosis in Spain after reports of human case series in the 1980 in the Basque Country[45], and in the whole country[46] led to consider the province of Gipuzkoa as “hyperendemic” in humans[47]. Those human cases seemed to be more linked to small ruminants, but prevalence in cattle was estimated at 42.9% in beef cattle in the Basque Country of Spain in 2010 in semi-extensive beef cattle[48] and in 66.9% in dairy cattle in Bizkaia in 2012[49]. More recently another survey in Asturias reported *C. burnetii* in aerosols of 80% of investigated farms[50] (Table 5). This is a disease that had received very little attention until recently in most countries, while several studies have been carried out in different species in Spain due to early realization of its impact in humans[45]. Its impact on production seems to be very low and its importance comes from its clear zoonotic behavior. Prevalence in Spain is within the figures reported from other countries (Table 5). Given its prevalence in other species of ruminants where it seems to have more impact that in cattle, any attempt at control beyond the management of local outbreaks by stamping out, seems to be far away.

f) Enzootic bovine leucosis

Spain included EBL in the group of diseases for which an EU supported compulsory control program was deployed in 1986 covering the whole country. Initial herd prevalence was very low (1.52%) and closely related to dairy cattle imports in Madrid and Asturias. After an initial increase upon increasing the program coverage (2.56% in 1988), EBL prevalence decreased to 0.05% in 1999 when the officially free status was reached (Table 5). The last positive herds were detected in 2009 and currently, Spain maintains the officially free status EBL. In Spain, EBL is a regulated

418 disease[27].That has allowed that the disease were successfully eradicated, so the situation is similar
419 to that in most European countries (Table 5).

420 g) Bluetongue

421 Spain had been free of bluetongue since eradication of an epidemic in the 1950s until
422 detection of a serotype 4 outbreak in 2004. Since then several waves have appeared with the same
423 serotype 4 (2010), but also with serotype 1 (2007) and 8 (2013 and 2020) (Table 5). This repeated
424 pattern is likely to be an effect of global warming on a country located at the limit of distribution of
425 the competent vectors and close to Africa where it is endemic. As a consequence, Spain is at risk and
426 with a highly fluid situation variably affecting different regions[29]. The geographical situation of
427 Spain makes the country susceptible of bluetongue repeated outbreaks coming from endemic Africa
428 like other Mediterranean states. Energetic national control programs have repeatedly controlled
429 successive outbreaks, but need to be fully active all the time[29].

430 h) Bovine genital campylobacteriosis

431 Although the disease is considered a threat for beef cattle production in extensive systems and
432 especially in regions were highland summer common pastures are shared by different herds that
433 usually bred then, there is no much information on its prevalence in part due to the difficulties of
434 detection of these bacteria. The agent has been detected in farms with reproductive problems, but
435 not in a recent survey in free-ranging bulls in Asturias where *T. foetus* was frequently detected[51].
436 In another study in the central Pyrenees, bull infection rates ranged between 1.7% and 7.0%[52].
437 The European Food Safety Agency (EFSA) reports the disease as continuously present in Spain since
438 2010[53] (Table 5). The low clinical impact of this disease that causes important losses in extensive
439 systems make difficult to implement effective control measures. Reports on BGC prevalence in
440 Europe are scarce (Table 5). Demonstration field trials are showing to farmers the benefits of
441 controlling their bull reproductive health[25]. Therefore it is expected an improvement and spread
442 of current local control programs that are linked to those against Trichomonosis.

443 i) Trichomonosis

444 Infection by *Tritrichomonas foetus* was reported at low prevalence in extensively managed
445 bulls in Northwestern Spain in 1998[54], later studies have found that the prevalence might be as
446 high as 41.5% of herds of one local breed in Asturias[51], although a related breed with a different
447 bull management system had a herd prevalence of only 5.2%[55] (Table 5). Trichomonosis seems to
448 be better documented in Spain than in other EU member states (Table 5), and local control programs
449 in the North are providing an excellent example for farmers from regions[25] with similar
450 management systems that promise substantial control or even eradication of this parasite.

