Factors associated with the risk of abortions in dairy cattle farms and their notification by farmers in Algeria

This paper (No. 21012021-00172-FR) is a translation of the original French article, which was peer-reviewed, accepted, edited, and corrected by authors before being translated. It has not yet been formatted for printing. It will be published in issue **39** (3) of the *Scientific and Technical Review*, in 2021.

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Summary

Whether or not the cause is infection, abortions result in major economic losses on Algerian cattle farms. Between September 2014 and February 2016, an epidemiological survey was carried out in the form of direct interviews with 162 dairy cattle farmers in eight wilayas in the north and centre of Algeria, in order to estimate the prevalence of notification of abortions and to identify the factors that influence notification by farmers. The prevalence of notification of abortions by

the farmers interviewed was estimated using a precise binomial distribution. Influencing factors were analysed using a classification tree analysis. It transpires from the responses obtained that when abortions occur 82.1% (confidence interval [CI] 95%: 75.3–87.7%) of farmers call a veterinarian to report when abortions have occurred and for post-abortion follow-up. The classification tree generated from the survey data indicates that the three most predictable variables for notification of abortions are, in order of decreasing importance: the type of cow affected by the abortion (importance of the variable = 100 on a scale of 0 to 100); the wilaya of origin (importance of the variable = 72.7); and the dominant physiological stage (importance of the variable = 42.5).

Recommendations were made to improve conditions for the notification of bovine abortions by farmers and their handling in Algeria. These recommendations relate to regular information and awareness campaigns aimed at farmers concerning bovine abortions and the possible repercussions of non-reporting on animal and human health; workshops for farmers, attended by veterinarians, on the appropriate handling of cows that have aborted and post-abortion products (milk, aborted foetuses, placenta and foetal membranes); and the creation of an agricultural fund to compensate farmers for losses incurred due to bovine abortions in the context of notifiable diseases. Finally, there is a reminder of the importance of the effective use of quarantine for all animals newly introduced into herds.

Keywords

Abortion – Algeria – Classification tree – Dairy cattle – Epidemiological survey – Farmer – Notification.

Introduction

In Algeria there are around 2 million dairy cattle, which contribute significantly to household income (1).

Bovine abortions can be variously defined depending on the point of view adopted. From a legal viewpoint, abortion is the expulsion of a

foetus or a calf, either stillborn or dead within 48 hours of birth (2). From a biological standpoint, abortion is the interruption of gestation between the 42nd and 260th day, whether or not it is followed by expulsion of the foetus. Before the 42nd day of gestation, it is considered to be embryonic mortality, while between the 260th and 285th days, parturition is considered to be premature. A distinction needs to be made between clinical abortion (evidence of abortion and/or foetal sacs) and abortions not properly established (presumed abortion), in other words, abortions identified by positive earlier gestation followed by later negative gestation (3).

Abortions are among the main causes of economic losses for dairy farmers because they result in longer intervals between calving and lost calves. They also incur costs for diagnoses and therapies and the purchase of replacement animals (4). Moreover, they pose a real risk to public health because they can be zoonotic in origin, as is the case for brucellosis (5). Although it is compulsory (6, 7), notification of bovine abortions by practising veterinarians and farmers is far from systematic (8). Various reasons are given, such as the obligation to slaughter animals in the case of notifiable diseases, the low compensation amounts given for slaughtering animals or poor knowledge of the risks to human health in the case of zoonotic diseases.

A recent study conducted in Algeria identified a significant link between the occurrence of bovine abortions and the presence of the following pathogens: *Neospora caninum*, bovine herpes virus 4, bovine viral diarrhoea virus (BVD), *Brucella abortus*, *Salmonella* Dublin, *Leptospira interrogans* serovar Hardjo and *Coxiella burnetii* (9).

