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# Economic Analysis of Efficiency of RB51 Strain Vaccine of *Brucella abortus* Applied in Herds Naturally Infected with Brucellosis in Tropical Climate

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**Abstract:** Annual economic losses by bovine brucellosis in Latin America are estimated at 600 million American dollars (USD). In Mexico, the economic impact has not been quantified since reliable information about disease prevalence in cattle is scarce. In endemic areas the use of RB51 strain is a common practice, nevertheless the information about their efficiency is also scarce. The objective of the present study was to evaluate by clinical trial the efficiency of this vaccine in dual purpose herds naturally infected with brucellosis under tropical conditions. Vaccinated and non-vaccinated groups were integrated with 88 females each one. Reactor animals were not eliminated or separated from cattle population. A herd with an initial seroprevalence rate of 5% was selected and monitored during eighteen months post-vaccination. The vaccination efficiency shows that there were no losses with the control program and without the control program there were losses in the amount of 38,680 USD ($406,140 Mexican currency [Mex. cy]) estimating the loss per animal at 325 USD ($3,419.56 Mex. cy). The preventive program cost was 6,112 USD ($64,184 Mex. cy). The cost for maintaining non-productive reactor animals in the herd was estimated at 31,137 USD ($326,940.00 Mex. cy). The most affected parameters were fertility and milk production indicators. Benefit/cost ratio was 4.7:1 for milk production, 6.2:1 for calf sales and 6.6:1 for the combination of milk production and calf sales. It was concluded that the use of RB51 vaccine in the control program gives assurance of economic profitability.

**Key words:** Bovine brucellosis, RB51 vaccine, vaccine efficiency, prafitability, fertility, Mexico

## INTRODUCTION

Brucellosis is an infectious and contagious disease that has a tendency towards becoming chronic and that is caused by the genus *Brucella* sp. (Cutler *et al*., 2005; Hawari, 2012) in adult animals, main clinical findings are infertility, abortion, placental retention and epididymitis (Nicoletti, 2005). Annual economic losses due to bovine brucellosis have been estimated for just Latin America at $600 million USD (Ragan, 2002). In Mexico, it is considered one of the main zoosanitary problems however, it has not been possible to quantify it due to lack of reliable data on real prevalence of the disease in cattle (Renteria *et al*., 2003). In sanitary aspects, prevention implies the establishment of measures that avoid and/or control the presence of brucellosis in a herd with a tendency to reduce incidence or prevalence of the disease to levels that are compatible with a profitable production (Spath, 2004; SAGDR, 1996). In countries where brucellosis is present due to its impact on the economy and on productivity and its zoonotic characteristics there is generally a program of prevention, control and eradication of the disease (Kouba, 2003; Godfroid *et al*., 2005).

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In ruminants, *Brucella abortus* RB51 vaccine is a viable alternative in the programs of disease control in endemic areas (Blasco, 2001; Halling, 2002) however, economic information on vaccination efficiency in extensive grazing under tropical conditions is scarce. Therefore, the objective of this study was determinate the RB51 strain vaccine efficiency in the control of bovine brucellosis in double purpose production systems under tropical conditions and also determinate the benefit/cost ratio.

## MATERIALS AND METHODS

**Study site and inclusion criteria:** Research was carried out in the community of El Desengano, Municipality of Las Choapas in the South of the State of Veracruz, Mexico between August 2006 and February 2008 (Cardena *et al*., 2009).

**Clinical assay:** Win Episcope 2.0 (Thrusfield *et al*., 2001) was used to estimate the sample size and establish the vaccinated and non-vaccinated groups under the modality of finding the difference between proportions by estimating an expected proportion of 6% brucellosis positive animals in the vaccinated population and 20% of positive animals in the non-vaccinated population with a confidence level of 95% and a potency of 80% also, the sample size was estimated at 88 animals per group. Vaccinated and non-vaccinated groups were identified by ear tags with pair and impair numbers respectively; once the animals were vaccinated, both groups were evaluated each quarter for 18 months by serology using the CT and RT in the modalities of screening and confirmatory tests, respectively.