j) Anthrax

In Spain, anthrax is a regulated disease[30] and no anthrax cases have been reported in the last 20 years which means that biosecurity measures and vaccination carried out at farmers cost are working well, like in other European countries.

k) Contagious bovine pleuropneumonia

Mycoplasma mycoides subsp. *mycoides* SC (bovine biotype) was historically present in Spain but a specific control program was not fully deployed until 1990. Like EBL, CBP was included in the EU co-funded Spanish compulsory animal health program along with tuberculosis and brucellosis. Since 1990, prevalence peaked at 0.2% in 1991 and quickly decreased in the following years until reaching the officially free status with over 99.9% free herds in 1994 (Table 5). The last outbreak occurred in 1996 and the country has remained free of CBP since then. This *Mycoplasma* infection is a nationally regulated disease that has not been observed in Spain in the last 40 years. That indicates that current individual farm measures are working well.

Summary:

There are 11 non EU-regulated diseases that have a regional or national control program and there is no much information on the effects of the NEURCD control programs on each disease. However, we think it should be possible to gather it and to use it to evaluate the saving of losses they bring at a relatively small cost since the more expensive part, sampling and testing is being carried out with an annual periodicity for control of brucellosis and tuberculosis. That is the case of IBR, BVD, neosporosis and paratuberculosis in ACs and provinces that are carrying out different control programs. However, an effort at coordination must be made to unify the information and its evaluation protocol. We hope that focusing on the subject and identifying gaps, as this paper has done might help to undertake this task. The single AC, Galicia, which has already reported results on IBR, BVD and neosporosis can show a satisfactory progress with reductions of 87%, 41% and 71%, respectively. The case of paratuberculosis appears to be special as Galicia only shows a 7% reduction, while the Basque country shows a 90%. This difference probably has to do with the population on which each one reports, since in Galicia the program covers nearly the whole cattle population, while in the Basque country it is focused on a small number of herds. Additionally, it is likely that the focusing of a research center on paratuberculosis in the Basque Country, with even an experimental vaccination strategy, might have also contributed to the high and sustained prevalence reduction.

Other diseases (epizootic hemorrhagic disease, fasciolosis, *Staphylococcus aureu*s infection, *Mycoplasma bovis* infection, Aujeszky's Disease, *Trichophyton verrucosum* infection, bovine

coronavirosis, bovine respiratory syncytial virosis, bovine digital dermatitis, *Streptococcus agalactiae* infection) control program situation have only been summarily revised by the experts in order to fill in Table 5 points, as very little information on them is available.

Conclusions:

Information on cattle diseases control programs in Spain is disperse and not readily available for the majority of them; there are some diseases that have been the subject of the MAPA reports and programs or that have been more output focused for which information is more readily available. These difficulties underline the relevance of this COST action objectives on standardization of NEURCD control programs.

Bluetongue, EBL, anthrax and CBP are submitted to national programs. The first is appearing repeatedly in the last years and usually it is quickly dealt with. Spain is officially free of CBP and EBL and perceived free of anthrax and Aujeszky's disease. The other diseases (IBR, BVD, neosporosis, paratuberculosis, Q fever, trichomonosis, salmonellosis, fasciolosis, *Staphylococcus aureus* infection, *Mycoplasma bovis* infection, *Trichophyton verrucosum* infection, bovine coronavirosis, bovine respiratory syncytial virosis and *Streptococcus agalactiae* infection) and two of unknown (leptospirosis and bovine digital dermatitis) are endemic.

The most popular regional control programs are focused on IBR and BVD that are submitted to control programs in 7 and 4 regions, respectively. Most of the regional ones have been developed during the first decade of the XXI century. At this point it is not possible to estimate the improvements achieved by the regional programs except for Galicia in IBR, BVD, neosporosis and paratuberculosis and the Basque Country in paratuberculosis. A lot of information that is collected at a substantial cost could be better exploited to monitor the programs themselves and to show the way to other regions or countries. An effort must be made to unify information collection systems and to keep them well maintained with periodical reports published either as scientific reports or, at least, in readily accessible internet sites. A benefit-cost analysis would be useful to motivate stakeholders to implement NRCD control programs. The examples from other European member states that have progressed more can be an example that would encourage regional authorities to expand the range of diseases and to draw practical consequences that could help improve the efficiency and public image of the cattle industry.