Studies devoted to the prevalence of abortions and related policies for notification by farmers or veterinarians are few and far between. According to Kardjadj (10), on the basis of a study carried out in 75 Algerian dairy farms, the herd prevalence of abortions was 41.3% (confidence interval [CI] 95%: 30.2–52.5%). This study also identified several risk factors associated with abortion notification, such as the coexistence of small ruminants and cattle (odds ratio [OR] = 2.5), contact with other herds (OR = 2.91) and the importation of cattle

(OR = 1.91), as well as the presence of dogs in herds (OR = 2.89), and limited professional experience (< 2 years) among farmers (OR = 2.69). Another study conducted on a non-random sample of 105 farmers of ruminants in northern Algeria (11) indicates that abortions are more common in sheep (56%) than in goats (34%) or cattle (10%). This study found that 90% of farmers had observed abortions several times a year and that 10% had never or very rarely observed them. When abortions occur, veterinarians are called in 55% of cases, most frequently because of concern for the general health of the animal concerned. Cows that have aborted are isolated from the rest of the herd in only 27% of cases and the placenta is destroyed by only 29% of farmers. Only 31% of farmers take sanitary precautions (mask, gloves) when handling aborted foetuses and the foetal sacs. Almost half (49%) of farmers say that they are inadequately informed of the causes of abortion and the measures to take in the event of abortion.

In this context, an epidemiological study was carried out among dairy cattle farmers in northern and central Algeria in order to estimate more accurately the prevalence of notification of bovine abortions and to analyse the risk factors that influence their occurrence and notification. This study should make it possible to reinforce information and awareness policies for farmers concerning this animal and human health problem.

Materials and methods

Region of study, sampling and type of survey

The region of study is in the north and centre of Algeria. This region, which covers a surface area of 30,929 km², contains 322,797 cattle in 52,099 herds. Two-thirds of cattle are breeding females (160,564 dairy cows and 42,199 heifers over one year old) (12).

The study was conducted between September 2014 and February 2016 among 162 dairy cattle farmers in eight wilayas (administrative and territorial divisions of Algeria; in total there are 48 wilayas in Algeria): Chlef (n = 40 farmers), Bouira and Tizi Ouzou (n = 43), Médéa (n = 28), Algiers, Blida and Tipaza (n = 31) and Aïn Defla (n = 20).

In the absence of a precise sampling framework for these farms, the choice of 162 dairy cattle farmers was made with the help of veterinarians (providing contact between the researcher and farmers), based on the willingness of farmers to participate in the survey (no farmers refused to participate) and ease of access to their farms (secure zones). The data was collected during direct interviews with the farmers lasting an average of 45 minutes.

Questionnaire

The survey questionnaire contained general data concerning the wilaya to which the farmer belonged, the number of dairy cows (< 10, between 10 and 30, and > 30), the presence or absence of a bull, the presence or absence of dogs and cats, the average age of the animals on the farms (< 5 years and > 5 years), the main breed of cattle (> 50% of the herd) on the farm (local breed, black-and-white Holstein, red-and-white Holstein, Montbéliarde), the main physiological stage on the farm during the visit (only drying-off, only lactation, drying-off and lactation), the type of stabling (loose, stabled, semi-stabled), the exercise area (inadequate, adequate), the feed provided (grazing, concentrates and hay, silage with hay and concentrates), whether or not the cattle are put out to pasture, the watering source (well, tank, communal water supply), or as more specific data on breeding management, namely the organisation of calving (seasonal or all year round), the insemination of heifers (weight, age, season), the insemination of females (natural mating, artificial insemination, or both), natural mating with the herd bull or otherwise, screening for brucellosis and tuberculosis (yes or no), together with data concerning abortions relating to the purchase and introduction of new animals during the past 12 months (yes or no), quarantining of new animals purchased, whether or not abortion had occurred during the 12 months prior to the visit, the category of females mainly affected by abortion during the 12 months prior to the visit (cows with more than three lactations, first-calf heifers, newly purchased animals, heifers born on the farm, pregnant heifers purchased), the stage of gestation usually reached at the time of abortion (first trimester, second trimester, third trimester), whether or not the veterinarian was called during the

abortion and whether or not there was post-abortion follow-up (Table I).

