DISTRIBUTIVE AND REGIONAL POLICY IMPLICATIONS OF *TRYPANOSOMA EVANSI* CONTROL IN THE PANTANAL, BRAZIL

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ABSTRACT - The Pantanal is a tropical seasonal wetland 138,000 km^2 in area located in the Central-West of Brazil. The Pantanal contains approximately 4,100 agricultural properties, 3 million cattle, 49,000 horses, and a unique diversity of wildlife. Cattle ranching is the most important economic activity in the Pantanal. This study explores the regional policy and distributive impacts of three economically feasible treatment strategies for mitigating the financial impacts of *Trypanosoma evansi* in the Brazilian Pantanal based on four agricultural property size categories. Horses are indispensable to the cattle ranching industry in the Pantanal and *T. evansi* kills horses. The estimated total annual cost of *T. evansi* to Pantanal cattle ranches is US$2.4 million. Results indicate that those ranches with the most horses stand to gain or to lose the most in gross figures but less in relative terms. While recommended strategies remain the same, economies of scale in curative treatment strategies result in diminishing treatment costs per animal as ranch size increases. Incentive-based policies should reflect the distinct financial incentives which motivate different size ranches in order to achieve wide adoption of treatment strategies for the least expense.

Key words: Animal health economics, *Trypanosoma evansi*, tropical horse disease, financial analysis.

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INTRODUCTION

Trypanosoma evansi is a principal cause of equine death in the Pantanal region of Brazil (Silva *et al.*, 1995). The annual impact of *T. evansi* on the Pantanal has been estimated at US$2.4 million (Seidl *et al.*, 1998b). Three potential treatment strategies to mitigate this impact were found to be economically feasible: (1) a curative treatment applied year-round; (2) a wet season application of the curative treatment; and (3) an imported preventive treatment. The estimated net benefits to the region using these treatment strategies may exceed US$2 million per year relative to the "no treatment" strategy. The economically "best available technology" at the regional level was found to be year-round application of a cure for the disease (Seidl *et al.*, 1998b). However, the best available technology at the regional level may not be the best option for all concerned ranchers. Scale effects may distort the distribution of benefits from treatment strategies when aggregated at the regional level. This work assesses the distribution of costs and benefits and the hypothetical influence on regional policy of the three control strategies for *T. evansi* over four property size categories. This analysis provides information to ranchers regarding the probable implications of the adoption of alternative strategies on their ranches. The regional policy implications of this work derive from greater insight into the probable distributive impacts of these economically feasible treatment strategies for *T. evansi* control.

MATERIALS AND METHODS

The choice to treat *Trypanosoma evansi* represents an investment decision for the individual Pantanal rancher. Each rancher should weigh the costs and benefits of each available alternative. The alternative or treatment strategy resulting in the greatest net benefit to the individual rancher over time should be chosen. Ranchers are assumed to seek to minimize the net impact of livestock diseases through their treatment investment decisions. A partial farm budget approach was used to calculate the costs and benefits derived from using one of the three treatment strategies for *T. evansi* on Pantanal ranches. A year-round

curative, a seasonal curative and an imported preventive treatment strategy were compared to a "do nothing" or "no treatment" strategy (Table 1).

The methodology focused upon aspects of the typical farm budget which may potentially vary as a result of the disease or its treatment. Components of the estimated models include risk of infection, costs of diagnosis, treatments, animal collection, and projected animal losses (Seidl *et al.*, 1998ab). The costs of diagnosis, treatments, and animal collection represent investments to the rancher. Although investments are necessarily costly, costs and investments are not synonyms since the rancher may incur other types of costs as well (e.g. animal losses). Returns on investment are in the form of expected animal losses foregone less investment costs incurred and are dependent upon the perceived risk and expected outcome of infection. Table 2 shows the components of the estimated relationships and their adopted values.

Table 1 - Strategies for *Trypanosoma evansi* control evaluated for Pantanal region, Brazil ranchers

Strategy	Description of rancher behavior
No treatment	Does not treat for *T. evansi* in any way.
Cure—annual	Treats outbreaks of *T. evansi* using a curative strategy. Chooses to monitor animals and apply this treatment over the entire year, not only in the high vector and easy monitoring rainy season.
Cure—seasonal	Treats outbreaks of *T. evansi* using a curative strategy. Applies this strategy only during the rainy season. "No treatment" strategy is chosen during the dry season. Thought to be most commonly adopted strategy.
Imported prevention	Treats *T. evansi* through an imported (not yet legal locally) preventive strategy which requires year-round application for full effectiveness.