**Vaccination:** All females that were negative to CT and RT were vaccinated only once subcutaneously in the middle third of the neck on the left hand side. RB51 strain was applied in females 6-12 months of age in doses of $5\times10^{10}$ Colony Forming Units (CFU) and in animals >12 months of age at doses from $3\times10^{8}$ to $3\times10^{9}$ CFU including gestating females according with Mexican regulations (SAGDR, 1996). Vaccination of animals was carried out during the month of August 2006; at the time the experimental groups were formed, 32 gestating females were integrated into the vaccinated group and 36 gestating females in the non-vaccinated group. Males were not vaccinated. Animals that were positive to serology by RT were not segregated or eliminated from the herd.

**Statistical analysis:** Seroprevalence rates, Relative Risk (RR) and Confidence Interval (CI) at 95% were estimated according to that which was mentioned by Thrusfield (2005). Statistical significance of observed frequencies in vaccinated and non-vaccinated groups was estimated by Chi-square and significant differences were established when $p<0.05$.

**Vaccination efficiency:** This was estimated by using the equation:

$$E = LNCP - (LWCP + C)$$

Where:

E = Vaccination efficiency
LNCP = Economic Loss in the Non Control Program
LWCP = Economic Loss in the group with Control Program implementation
C = Total cost of the control program (Vera *et al*., 1992)

The following costs were considered within LNCP and LWCP: female replacement, 285 USD ($3,000 Mex. cy); maintenance of a non-fertile diseased female 257 USD ($2,700 Mex. cy) (270 grazing days at $10/day) and the cost of lost calves due to abortion in 240 USD ($2,520 Mex. cy) (C) included serological diagnostics payment in the amount of 0.19 USD ($2.00 Mex. cy) per CT test and 0.28 USD ($3.00 Mex. cy) per confirmation RT test on animals reactors to CT; cost of elimination of a confirmed reactor animal 152.38 USD ($1,600 Mex. cy) (transportation to a TIF slaughterhouse + cost of sanitary guides + invoicing cost + cost per slaughter), veterinary fees (including biological product and other inputs) 4 USD ($50 Mex. cy/animal) and labor cost 11 USD ($120 Mex. cy per labor h/person/day).

**Economic analysis:** In order to know the economic profit obtained due to the implementation of the vaccination program, income was estimated per milk sales in the amount of 0.21 USD ($2.30 Mex. cy /liter) and sales of male calves on the hoof, 180 kg in weight or more, at 6 months of age 291 USD ($3,060 Mex. cy) and expenses (due to maintenance of reactor females that are not productive, female replacement and implementation of the control program in the production unit). Costs of labor for milking and female replacement were considered to be fixed and the control program and loss of calves due to abortion were considered to be variable costs.

**Benefit/Cost Ratio (BCR):** This was estimated by dividing annual profit per cow by control program cost per cow.

## RESULTS AND DISCUSSION

**Vaccination efficiency:** The best option to evaluate pertinence of a sanitary program in a production unit is the reduction of economic loss plus production increment in this sense Fig. 1 shows a graph with quarterly costs of program implementation (C) in the herd, together with LNCP and LWCP in the non-vaccinated and vaccinated groups, respectively.

During the period, accumulated LNCP were in the amount of 38,680 USD ($406,140 Mex. cy) or 386 USD ($4,061 Mex. cy/cow) while LWCP were nil and the cost of (C) was 6,112 USD ($64,184 Mex. cy) or 61 USD ($641 Mex. cy/cow) in this context, the cost of (C) during the 18 months is equivalent to 16% of the total accumulated LNCP. Estimates of vaccination efficiency gave results that indicated that in a year 305 USD ($3, 206 Mex. cy/cow) are lost if a program of brucellosis control is not implemented in the herd in a year and a half of monitoring this amount increased to 325 USD ($3,419 Mex. cy/cow).

**Economic analysis income-expenses:** The milking area was integrated by an average of 20 animals/month of the vaccinated group with an average milk production of 2.5 L/cow/month. Since there are no economic losses with the sanitary program (LWCP), annual profit obtained due to milk production was 1,918 USD ($20,149 Mex. cy) in animals of this group for a net profit of 83 USD ($876 Mex. cy/cow) in a year and a half of the study, total profit obtained per sales of milk was 3,327 USD ($34,934 Mex. cy) or an average of 166.35 USD ($1,746 Mex. cy/cow).