Table I

Description of variables considered to be risk factors for abortions in dairy cattle farms and their notification by farmers to veterinarians, and results obtained (162 dairy farms surveyed in eight wilayas*)

*Administrative and territorial entities in Algeria (Algeria has a total of 48 wilayas)

Variable	Codification	Modality	Number of farmers (%)
Explanatory variable			
Veterinarian called following an abortion and post-abortion follow-up carried out (during the 12 months preceding the study)	AV	Yes	133 (82.1%)
		No	29 (17.9%)
Explanatory variables (factors influencing notification of abortion)			
Region	REG	Aïn Defla	20 (12.3%)
		Algiers, Blida and Tipaza	31 (19.2%)
		Bouira, Tizi Ouzou	43 (26.5%)
		Chlef	40 (24.7%)
		Médéa	28 (17.3%)
Number of dairy cows	EVL	< 10	39 (24.1%)
		10–30	82 (50.6%)
		> 30	71 (25.3%)
Bull present on the farm	PT	Yes	77 (47.5%)
		No	85 (52.5%)

Dogs and/or cats on the farm	PCC	Yes	129 (79.6%)
		No	33 (20.4%)
Average age of cows on the farm	AM	< 5 years	87 (53.7%)
		> 5 years	75 (46.3%)
Dominant cattle breed on the farm	RB	Local breed	39 (24.1%)
		Black-and-white Holstein	49 (30.2%)
		Red-and-white Holstein	26 (16.1%)
		Montbéliarde	48 (29.6%)
Dominant physiological stage on the farm	SPD	Drying-off	11 (6.8%)
		Lactation	71 (43.8%)
		Drying-off and lactation	80 (49.4%)
Type of stabling	ST	Loose	45 (27.8%)
		Stabled	57 (35.2%)
		Semi-stabled	60 (37%)
Exercise area	AE	Inadequate	74 (45.7%)
		Adequate	88 (54.3%)
Feed provided	AL	Grazing	46 (28.4%)
		Concentrates and hay	60 (37%)
		Silage with hay and concentrates	56 (34.6%)
Grazing	P	Yes	74 (45.7%)
		No	88 (54.3%)
Type of watering source	SAB	Well	56 (34.5%)
		Tank	44 (27.2%)
		Communal water supply	62 (38.3%)
Organisation of calving	OV	Seasonal	19 (11.7%)
		All year	143 (88.3%)

Main method used for insemination of heifers	IG	Weight	66 (40.7%)
		Age	90 (55.6%)
		Season	6 (3.7%)
Insemination of females	IF	Natural mating (SN)	35 (21.6%)
		Artificial insemination (IA)	79 (48.8%)
		IA and SN	48 (29.6%)
Natural mating with farm bull	SN	Yes	11 (31.4%)
		No	24 (68.6%)
Screening for brucellosis and tuberculosis	D	Yes	138 (85.2%)
		No	24 (14.8%)
Purchase and introduction of new animals during the 12 months prior to the survey	AA	Yes	76 (46.9%)
		No	86 (53.1%)
Quarantine of newly purchased animals	MC	Yes	0 (0%)
		No	162 (100%)
Previous abortion(s)	PAV	Yes	106 (65.4%)
		No	56 (34.6%)
Type of female affected by abortion	AVT	Cows > 3 lactations	58 (35.8%)
		First-calf heifers	37 (22.8%)
		Newly purchased animals	17 (10.5%)
		Heifers on the farm	12 (7.4%)
		Pregnant heifers purchased	38 (23.5%)
Stage of pregnancy most affected by abortions	SGA	First trimester	13 (8%)
		Second trimester	65 (40.1%)
		Third trimester	84 (51.9%)

Statistical analysis

Descriptive analysis

The herd prevalence data for abortions during the 12 months prior to the survey were estimated using a precise binomial distribution.

