Herd Evolution as Forensic Tool

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Abstract. The livestock sector has been identified as vulnerable to money laundering, according to the National Strategy against Corruption and Money Laundering - ENCCLA. Besides its importance for livestock management, the technic of herd evolution, as used in the present study, may be helpful in solving doubts about the compatibility between the growth or decline of a particular herd and the reproduction and movement of their animals. In this work, proceeded to the evolution of a cattle herd investigated through three scenarios for the period 2000 to 2007. Therefore, Animal Transit Guides (GTA's) and Statements of Vaccination against Foot-and-Mouth Disease (FMD) related to property investigated were used. These documents had, respectively, the record of the moved and vaccinated animals by sex and age group during the analyzed period. The results showed the occurrence of fraud in these livestock records. Therefore, the technic of herd evolution constitutes an important forensic tool, very helpful in combating money laundering through cattle ranching.
Keywords: Forensic scienses; Animal reproduction; Money loundering.

1. Introduction

The cattle industry is an activity of great economic importance to Brazil, since it is responsible for a significant portion of the value of agricultural production[1,2] and the generation of a great number of employments, income, taxes and foreign exchange. Holding the largest commercial herd in the world, Brazil stands out as the world's leading beef exporter (1.8 million tons carcass weight equivalent in 2013) and the second largest producer (9.6 million tons carcass weight equivalent in 2013). Its domestic production has grown on average 2% per year[3].

With the predominance of pasture production systems, which ensures low costs[4] and high competitiveness in the international scenario, the Brazilian cattle industry is also boosted by the strong domestic market, which has consumed, on average, 83% of national beef production[3]. Unfortunately, this economic strength has attracted, in addition to the many investments for the sector, also funds derived from illegal activities, in order to process them and hide their illicit origin.

The livestock sector is characterized by significant movement of resources, large dispersion of production and gaps in registration of property and transport of animals. Therefore, the National Strategy against Corruption and Money Laundering – ENCCLA has identified that sector as vulnerable to money laundering due to the difficulty of objectively determining the value of traded goods and their origin. ENCCLA consists in the joint, led by Brazil's Ministry of Justice, of various agencies and organizations engaged, directly or indirectly, in preventing and combating corruption and money laundering.

According to data from the Agricultural Census 2006, Brazil had a cattle herd of about 176 million heads, distributed in approximately 2.68 million properties[5]. About 89% of these properties had less than 100 animals, showing the spraying of production. As stated by ENCCLA, this characteristic favors the main objective of the washer, which is the pursuit of anonymity, with the establishment of hiding places for dirty money, from which one can legitimize it gradually and cautiously, so as not to cause a disproportionate and suspected increase of heritage.

Among the strategies used by money launderers, ENCCLA cites the schemes known as "paper cows" and extraordinary reproduction. In the first, the rancher simulates the birth, purchase, fattening, vaccination and selling of cattle that never existed. There are only the matching records, which are used to legitimate financial transactions and justify your equity gain. In the second, the washer declares that cattle purchased with illicit funds originate from the reproduction of the registered herd. This extraordinary reproduction shows up fictitious, since the equity declared as the result of natural reproduction already existed.

As noted, such schemes are closely related to herd evolution. For Lopes et al. (2000), herd evolution may be defined as quantitative changes occurring in each animal category over the years. These authors understand animal category as a group of animals of similar age, as calves or heifers, or with similar productions functions, such as lactating cows or bulls.

Herd evolution is a very important tool for the livestock planning. Proceeding both the dimensioning and evolution of a cattle herd, raisers and technicians can estimate the time required to reach the optimum number of animals on a property. According to Lopes et al. (2000), dimensioning a herd consists in determining the number of animals per category in aiming at the rational exploitation of the area. This planning allows properly quantify the infrastructure and manpower needed.