In this same area there was an average of 22 females/month that belonged to the non-vaccinated group with an average production of 2.5 L/cow/month. In this group, the total annual income by way of milk sales was 3,098 USD ($32,538 Mex. cy) and total expenses for milk production was 5,714 USD ($60,000 Mex. cy) difference between both concepts originates a negative yield or profit of -2, 615.41 USD (-$27,461 Mex. cy) or an average negative yield of -118 USD (-$1,248 Mex. cy/cow) in a year and a half of this study, total income for milk sales was 4,445 USD ($46,673 Mex. cy) and total expenses were 7,542 USD ($79,200) for a negative yield or profit of -397 USD (-$32,526 Mex. cy) or an average profit of -140 USD (-$1,478 Mex. cy/cow). In other words in economy terms, it can be stated that this production unit does not earn for milk sales approximately 119 USD ($1,250 Mex. cy/cow/per year) and 140 USD ($1,480 Mex. cy/cow in a year and a half) if within the milked animals there is at least one female affected with brucellosis.

Since, there were no diseased animals in the vaccinated population that was milked, the income due to milk production was favorable since, income was not affected by expenses as were observed in animals in the non vaccinated population that were being milked (Fig. 2). It was estimated that from the economic and productive point of view the cost of a brucellosis affected in the milking area during one lactating period is approximately 782 USD ($8,220 Mex. cy) taking into consideration losses due to infertility and lack of calves production (abortion) as well as expenses generated by its replacement, adding to this amount expenses in the amount of 157 USD ($1,655 Mex. cy) due to payment of veterinarian fees, serology diagnosis and elimination of reactor animal which increases maintenance costs to 940 USD ($9,875 Mex. cy) per lactating period.

In the production unit there is an internal replacement of dams and therefore females older than 6 months of age are not sold. Distribution of quarterly income by sale of calves on the hoof in the vaccinated and non-vaccinated groups is shown in Fig. 3.

During the 18 months of research, in the non-vaccinated group 71 calves were sold on the hoof which gave an income of 20,691USD ($217,260 Mex. cy) or a profit/cow of 206 USD ($2,172 Mex. cy) and in the vaccinated group 46 calves were sold for an income of 13,405 USD ($140, 760 Mex. cy) or profit/cow of 134 USD ($1, 407 Mex. cy).

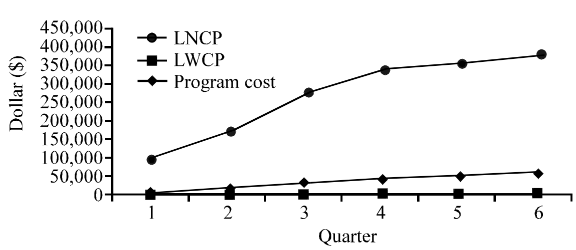


Fig. 1: Vaccination efficiency when a bovine brucellosis control program is implemented applying RB51 strain vaccine

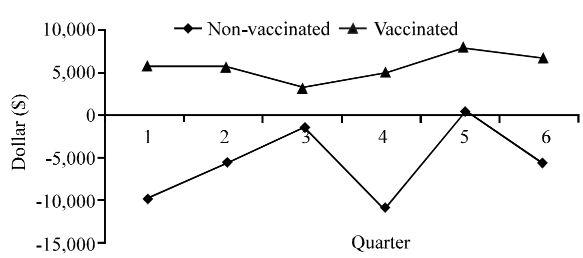


Fig. 2: Quarterly profits by milk production of non-vaccinated and vaccinated animals during the study period

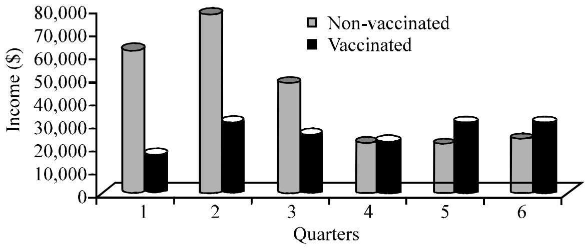


Fig. 3: Income due to the sale of calves on the hoof in the vaccinated and non-vaccinated animals during the study period