Classification tree analysis

A classification and regression tree (CART) analysis is a discrimination method based on the construction of a binary decision tree. The goal is to construct subgroups of a population that are as homogeneous as possible for a given characteristic (variable to be explained). In this study, the variable to be explained is notification or non-notification of abortions by the farmer to a veterinarian. The CART analysis is used to construct a tree with successive divisions according to the explanatory variables, which can be continuous or categorical. Here the explanatory variables are the factors influencing whether or not the farmer notifies the veterinarian of abortions. The extremities of the tree represent homogeneous subgroups. The basic idea is to create subgroups (referred to as children) where the mix is less than in the initial population (referred to as the parent group). When the dependent variable is categorical (which is the case in this study), it is referred to as a classification tree, as opposed to a regression tree, which concerns a continuous dependent variable (13, 14). The Salford Predictive Modeler® software (Salford Systems, San Diego, California, United States of America) was used to split all data into increasingly homogeneous subgroups until they were stratified and satisfied the specified criteria. The Gini index method is used for splitting with tenfold cross-validation to test the predictive capacity of the trees obtained. The CART analysis carries out cross-validation, growing optimum trees on data subgroups, then calculating the error rates based on the parts of the complete dataset not used. The CART analysis divides all the data into ten almost equal parts selected at random, with each part containing a similar distribution of data from the populations under consideration (namely notification or non-notification of abortions by the farmer). The analysis then uses the first nine datasets (9/10) to construct the largest possible tree and uses the last part of the

data (1/10) to estimate the error rate of the selected tree. The process is repeated using different combinations of the nine remaining data subsets and a different data subset to test the resulting tree. This process is repeated until each 1/10 data subset has been used to test a tree developed using another data subset (remaining 9/10). The results of the ten mini-tests are then combined to calculate the error rates for each possible size of tree. These error rates are then applied to prune the tree that was developed using all the data. The outcome of this complex process is a set of relatively reliable independent estimates of the accuracy of the clinical decision tree prediction. For each node in a tree generated by CART, the main separator is the variable that best divides the node, thereby maximising the purity of the resulting nodes. To test the diagnostic power of the final decision tree generated, a receiver operating characteristic (ROC) was employed both for the original dataset used to construct the tree (training data) and for the dataset used to test the relevance of the data tree (test data).

Results

Descriptive analysis

The results of the descriptive analysis appear in Table I. Of the farmers interviewed, 26.5% had their farms in the regions (wilayas) of Bouira and Tizi Ouzou. Half of the farmers (50.6%) had farms with between 10 and 30 head of dairy cows. Just over half (52.5%) of farms had their own bulls for natural mating. During the survey of farmers, cats or dogs were found to be present on 79.6% of the farms visited. The average age of farm animals was less than 5 years in 53.7% of cases, with 49.4% of farms having females both drying-off and in lactation. Black-and-white Holsteins and Montbéliarde represented 30.2% and 29.6% respectively of breeds in the herds. Housing was semi-stabling on 37% of farms. Room for exercise was deemed to be adequate in 54.3% of cases. The feed provided was concentrates and hay on 37% of the farms visited. The animals had access to grazing in 54.3% of the farms surveyed. As for the watering source, 38.3% used the communal water supply and 34.5% used well water. More than half (55.6%) of farmers inseminated their heifers according to age, while 40.7% did so

according to weight. To inseminate females, 48.8% of farmers resorted to artificial insemination, 21.6% opted for natural mating and 29.6% used a combination of the two methods. For natural mating, a bull from outside the farm was used on 68.6% of the farms studied, compared with 31.4% that had their own bull for breeding. Calving was spread over the whole year on 88.3% of farms, while it was seasonal on the remaining 11.7%. Screening for brucellosis and tuberculosis was carried out by 85.2% of farmers. When questioned about commercial transactions, 53.1% of farmers stated that they had not purchased or introduced new animals during the past 12 months. However, no quarantining of new animals took place on farms that had introduced new animals. Around two-thirds (65.4%) of the farmers interviewed stated that there had been abortions on their farms. These abortions affected far more cows that had had more than three lactations (35.8%) and pregnant heifers purchased (23.5%) than other females. The stage of gestation most affected by abortion was the third trimester (51.9%). As for calling the veterinarian during abortion for post-abortion follow-up, 82.1% of participants in this survey (CI = 95%: 75.3–87.7%) said they had called the veterinarian for this purpose (Table I).

Classification tree analysis

The classification tree that best explains whether or not abortions were reported by the farmer, together with factors of influence, is shown in Figure 1. On a scale of 0 to 100 for the importance of variables, the five main predictive variables of the classification tree, are (in decreasing order of importance): the type of bovine female affected by abortion (relative importance of the variable: 100); the wilaya of origin (relative importance of the variable: 72.7); the dominant physiological stage (relative importance of the variable: 42.5); the stage of gestation (relative importance of the variable: 36.6); the type of mating (relative importance of the variable: 29.5).