Another benefit of the technic of herd evolution is the establishment of zootechnical indexes to be achieved and the possibility of monitoring them. This is necessary because the profitability of livestock farming is closely linked to the indices obtained, which have direct influence on the production and hence the profits of the farmer. Among the main zootechnical indexes, we can cite age at the first birth, birthrate, death rates and replacement rate[1,6,7].

Indeed, a herd evolution can be developed from the application of zootechnical indexes resulting from regional customs and usages or by applying indexes researched and published by credible institutions, for example, the Brazilian Agricultural Research Corporation (Embrapa), state companies of technical assistance and rural extension, universities and associations of breeders.

In addition to its relevance to the planning and management of livestock activity, the technic of herd evolution, since it demonstrates the dynamics of the flock, can be used to answer questions about the compatibility between changes in the stock of cattle of certain property and the reproduction and movement of its animals. This paper aims to report the use of the technic of herd evolution in a forensics whose purpose was to verify the aforementioned compatibility, and which was motivated by suspicions of fraud and use of livestock for money laundering.

2. Material and Methods

The compatibility between the evolution of a cattle herd, located on a property under investigation in northern Brazil, and the reproduction and movement of its animals was checked by examining the photocopies of Statements of Vaccination against Foot-and-Mouth Disease (FMD) and Animal Transit Guides (GTA's) forwarded by the local agricultural defense agency. The first documents contained the number of cattle, divided by gender and age, existing and vaccinated against FMD between the years 2000 and 2006 at the property. The GTA's recorded the movement of its herd between 2000 and 2007, quantifying the inputs and outputs of animals by sex and age.

From the cattle inventory declared in 2000, proceeded to the evolution of the questioned flock until 2007, year that was issued the last GTA received for examination. To this end, the following zootechnical indexes were used: birthrate; death rate for males and females by age group; annual replacement rate of matrices and bulls; culling rate of heifers; bull / cow ratio; age at the first birth and slaughter age. The methodology used to estimate the herd evolution was adapted from Embrapa and is presented in Table 1.

Table 1. Methodology used to calculate the herd evolution.

Categories	Year 1
Cows	((cows at the beginning of year 0 – death rate – replacement rate) + (females 2-3 at the beginning of year 0 – death rate – culling rate))
Females 2-3 years	females 1-2 at the beginning of year 0 – death rate
Females 1-2 years	females 0-1 at the beginning of year 0 – death rate
Females 0-1 year	((cows + females 2-3 at the beginning of year 0) x birthrate x 50%[*])) – death rate 0-1 year
Males 0-1 year	((cows + females 2-3 at the beginning of year 0) x birthrate x 50%[*])) – death rate 0-1 year
Males 1-2 years	males 0-1 at the beginning of year 0 – death rate
Males 2-3 years	males 1-2 at the beginning of year 0 – death rate
Males > 3 years	(males 2-3 at the beginning of year 0 – death rate – culling rate)
Bulls	(cows + females 2-3 at the beginning of year 0) x bull / cow ratio

[*] It was considered 50% birth of males and 50% females.

Using this calculation methodology, we proceeded to the evolution of the herd questioned considering three (03) different scenarios, as described below.

Natural evolution: This scenario was built from the declared herd in 2000 of the property under analysis. The herd evolution was designed according to the trend of the performance parameters of the federative unit in which the farm was located. For this, the property was considered a closed flock, i.e. a herd in which there is no buy of cows or heifers, since these animals when discarded are replaced by offspring (calves and heifers) arising from the herd itself. The forecasts of births, deaths and sales of animals, as well as the necessary purchase of bulls over the years, were calculated based on the predominant livestock production system in that federative

unit, identified and characterized by Embrapa in 2005. This scenario is a theoretical model, which represents the projection of the natural evolution of the questioned flock under the conditions prevailing in the state in which the property was located.