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741 Table 1.- Questionnaire administered to the heads of autonomic livestock services
742
743 QUESTIONNAIRE ON CATTLE DISEASE CONTROL PROGRAMS
744 COST SOUND Control action
745 SPAIN
746 1.- Autonomous community:
747 2.- Bovine population:
748 2.1.- Dairy: Farms: <= 10 heads > 10 and <100 > 100
749 Heifers <1 year Cows Bulls
750 2.2.- Beef: Farms: <= 10 heads > 10 and <100 > 100
751 Heifers <1 year Cows Bulls
752 3.- Associations managing cattle control programs:
753 3.1- Number and size of farms and heads:
754 4.- Diseases in programs:
755 Infectious Bovine Rhinotracheitis (IBR)
756 Enzootic Bovine Leukosis (EBL)
757 Bovine Viral Diarrhea (BVD)
758 Bluetongue
759 Paratuberculosis
760 Bovine Genital Campylobacteriosis
761 Anthrax
762 Trichomonosis
763 Salmonella
764 Q-fever
765 Neosporosis
766 Leptospirosis
767 Epizootic Hemorrhagic Disease
768 Liver fluke
769 Staphylococcus aureus
770 Mycoplasma bovis
771 Surra
772 Aujeszky's Disease
773 *Mycoplasma mycoides*
774 *Trichophyton verrucosum*
775 Bovine Coronavirus
776 Bovine Respiratory Syncytial Virus
777 Digital bovine dermatitis
778 *Streptococcus agalactiae*
779 5.- For each disease describe:
780 Objective (Eradication or control):
781 Number of farms in the program
782 When did the program start
783 How infection-free status is defined
784 Type of strategy (Test & Cull or vaccination):
785 What was the initial prevalence and what is the current one
786 Diagnostic and sample tests
787 Links to sources of information regarding each program
788 Testing periodicity
789 Periodicity of results reports
790 How the state of free is maintained
791 What are the requirements to introduce cattle in free farms
792 What is required to participate in fairs and markets
793 Is there any cost / benefit evaluation
794

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Table 2.- General results

a) Territorial structure of cattle population in Spain. * Source: MAPA

		Herds							
	Autonomous Community	≤10	<100	≥100	Total	Cows	Bulls	<1 year	Total
	Andalusia*	203	130	357	690	95395	2791	19384	117570
	Aragon	21	13	46	80	17318	67	12555	29940
	Asturias	539	1116	294	1949	82626	2794	17375	102795
	Balearics	10	96	55	161	10119	182	3099	13400
	Canary islands*	53	17	4	74	1521	264	478	2263
	Cantabria	10	715	315	1040	60000	427	15376	75803
	Castilla La Mancha	47	50	132	229	44710	2011	10349	57070
	Castile and Leon	279	1101	631	2011	101357	564	63273	165194
Dairy	Catalonia	32	185	362	579	78,424	411	44,308	123143
	Extremadura*	136	44	18	198	4,729	418	1,202	6349
	Galicia	560	4727	1614	6901	414895	703	104717	520315
	Madrid*	23	14	22	59	8665	316	1549	10530
	Murcia	3	4	22	29	9944	74	1381	11399
	Navarre	6	48	148	202	25215	14	15568	40797
	Basque Country*	7	137	101	245	27793	623	5688	34104
	The Rioja*	1	2	7	10	3614	143	473	4230
	Valencia*	4	6	17	27	11240	371	2144	13755
	SPAIN	**1934**	**8405**	**4145**	**14484**	**997565**	**12173**	**318919**	**1328657**
	Andalusia*	2749	3288	1185	7222	311684	76372	89410	477466
	Aragon	150	599	254	1003	45227	1785	8790	55802
	Asturias	6244	5809	409	12462	191069	47128	46395	284592
	Balearics	175	20	182	377	3057	300	920	4277
	Canary islands*	615	166	28	809	11190	3069	4063	18322
	Cantabria	1923	3328	370	5621	115888	5830	28723	150441
	Castilla La Mancha	332	1069	647	2048	154069	36415	51762	242246
	Castile and Leon	1583	7223	3578	12384	603371	26942	247341	877654
Beef	Catalonia	348	2177	1552	4077	112641	4758	32813	150212
	Extremadura*	4669	6861	2874	14404	730326	150803	248667	1129796
	Galicia	23921	9049	516	33486	254304	2490	172382	429176
	Madrid*	618	779	192	1589	54695	16034	18189	88918
	Murcia	19	11	5	35	729	239	148	1116
	Navarre	453	668	146	1267	27903	32495	13051	73449
	Basque Country*	2980	1826	172	4978	79387	16388	26285	122060
	The Rioja*	42	119	95	256	21443	3124	5359	29926
	Valencia*	118	250	53	421	15862	4439	4233	24534
	SPAIN	**46939**	**43242**	**12258**	**102439**	**2732845**	**428611**	**998531**	**4159987**
Total	**SPAIN**	**48873**	**51647**	**16403**	**116923**	**3730410**	**440784**	**1317450**	**5488644**