The sensitivity (Se) and specificity (Sp) of the classification tree are 70.7% (CI = 95%: 62.2–78.2%) and 89.7% (CI = 95%: 72.6–97.8%) respectively for the dataset used to construct the clinical decision tree

(training data) and 61.7 % (CI = 95%: 52.8–70.0%) and 69.0 % (CI = 95%: 49.2–84.7%) for the test dataset.

The classification tree in Figure 1 shows that notification of abortions by farmers to their veterinarians is more frequent in the following configurations:

– where the farms are in the wilayas of Bouira, Tizi Ouzou, Chlef and Médéa, and when the abortions affect either cows with more than three lactations or newly purchased cows and heifers, or first-calf heifers born on the farm where natural mating is practised; or,

– where the farms are in the wilayas of Algiers, Blida, Tipaza and Aïn Defla and the abortions affect either animals mainly in the drying-off period, or animals mainly in lactation but in the first trimester of gestation.

By contrast, notification of abortions by farmers to their veterinarians is less frequent in the following configurations:

– where the farms are in the wilayas of Bouira, Tizi Ouzou, Chlef and Médéa, and the abortions affect first-calf heifers or heifers born on a farm that does not practice natural mating; or,

– where the farms are in the wilayas of Algiers, Blida, Tipaza and Aïn Defla, and the abortions affect females mainly in lactation but in the second or third trimester of gestation.

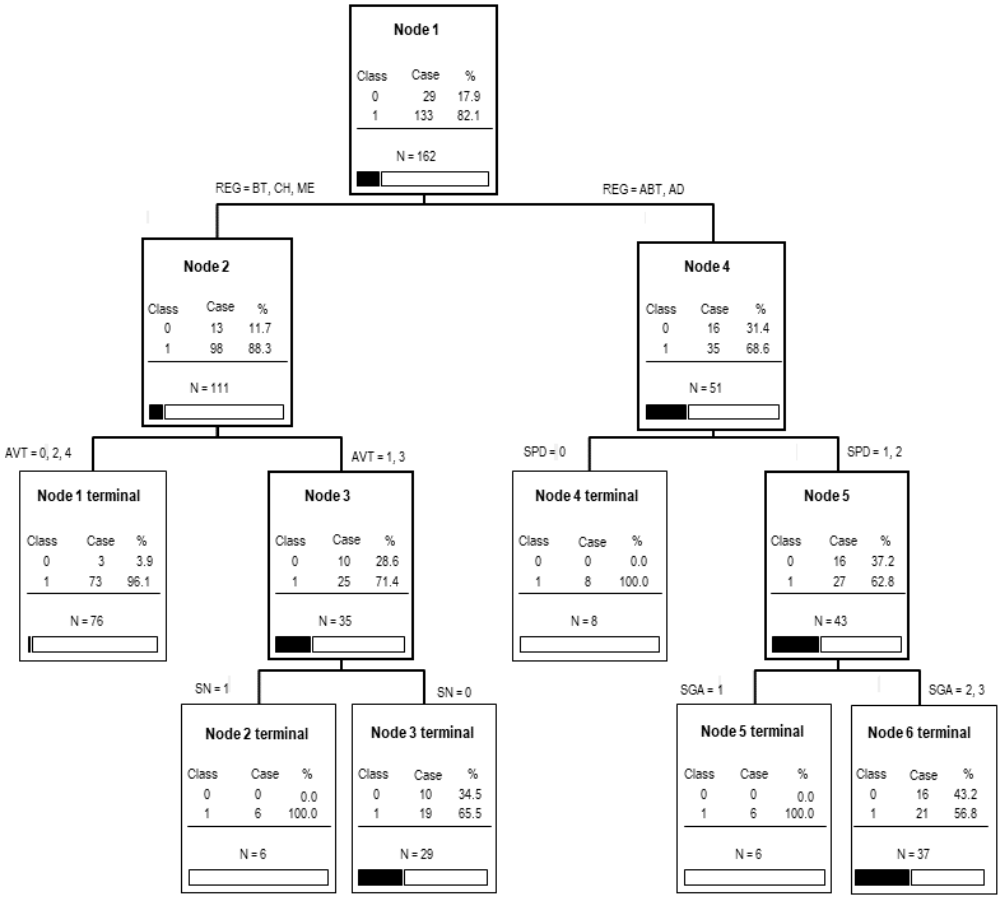

Fig. 1

Classification tree indicating notification or non-notification of abortions by farmers in Algeria