Evolution with data from Animal Transit Guides (GTA's): Assuming as true the information contained in GTA`s appreciated, and considering the same values of performance the previous scenario, which are representative of the farm region, we constructed the present scenario, which shows how the flock analyzed should evolve from year to year. It is necessary to clarify that, in this analysis, the same zootechnical indexes of the previous scenario were used, except those that directly influence the marketing of animals, such as culling rates. In this case, forecasts of sales and acquisitions were replaced by the data input and output of animals recorded in GTA`s, i.e. the movement of cattle declared by the examined property. This analysis therefore represents the evolution of the questioned flock under regional typical conditions and under the influence of the declared movement of cattle.

Evolution with adjusted indexes: Assuming as true the information contained in the GTA`s and Statements of Vaccination against FMD appreciated, were calculated, year by year, the birth and death rates necessary to questioned herd assume the quantities declared in the documents considered. It is noteworthy that other performance values were kept constant. Thus, forecasts of sales and acquisitions were again replaced by the data input and output of animals recorded in GTA`s, and the performance parameters birthrate and death rates were adjusted every year, so that the herd evolution could result in a total number of animals compatible with the cattle inventory declared in the Statements of Vaccination against FMD. The aim of this analysis was to determine the reasonableness of such adjusted indexes. It is noted that the authenticity of GTA`s was not checked in this forensics.

3. Results and discussion

In Figure 1, are presented the results of the herd evolution for the first two scenarios (natural evolution, and evolution with data from GTA's), comparing them with the total number of cattle declared in the Statements of Vaccination against FMD. As the Figure 1 points out, the analyzed flock would grow at an average rate of 13% per year in Scenario 1 (natural evolution), reaching 1,244 (one thousand, two hundred

and forty-four) heads of cattle in 2007. Such number of animals would be compatible with the total support capacity of the property, estimated at 926 AU.

For Scenario 2 (evolution with data from GTA's), it is observed that at no time the results were consistent with declared cattle inventory, especially in the years 2006 and 2007 (Figure 1). Noteworthy is the end result in 2007, in which it has a deficit of 429 (four hundred twenty-nine) animals. This means that under the conditions normally found in that unit of the federation and the light of the records of GTA`s, would have left the property a greater number of animals than the available inventory generated by the reproduction of the herd (births) and the input / purchase of cattle in the analyzed period, which cannot happen.
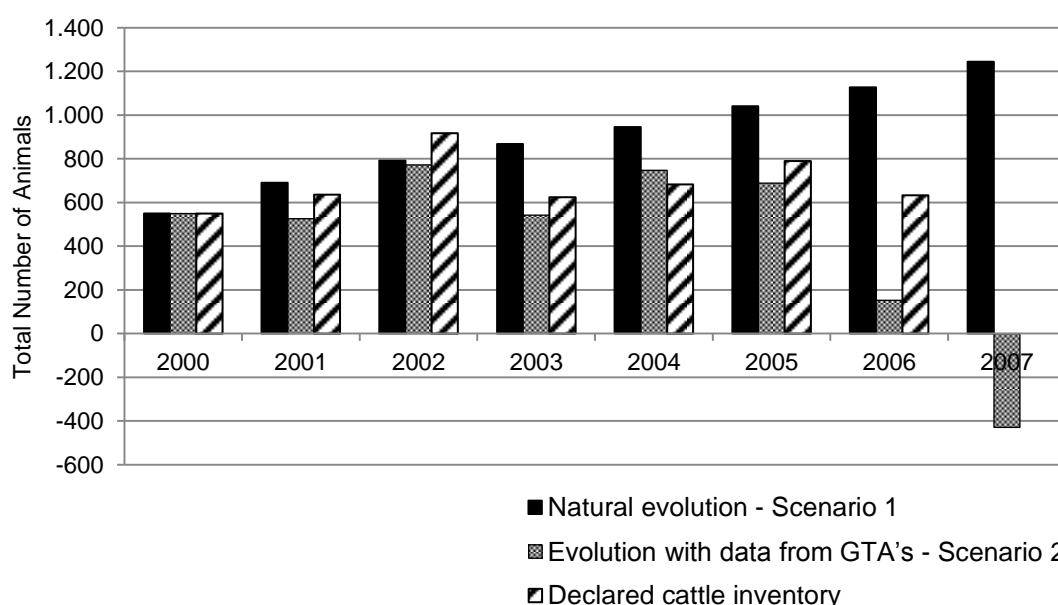

Figure 1. Projection of the evolution of the questioned herd compared to the declared cattle inventory, 2000-2007.