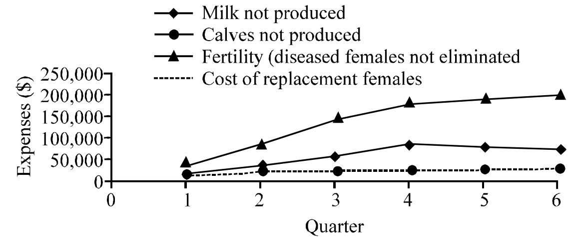


Fig. 4: Total cost accumulated per quarter due to maintenance of reactor, non-productive animals in the herd

The economic analysis established that in the non-vaccinated group, total profit per milk and calves on the hoof sales was 66 USD ($694 Mex. cy/cow) and in the vaccinated group total profit for these items was 300 USD ($3,154 Mex. cy/cow). Accumulated LNCP during the year and a half were around 38,680 USD ($406,140 Mex. cy), maintenance of non-productive reactor animals was the main generator of costs within LNCP. Total accumulated expenses per quarter caused by these females are shown in Fig. 4. In relation to productivity, cost of maintenance of reactor animals in the herd during the 18 months was 28,851 USD ($302,940 Mex. cy) listed in order of importance, losses due to fertility of diseased females that were not eliminated was the indicator that caused 66% of expenses with the amount of 19,028 USD ($199,800 Mex. cy) reduction of milk production caused 26% of expenses with the amount of 7,491 USD ($78,660 Mex. cy), lack of sales of calves that were not produced meant only 8% of losses with a value o f 2,331 USD ($24,480 Mex. cy).

Cost of maintenance in the herd of reactor, non-productive animals was increased by 2,285 USD ($24,000 Mex. cy) due to the payment of replacements for the non-productive reactor females. Because of the above, total cost of maintenance and replacement of reactor, non-productive animals during the 18 months was increased to 31,137 USD ($326,940 Mex. cy) (Fig. 4).

**Benefit (cost ratio):** Since, it is a production unit whose objective is the production derived from a double purpose herd, the BCR was analyzed in three scenarios: dairy production, calf sales and dairy production with calf sales. In this context, obtained annual BCRs were 4.7:1, 6.2:1 and 6.6:1, respectively.

**Vaccination efficiency:** Techniques and economic procedures combined with epidemiological research methods are very useful tools to carry out a more critical analysis of the sanitary problem thus generating information that is more precise and objective on the impact of the disease and allows the definition of a program or in its case a main alternative for its control (Rich *et al*., 2005) therefore when analyzing the results of vaccination efficiency shown in Fig. 1 when there are animals infected with brucellosis in the herd the impact of the disease is observed as important economic losses.

In this sense, the differences between the LNCP and LWCP were mainly due to the vaccination efficacy of RB51 strain vaccine. The sanitary program implementation cost is equal to 16% of the total accumulated LNCP; this figure lets us reflect that if only this amount were invested in a preventive program against brucellosis in the herd, 84% of LNCP caused by brucellosis could be avoided since, due to the fact that the disease was sub-clinical during the 18 months of monitoring, the losses were not evident for the producer. Differences between LNCP and expenditures due to the implementation of the control program confirms that which was indicated by Spath (2004) who mentions that the costs of an efficacious preventive program should be considered from the economical point of view as an investment, not as an expenditure.

## Economic analysis

**Income-expenses:** The concept negative profit or yield is explained as the amount of money that the producer didn't receive in the area of milking when females with brucellosis are maintained in the herd and in the population a control strategy or preventive program is not implemented. This negative profit is a direct consequence of the impact of the disease on productivity expressed in economic loss given by the cost of infertility of affected females and the cost of the respective replacement.