Class: 1 where abortions are notified and 0 where abortions are not notified by the farmers interviewed
Case: number of cases per class
%: percentage of cases
N: number of veterinarians concerned
AVT: type of animal affected by abortion (0 = cow > 3 lactations; 1 = first-calf heifer; 2 = newly purchased cow; 3 = heifer born on the farm; 4 = pregnant heifer purchased)
REG: wilaya of origin (ABT = Algiers, Blida and Tipaza; AD = Aïn Defla; BT = Bouira and Tizi Ouzou; CH = Chlef; ME = Médéa)
SGA: stage of pregnancy of females that abort (1 = first trimester; 2 = second trimester; 3 = third trimester)
SN: natural mating with own breeding bull (0 = no; 1 = yes)
SPD: dominant physiological stage (0 = drying-off; 1 = lactation; 2 = drying-off and lactation)

The ROC curves of the training dataset and the test dataset are shown in Figure 2. The area under the ROC curve of the training data (scale of 0 to 1, where a value of at least 0.5 indicates that the tree has diagnostic potential) is 0.82, while the area under the ROC curve of the test dataset is 0.64.

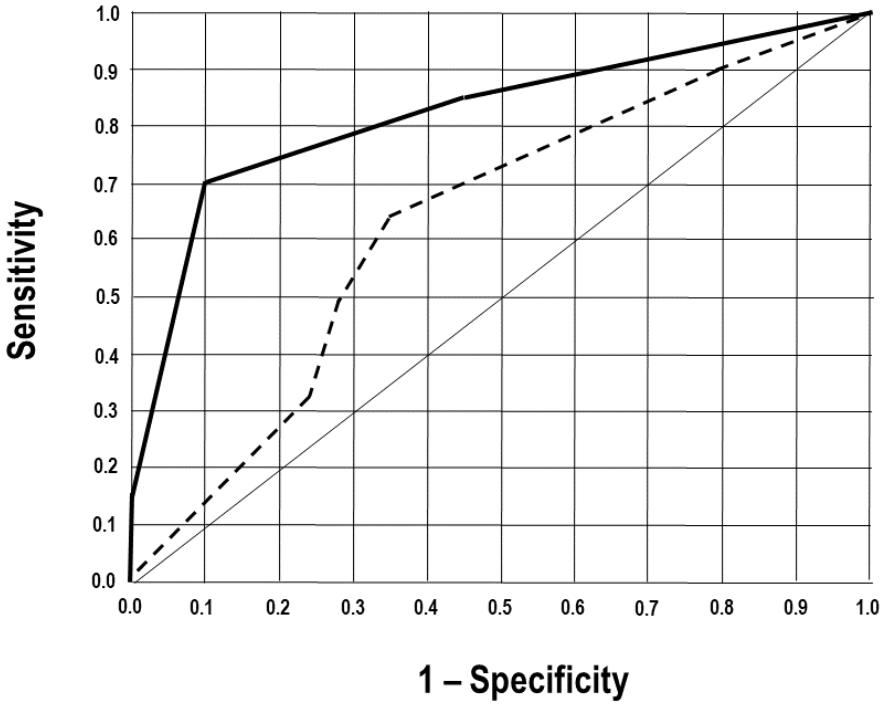

Fig. 2

Receiver operating characteristic (ROC) curve obtained using a classification tree for the training dataset and test dataset

Continuous thick black line: training dataset
Black dotted line: test dataset

The area under the ROC curve of the training dataset is 0.82, while the area under the ROC curve of the test dataset is 0.64.