b) Cattle associations with health defense activities in the Spanish autonomous communities

Autonomous Community	Number	Farms	Cattle
Aragon	22	887	73525
Asturias	33	2470	138682
Balearics	4	297	18989
Cantabria	14		
Castile and Leon	84	7451	19221
Castilla La Mancha	67	2268	321652
Catalonia	4		
Galicia	52	8112	540542
Navarre			
Madrid	16		103459
Murcia		64	12515
Basque Country	12		
SPAIN	308	21549	1228585

Table 3.- Control programs for cattle diseases in Spain

								Prevalence			Testing				
Disease	Autonomous Community	DS	Type	Obj	Farms	Start	Strategy	Initial	Current	% reduc	Sample	Test	Freq	Maint	FM
IBR	Aragon	End	V	C											
	Asturias[56]	End	V	C	2470	2013	TandC + Vac				B, M	ELISA gE and gB	A, TM	AN	Neg
	Balearics[57]	End	V	C	297	2007	ND								
	Castilla La Mancha[58]	End	V	C	134	2018	TandC + Vac	31.9		-	B, M	ELISA gE and gB	A		Neg
	Castile and Leon	End	V	C											
	Galicia[59]	End	V	C	8112	2004	TandC + Vac	34.9	4.4	87%	B, M	ELISA gE, gB and total	A, W		Neg
	Basque Country	End	V	C			TandC + Vac				B, M				
BVD	Asturias	End	V	C	2470	2013	TandC				B	ELISA Ab	A	AN	-
	Balearics	End	V	C	297	2007	TandC + Vac								
	Galicia	End	V	C	8112	2004	TandC	26.4	15.6	41%	E, B, M	ELISA Ab, ELISA Ag and PCR	W	AN	Neg
	Basque Country	End	V	C											
Neosporosis	Asturias	End	V	C	2470	2013	TandC OS								
	Galicia	End	V	C	8112	2004	TandC OS	23.7	6.9	71%					
	Basque Country	End	V	C											
Paratuberculosis	Asturias	End	V	C	2470	2013	TandC				B	ELISA PPA3	A	AN	-
	Galicia	End	V	C	8112	2004	TandC	2.25	2.1	7%	B, F	ELISA PPA3 and PCR	A	AN	Neg
	Basque Country	End	V	C	30	2005	TandC + Vac	10.68	1.11	90%					
Q fever	Asturias	End	V	C	2470	2013									
	Balearics	End	V	C	456	2019	SV				B, M, F	ELISA and PCR	OR	-	-
	Basque Country	End	V	C											
Enzootic bovine leukosis	All[27]	OF	C	E	48865	1986	TandC	1.3	0	100%	B	ELISA	A (1%)	AN	Neg
Bluetongue	All[29]	Spo	C	E	48865	1986	SV								
Bovine genital campylobacteriosis	Asturias	Spo	-	-	-	-	-	-	-	-	-	-	-	-	-
	Basque Country	Spo													
Trichomonosis	Asturias	End	-	-	-	-	-	-	-	-	-	-	-	-	-
	Basque Country	End													
Anthrax	All	PF	C	E	48865	1986	-	-	-	-	-	-	-	-	-
Contagious bovine pleuropneumonia	All	OF	C	E	48865	1986	-	-	-	-	-	-	-	-	-