Milk production and profit derived from the sale of milk in the non-vaccinated group is always below economic balance point as shown in Fig. 2. This situation caused during the study period important economic losses that at the end of the economical analysis were reflected as a negative profit. In Fig. 2 it is seen that in this group there is a quarterly fluctuation between profits by dairy production that is due to the entry and exit of reactors into the milking area, at the end or beginning of their lactation in this sense, it is seen that during the fifth quarter since, there are no reactor animals in the milking area, the economic balance point is reached although, it is then lost in the next quarter when a new reactor female enters into the area.

It is estimated that the cost per cow with brucellosis in the milking area during one lactation is in the amount of 940 USD ($9,875 Mex. cy); nevertheless, losses due to reduction of up to 30% of milk production due to presence of brucellosis in affected animals should be added as mentioned by Gurria and also the additional costs due to the transmission and dissemination of the disease from an infected female to the rest of the susceptible population.

Difference between vaccinated and non-vaccinated groups in the number of calves sold is due to the random distribution of females in the formation of experimental assay groups; nevertheless in Fig. 3 it can be seen that during the 18 months, the vaccinated group has an economic stability behavior due to sales of calves on the hoof which is different from the earnings in the non-vaccinated group that after the second quarter progressively taper down and since the time of vaccine application are below the results obtained in the vaccinated group.

This situation could be associated among other factors to infertility problems in animals that are serology reactors in the non-vaccinated group. In relation to this, Dajer-Abimerhi *et al.* (2003) mention the high impact that brucellosis has on productivity in relation to the reduction of fertility of the herd, the lengthening of the time between calvings, significant losses by abortions that reduce calf crop, birthing of weak and low weight calves and low weaning weight of calves that come from infected mothers. Rodriguez *et al.* (2005) estimate that between 40 and 50% of cows serology reactors to brucellosis have their reproductive capacity affected as a direct consequence of the disease. This and all the clinical alterations, give way to a reduction of the productive parameters and in consequence, important economic repercussions in the affected productive units.

Economical analysis established that in the vaccinated group productive yield was above that obtained by the non-vaccinated group due to the sale of milk and calves on the hoof. The description is a consequence of the negative profit or yield expressed in terms of economic losses that were generated in the non-vaccinated group that substantially reduced total income from this group of animals.

Lopez *et al.* (1998) and Dajer-Abimerhi *et al.* (2003) reported that at the level of herd, the main indicators affected by brucellosis and that represent increases in production costs and reduction of productivity of diseased animals were in relation to fertility reduction, reduction of milk production, high rate of replacement; all of these indicators were also identified during this study (Fig. 4) and caused high maintenance costs of the non-productive reactor animals in the herd which represented 80% of the total LNCP.

In general in order to justify investment in sanitary programs, losses caused by the disease should be above the costs derived from the control program (Tisdell *et al.*, 1999). Within this study, the economic evaluation of accumulated LNCP were estimated at 38,680 USD ($406,140 Mex. cy) and the total cost of the control program was 6,112 USD ($64,184 Mex. cy) which demonstrated, based on the indications of this researchers that to implement a preventive program against brucellosis in the herd is economically pertinent.

In relation to animal health, Chilonda and Van Huylenbroeck (2001) mention that the researches that are to be carried out in this field should quantify the economic impact of the disease in the population, develop methods that facilitate decision-making to be able to define the best control alternatives and above all, evaluate the results of the implemented sanitary measures taken by BCR that is considered a good indicator of profitability of money that is invested in a preventive program. Analysis of investment in programs for brucellosis eradication carried out in different countries indicate a BCR that oscillates between 1.5:1-140:1, the BCR obtained in this study is found within the range of parameters included in the OPS-OMS indicators.

Aguero mention that BCR with values below the unit are considered as inefficient while much higher values should be analyzed with skepticism; emphasizing also that if the benefits of a project are more than its costs, its execution is recommendable. In agreement and based on the BCR indicators established in the herd, the implementation of a bovine brucellosis control program using the RB51 strain vaccine is an adequate sanitary strategy that from the economy point of view is reflected as a short term investment to achieve a profitable productive long term outlook.

## CONCLUSION

The results to conclude that under extensive grazing double purpose cattle production conditions, RB51 strain vaccine is an effective and efficient biological product for the control of bovine brucellosis in herds naturally infected with the economic assurance of profitability of the control program that is carried out.

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