Discussion

In the absence of a sampling framework based on an accurate census of farms, the sampling plan used in this survey is based on the recruitment of farmers via a previous survey involving 331 veterinary practitioners randomly spread over ten wilayas in the north and centre of Algeria (8). The veterinarians concerned in the wilayas covered by this study contacted farmers for inclusion in the survey. No farmer refused to

participate. There was no selection of farmers based on the reporting or non-reporting of abortions. Even if farmers do not report abortions, they nevertheless contact a veterinarian for other reasons (such as an anti-parasite treatment or a vaccination). Therefore, without being purely random, the survey is close to being random, with the exception of insecure zones that could not be investigated. This survey is, however, declarative. It is therefore recommended to cross-check the results of several surveys (for example, declarative and analytical) to consolidate the value.

Descriptive analysis

Ultimately, 65.4% (106/162) of the farmers interviewed reported abortions on their cattle farms over the course of the 12 months preceding the survey. This result is higher than the 41.3% (31/75) previously reported on cattle farms in Algeria (10). It is not easy to compare the two studies because the geographical coverage (north and centre of Algeria for the first, but the whole of Algeria for the second) and the sample sizes (162 samples for the first and 75 samples for the second) are not the same. One hypothesis that could explain the difference in herd prevalence of abortions reported in these studies could be the differing prevalence of abortions (itself linked to the prevalence of abortive diseases), risk factors that vary between regions and different rates of abortion notification from one region to another. Further wider-scale studies would allow a fuller investigation of these theories.

Following abortion, a veterinarian was called by 82.1% (133/162) of the participants in this study. This result is lower than the 95.2% (315/331) obtained in a similar study conducted in the same wilayas among 331 veterinarians who reported that they had been called by farmers to deal with abortions within 24 hours (8). It is far higher than the 58.5% reported in another serological study combined with a survey questionnaire in the same context and in the same zone in 2010, where farmers only called out a veterinarian in the event of a retained placenta (15). Although the significant increase between this study and more recent ones indicates greater awareness among farmers of the

importance of notification of bovine abortions, much remains to be done. This should include regular information and awareness campaigns concerning bovine abortions and the possible repercussions of not reporting these events on animal and human health. Workshops for farmers, attended by veterinarians, on better management of aborted cattle and post-abortion products (milk, aborted foetuses, placenta and foetal membranes) should also be encouraged. The creation of an agricultural fund to compensate farmers for losses resulting from bovine abortions caused by notifiable diseases is an idea that should be pursued. This model, based on the principle of co-management, co-responsibility and co-financing, has already proven its worth in the past (16).

In total, 53.1% of farmers stated that they had not purchased new animals or introduced new animals during the past 12 months. On farms that had introduced new animals during this period, none of them were placed in quarantine. This is an important biosecurity (bio-exclusion) measure, which should be promoted. The introduction of new animals from other herds, with unknown health status and contact with other farms and species mixing (cattle and small ruminants), could increase the risk of transmission of pathogenic agents (10, 17). The probability of abortion is 2.91 times higher in herds that have had contact with other herds than among those with no contact (10). This amply justifies the need for quarantine accompanied by laboratory tests of animals newly introduced into the herd.

Classification tree analysis

Several methods were used to identify the risk factors. These methods are complementary. Without claiming to be comprehensive, two examples are multivariate logistic regression and classification tree analysis. The authors used the classification tree method in this survey because it provides solutions in graphic form that are easy to interpret, it is capable of handling quantitative and qualitative variables simultaneously and it requires only a few hypotheses. In addition, the importance of the variables in relation to each other is given, allowing management options to be focused directly on the most important

variables. An ROC curve is used to gain a direct idea of the quality of the model.

The classification tree analysis highlighted notifications of bovine abortions by farmers in all the wilayas covered by this study. This supports the result of a study conducted among veterinarians practising in the same wilayas where the majority of the veterinarians interviewed reported a herd prevalence of abortions greater than 5% (8). This percentage confirms that the abortions are probably epizootic in nature, taking into account an alert level of 5% of abortions in a herd proposed by Givens & Marley (18), in the knowledge that if the number of abortions in a herd exceeds this threshold, the probability of notification will rise. Moreover, the wilayas with a higher number of reported abortions correspond to those where similar results were reported during a randomised survey among practising veterinarians (8).