No region has a control program for: Epizootic haemorrhagic disease, fasciolosis, *Staphylococcus aureus* infection, *Mycoplasma bovis* infection, Aujeszky's disease, *Trichophyton verrucosum* infection, Bovine coronavirosis, Bovine respiratory syncytial virosis, Bovine digital dermatitis, *Streptococcus agalactiae* infection.

DS: Disease situation (End: Endemic, Spo: Sporadic cases, OF: Officially free, PF: Perceived free); Type: Program type (V: Voluntary, C: Compulsory); Obj: CP goal (C: Control, E: Eradication); Farms: Number of farms in the control program; Start: CP starting year; % reduc: Prevalence percent reduction from initial to current; Testing sample (B: Blood; M: Milk; E: Ear; F: Feces); Freq: Frequency of testing or reporting (A: Annual; T: Trimestral; W: Weekly); Test: Type of testing method (gE: glycoprotein E, gA: glycoprotein A, Ab: specific antibody, Ag: virus antigen); Maint: Negative status maintenance (AN: All negative); FM: Fair and market access requirements.

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801 Table 4.- Reported prevalence of cattle diseases in Spain and in Europe

Disease	Years	Initial herd prevalence estimates (%)	Prevalence in other European countries	SOUND-Control members with control program program[60]
IBR	2018	33.7 - 63.5	13.4 -100[61]	79.3%
BVD	1971-1999	70.9 - 94.2	60 -80[62]	75.9%
Neosporosis	1999-2010	30.6 - 87.7	30 - 80[37]	24.1%
Paratuberculosis	2003-2014	8.0 – 72.4	0 – 68[63]	55.2%
Q fever	2010-2012	42.9 – 66.9	21.0 – 78.6[64–69]	17.2%
BGC	2012	1.7 – 7.0*	0 - 17[53]	44.8%
Trichomonosis	2013-2016	5.2 – 41.5	0 – No data[70]	37.8%
EBL	1986-1999	1.5 - 2.6	0 – 0.21[71]	86.2%
CBP	1990-1996	0.05 – 0.20	0 – 1.34[72]	17.2%
Bluetongue	2014-2015	Variable, max at about 0.33	Variable[29]	82.8%
Anthrax	2000	Rare	Rare[30]	51.7%

*Animal prevalence. IBR: Infectious bovine rhinotracheitis; BVD: Bovine viral diarrhea; BCG: Bovine genital campylobacteriosis; EBL: Ezoootic bovinwe leukosis; CBP: Contagious bovine pleuropneumonia.

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Figure 1.- Distribution throughout the Spanish Autonomous Communities of cattle population according to type of production system. Percent of total population. Interactive maps at: Beef (https://datawrapper.dwcdn.net/UlXue/1/) and dairy (https://datawrapper.dwcdn.net/3dJnO/1/)