Once observed this discrepancy, the third scenario was developed, which aimed to establish the rates of birth and death for the questioned flock so he could assume the amounts declared in appreciated documents. Thus, the evolution of the questioned flock was recalculated adjusting the aforementioned zootechnical indexes so that the results were consistent with the cattle inventory declared between 2000 and 2007. The results of this analysis (Scenario 3) are shown in Table 2 and Figure 2.

Figure 1 highlights that, between the years 2005 and 2006, the declared herd suffered a incompatible decrease, lower than expected, with the intense output of animals, which exceeded the inputs in 654 (six hundred fifty-four) heads. According

to Scenario 2 (predominant system), such movement of animals would result in a total of 154 (one hundred fifty-four) heads of cattle in 2006, and not 633 (six hundred thirty-three) heads as stated. To achieve this cattle inventory considering the declared animal movement, the farm under consideration should present a death rate of 0% in all animal categories, and the unthinkable birth rate of 151% (Table 2 and Figure 2).

Table 2. Zootechnical parameters adjusted both to declared cattle inventory and to movement of animals of the property under analysis, 2000-2007.

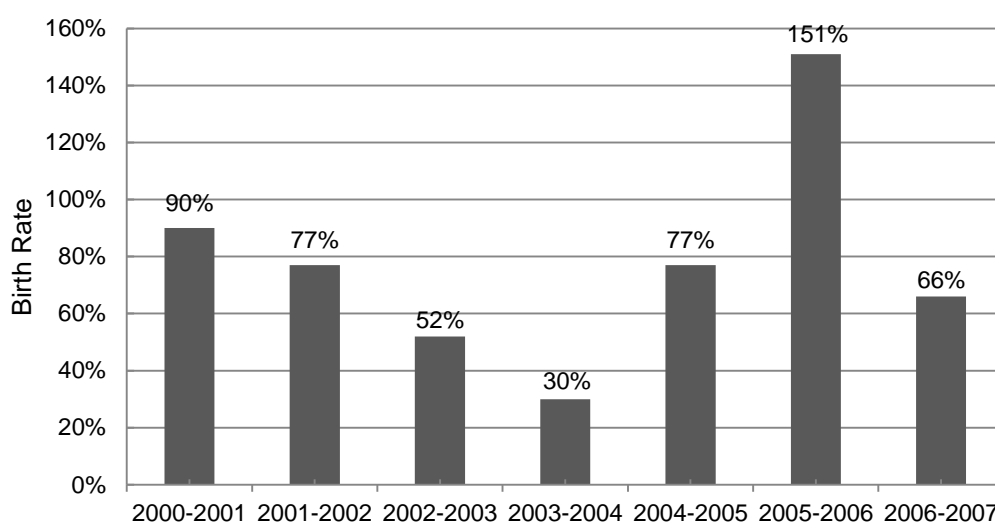| Zootechnical Parameters	2000 to 2001	2001 to 2002	2002 to 2003	2003 to 2004	2004 to 2005	2005 to 2006	2006 to 2007
Birth Rate	90%	77%	52%	30%	77%	151%	66%
Death Rate 0-1 year	3%	5%	5%	10%	5%	0%	5%
Death Rate other categories	0%	1%	1%	5%	1%	0%	1%

Figure 2. Birth rates adjusted both to declared cattle inventory and to movement of animals of the property under analysis, 2000-2007.