The abortions notified by farmers concerned mainly cows after their third lactation, newly purchased heifers and first-calf heifers. This result is comparable with that reported in the Republic of Korea by Lee & Kim (19), who found that the prevalence of losses during gestation for cows in their first and second lactation was 0.6 or 0.5 times lower than that observed in cows in their third or subsequent lactation (19). One explanatory theory is that milk production increases with the number of lactations, in parallel with loss of physical condition as a possible cause of an increased risk of abortion (20). However, the influence of the number of lactations on the frequency of pregnancy losses is not supported by the literature. The result of our study conflicts with a study carried out in Mexico by Segura-Correa & Segura-Correa (21), where the risk of abortion was significantly higher in the second lactation (OR = 4.02), third lactation (OR = 2.30) and first lactation (OR = 1,56), compared with older cows. The result of our study also contrasts with that of Norman *et al.* (22), who identified a strong prevalence of abortions in first-calf heifers compared with females with more than eight lactations. According to the study by Waldner (23), the cows most susceptible to abortion were replacement heifers and cows over the age of ten years. Younger cows may have lower acquired immunity and be more sensitive to infectious agents than older cows. The differences

between these studies may result from the range of pathogenic agents encountered and other causes of abortion depending on the country and continent under study.

The notification rate for abortions by farmers was higher on farms using natural mating as the breeding method than on farms resorting to artificial insemination. In Algeria, frequent use is made of itinerant bulls for natural mating. The use of breeding bulls is presumed to present a risk of transmission of abortive diseases via sperm in herds of dairy cows (24, 25). This result corroborates that of another study conducted in the same area, where the use of artificial insemination rather than natural mating represented a lower risk of exposure, reducing the frequency of bovine abortions due to exposure to *Coxiella burnetii*, *Chlamydia abortus* and *Toxoplasma gondii* (26).

According to the classification tree analysis, a large proportion of abortions notified by farmers concerned cows in the first trimester of gestation, with lower rates of notification for cows in the second or third trimester. This result supports those of Norman *et al.* and Forar *et al.* (22, 27), who detected a higher risk of abortion during the first trimester of gestation, reducing progressively as the pregnancy advanced. Moreover, the result of our study conflicts with that of Lee & Kim (19) where pregnancy loss was greater during the second trimester (3.4%), followed by the third trimester (2.3%). This result also conflicts with that obtained by a survey conducted among veterinarians in the same wilayas under study, where the risk of abortion was higher during the third trimester (OR = 2.66) (8). It also conflicts with another study carried out in Algeria where a higher frequency of abortions was found during the second trimester (28).

The classification tree generated from the survey data identified predictive variables (influencing factors) for the notification of abortions. This is an interesting first study because these variables could be used to design future information and awareness campaigns based on a better understanding of the risk factors for bovine abortions with a view to increasing the notification rates for abortions on cattle farms in

Algeria. It is also recommended that studies be conducted on a wider scale.

In addition, the multiple reasons for non-reporting include fear of repercussions from notification, mainly in the case of brucellosis (culling of cattle, inadequate compensation to purchase replacement cattle) and/or the lack of knowledge among farmers of the dangers of abortion to animal and public health. Several approaches could be used to improve the notification of abortions by farmers, such as compensation amounts that take into account the replacement value of a pregnant animal suffering from brucellosis or another abortive infectious disease, state financing of research into bovine brucellosis and other abortive agents (laboratory analyses), as well as regular outreach, information and awareness-raising campaigns targeted at cattle farmers to give a better understanding of the scourge of abortion.

Conclusion

This study provides an initial assessment of notifications of bovine abortions by farmers in Algeria and the factors that influence them. Notification rates depend on the wilaya, the type of female affected by abortion, the stage of gestation and the use of natural mating as a breeding method. Although all the wilayas surveyed had reported abortions, they were more frequent in cows following their third lactation, in newly purchased heifers and in first-calf heifers. They were more frequent during the first trimester of pregnancy. Abortions are also more frequent on farms that use natural mating than on farms that resort to artificial insemination. Finally, these results illustrate the need for awareness-raising and outreach campaigns targeted at farmers and veterinarians concerning bovine abortions in Algeria. Improved management of bovine abortions could reduce losses for both farmers and the country's economy.

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