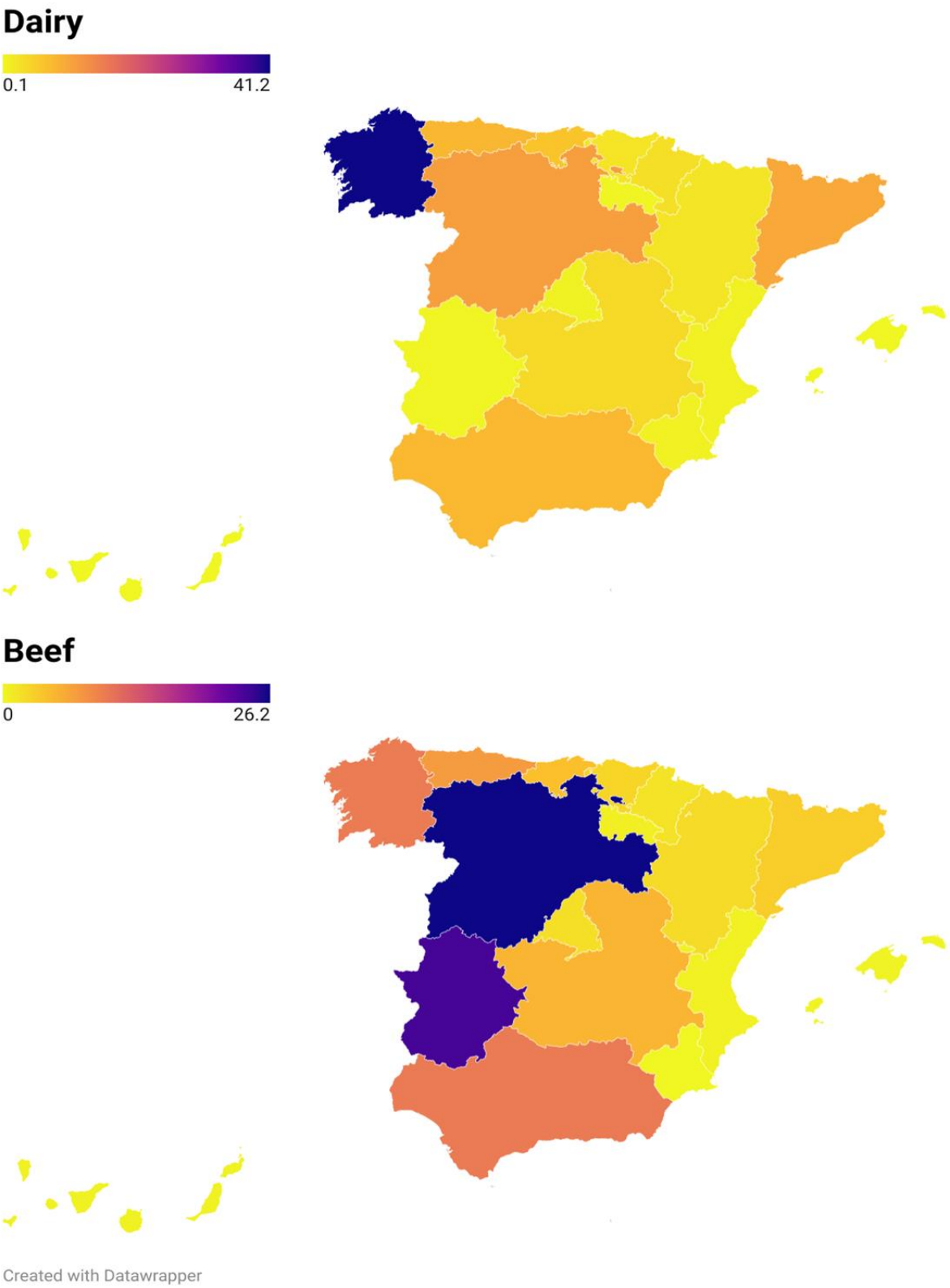

Table S1.- Sources on disease status in Spain and the EU.

Disease	Indexed journal	Non-indexed journal	MAPA programs	Expert opinion	PhD Thesis	Proceedings	Legislation	EFSA reports
IBR		1	1					1
BVD		3			1	1		1
Neosporosis	3							
Paratuberculosis	3	1			1	1		
Q fever	12		1					
Enzootic bovine leukosis			1					
Bovine genital campylobacteriosis			1					
Trichomonosis	4		1			1		1
Contagious bovine pleuropneumonia							1	1
Bluetongue			1					
Anthrax			1					
Trichophyton verrucosum infection				1				
Bovine coronavirosis				1				
Bovine respiratory syncytial virosis				1				
Bovine digital dermatitis				1				
Streptococcus agalactiae infection				1				
Epizootic hemorrhagic disease				1				
Fasciolosis				1				
Staphylococcus aureus infection				1				
Mycoplasma bovis infection,				1				
Aujeszky's Disease				1				
Salmonellosis				1				
Leptospirosis				1				
Total	22	5	7	12	2	3	1	4