The birth rate is the zootechnical index with greater influence on the composition and evolution of the herd. For this reason, ranchers and technicians should make efforts to improve reproductive efficiency and herd management in order to obtain the maximum possible of births, i.e., birth rates close to 100%[6]. This ideal value corresponds to a calving interval of 12 months[7]. However, this is a very

difficult rate to be achieved[6]. It is noteworthy that birth rates cited in the technical literature usually are below 84%[8,9,10,11,12,13,14]. The Brazilian average for beef cattle is equal to 60%[15].

A birth rate of 151%, as obtained in this work, means that all cows and heifers 2-3 years of the herd gave birth between 2005 and 2006, and that 51% of these developed twin pregnancies. However, according to Komisarek and Dorinek (2002), cattle (*Bos taurus*) are a uniparous species, and the twinning occurs in only 1% to 4% of pregnancies. Besides being quite rare, twinning entail a series of economic and reproductive losses, being often associated with increased perinatal mortality of calves, longer return-to-estrus intervals, increased rates of dystocia, placental retention, abortion, stillbirth, reduced birth weights, increased involuntary culling, calf abandonment and occurrence of freemartin heifers, which are sterile[17,18,19,20]. So, twin pregnancies decrease reproductive performance and contribute nothing to the numerical evolution of the herd.

Therefore, a birth rate of 151% is not compatible with reality and the physiology of animals. This shows that, between the years 2005 and 2006, there were inputs of cattle on the questioned farm without their GTA's, or otherwise, that data contained in analyzed GTA's do not correspond to reality, recording outputs of animals that actually did not occur.

From the first hypothesis, inputs of animals without GTA's, it can be inferred that the investigated property was being used to launder money through the scheme called by ENCCLA as extraordinary reproduction. The second hypothesis, simulated outputs, indicates the occurrence of money laundering through the scheme known as "paper cows." It is emphasized that one cannot exclude the simultaneous use of these two schemes.

For the other periods, the zootechnical indexes needed to match the evolution of the declared flock with the movement of cattle were considered feasible (Table 2 and Figure 2).

4. Conclusion

The technic of herd evolution proved to be efficient in solving doubts on the compatibility between numerical changes in a particular cattle herd and the reproduction and movement of their animals. From the analysis of the Animal Transit Guides (GTA's) and Statements of Vaccination against Foot-and-Mouth Disease

(FMD) was possible to calculate the zootechnical indexes required to match the data recorded in these documents. The birth rate calculated, up from 100%, unequivocally demonstrated the occurrence of fraud in the records for 2005 and 2006.

However, when the document analysis is not sufficient to clarify the issue, inspection in loco is recommended with the aim of analyzing the technological level of the property, the quality of management and, if applicable, farm's own zootechnical records. In doubtful cases, this procedure becomes important, since it allows the expert to check and confirm the indexes calculated from the documentary records.

The technic of herd evolution constitutes an important forensic tool, able to unravel fraud in livestock records and combat money laundering through cattle ranching. Besides the criminal area, the abovementioned technique can also be employed in the solution of civil issues, although not part of the scope of this work.

References

1. Lopes MA, Vieira PF, Castro Neto P, Malheiros EB. Desenvolvimento de um sistema computacional para dimensionamento e evolução de rebanhos leiteiros. Revista Brasileira de Zootecnia. 2000; 29 (5): 1511-1519.

2. Zucchi JD, Caixeta-Filho JV. Panorama dos principais elos da cadeia agroindustrial da carne bovina brasileira. Informações Econômicas. 2010; 40 (1): 18-33.

3. USA. Department of Agriculture. Foreign Agricultural Service. Livestock and poultry: world markets and trade. 2013. 29 p.

4. Jorge Júnior J, Cardoso VL, Albuquerque LG. Modelo bioeconômico para cálculo de custos e receitas em sistemas de produção de gado de corte visando à obtenção de valores econômicos de características produtivas e reprodutivas. Revista Brasileira de Zootecnia. 2006; 35 (5): 2187-2196.

5. Brasil. Instituto Brasileiro de Geografia e Estatística. Censo agropecuário 2006: Brasil, grandes regiões e unidades da federação - segunda apuração. Rio de Janeiro: IBGE; 2012. 758 p.

6. Lopes MA, Cardoso MG, Demeu FA. Influência de diferentes índices zootécnicos na composição e evolução de rebanhos bovinos leiteiros. Ciência Animal Brasileira. 2009; 10 (2): 446-453.

7. Lopes MA, Demeu FA, Santos G, Cardoso MG. Impacto econômico do intervalo de partos em rebanhos bovinos leiteiros. Ciência e Agrotecnologia. 2009; 33: 1908-1914.

8. Catto JB, Afonso E. Taxa de natalidade de vacas e desempenho de bezerros sob desmama antecipada no Pantanal. Pesquisa Agropecuária Brasileira. 2001; 36 (9): 1205-1211.

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9. Abreu UGP, Cezar IM, Torres RA. Análise bioeconômica da introdução de período de monta em sistemas de produção de rebanhos de cria na região do Brasil Central. Revista Brasileira de Zootecnia. 2003; 32 (5): 1198-1206.

10. Melo Filho GA, Costa FP, Corrêa ES, Pereira MA, Cezar IM, Silva Netto FG. Sistema e custo de produção de gado de corte no Estado de Rondônia. Campo Grande: Embrapa Gado de Corte; 2005. 7 p.

11. Vieira A, Lobato JFP, Correa ES, Torres Junior RA, Cezar IM. Produtividade e eficiência de vacas nelore em pastagem de *Brachiaria decumbens* Stapf nos cerrados do Brasil Central. Revista Brasileira de Zootecnia. 2005; 34 (4):1357-1365.

12. Fassio LH, Reis RP, Geraldo LG. Desempenho técnico e econômico da atividade leiteira em Minas Gerais. Ciência e Agrotecnologia. 2006; 30: 1154-1161.

13. Costa FP, Corrêa ES, Cardoso EE, Oliveira SJM, Silva FG, Brito LG, Salman AKD, Figueiró MR, Pereira RGA. Produção de gado de corte no Estado de Rondônia: uma proposta de sistema melhorado. Campo Grande: Embrapa Gado de Corte; 2009. 9 p.

14. Vaz RZ, Lobato JFP, Restle J. Productivity and efficiency of cow herds submitted to two weaning ages. Revista Brasileira de Zootecnia. 2010; 39 (8): 1849-1856.

15. Euclides Filho K. Produção de bovino de corte e o trinômio genótipo-ambiente-mercado. Campo Grande: Embrapa Gado de Corte; 2000.

16. Komisarek J, Dorynek Z. Genetic aspects of twinning in catlle. Journal of Applied Genetics. 2002; 43 (1): 55-68.

17. Kirkpatrick BW. Management of twinning cow herds. Journal of Animal Science. 2002; 80 (2): 14-18.

18. Quaresma MA, Costa LL, Horta AEM, Silva JR. Twinning induction and its effects on

19. embryo-foetal and calf survival, and on reproductive efficiency of Mertolengo cattle kept at pasture. Revista Portuguesa de Ciências Veterinárias. 2004; 99 (550) 109-115.

20. Bierman CD, KIM E, Weigel K, Berger PJ, Kirkpatrick BW. Fine-mapping quantitative trait loci for twinning rate on Bos taurus chromosome 14 in North American Holsteins. Journal of Animal Science. 2010; 88 (8): 2556-2564.

21. Kim ES, Shi X, Cobanoglu O, Weigel K, Berger PJ, Kirkpatrick BW. Refined mapping of twinning-rate quantitative trait loci on bovine chromosome 5 and analysis of insulin-like growth factor-1 as a positional candidate gene. Journal of Animal Science. 2009; 87 (3): 835-843.