The relative attractiveness of a particular strategy may depend upon ranch size and the objectives of municipal and state authorities. The number of people, horses, and cattle were estimated for four property sizes. The models were re-estimated to determine the cost and benefit implications of control strategies across ranch size using both financial

and animal welfare considerations. Policy implications were explored derived with reference to the results of these estimations and potential regional and individual objectives.

Agricultural properties, people, and cattle in the Pantanal

Cattle ranching is the primary economic activity in the Pantanal region. Horses are an integral part of the region's extensive cattle ranching system. The Pantanal is a geophysical and not a geopolitical entity. The Pantanal region lies within the Upper Paraguay River Basin and covers parts of two states (Mato Grosso and Mato Grosso do Sul) and 15 municipalities (Figure 1). None of these geopolitical designations falls completely within the Pantanal. As a result, it is inaccurate to use census data, in its reported form, concerning the Pantanal.

Table 2 - Components of the estimated treatment strategies available to Pantanal region, Brazil ranchers for *Trypanosoma evansi* control

Variable	Published Information	Value	Low range	High range	Units
Risk of infection	Franke *et al.*, 1994	13.20	0.30	56.30 %	
Risk-high season	Silva *et al.*, 1995	90	-	-	%
Animal losses	Seidl *et al.*, 1998a	10.50	0.00	51.60 %	
Ranches	Silva *et al.*, 1998	1,131	-	-	#
Horses	Cadavid Garcia, 1985; Silva *et al.*, 1998	48,958	18,240	79,676	#
Horse prices	None	375	100	1,200	US$
Diagnostic costs	Seidl *et al.*, 1998a	175.00	29.51	1,024.51	US$
Animal collection	None	7.32	-	-	US$/130/ horse-day
Isometamidium chloride (preventive strategy)	Peregrine, 1994	23.92	23.57	24.27	US$/ horse-yr
Diminazine aceturate (curative strategies)	Peregrine & Mammon, 1993	10.12	10.05	10.19	US$/horse

Census data (IBGE, 1990) can used in conjunction with GIS images to reveal that within the Pantanal there are 4,104 agricultural properties, 3,028,786 cattle, and 27,793 people living and working on those

properties which cover a total area of over 118,000 km² (86% of the Pantanal region). There are 3,381 (82%) agricultural properties 3,600 ha or less; 271 (6.6%), 3,601 to 7,200 ha; 239 (5.8%), 7,201 to 14,400 ha; and 213 (5.2%), 14,401 ha or greater (Silva *et al.*, 1998) (Table 3).

Table 3 - General features of Pantanal, Brazil agricultural properties, by property size

Feature	Size of agricultural property (ha)					
	Total	<3,600	1,000-3,600	3,601-7,200	7,201-14,400	>14,401
Total area	11,880,515	1,175,350	894,076	1,422,889	2,492,199	6,790,078
Mean area	2,895	348	2,191	5,251	10,428	31,878
Total properties	4,104	3,381	408	271	239	213
Total cattle	3,028,786	431,286	296,067	404,018	719,971	1,473,511
Total people	27,793	17,250	2,881	2,384	2,831	5,328
Total horses	48,958	n.a.	8,976	6,233	14,579	19,170

Source: Calculated from IBGE, 1990 and Cadavid Garcia, 1985. Obs.: Columns do not sum to total provided in column 1 since information in column 3 is a proper subset of column 2.

More than 60% of the people live on the smallest properties. Approximately 9% and 10% of the people live on the next two larger size holdings, respectively, and 19% live on the largest agricultural property. About 14% of the cattle are found on the smallest properties, while 13%, 24%, and 49% are found on the three successively larger properties. Data indicates that 10% of the agricultural land is held in the smallest properties. About 12%, 21%, and 57% of the land is found on the three successively larger property sizes (Silva *et al.*, 1998) (Table 3).

Correlated with ranch size, the number of cattle and people per ranch increases from 7 people and 726 head of cattle per ranch (1,000-3,600 ha) to more than 25 people and 6,918 head per ranch (>14,401 ha). The regional means fall most closely within the 7,200-14,400 ha ranch size (Table 4).

Cattle ranches and horses in the Pantanal

Precise information on the current total number of horses in the Pantanal region is not available. Horses are found on cattle ranching operations, and there is no large scale agriculture within the Pantanal. Cadavid Garcia (1985) reported 22 (standard deviation, 19), 23 (sd, 9), 61 (sd, 44), and 90 (sd, 47) horses per ranch on holdings of 1,000-3,600 ha, 3,601-7,200 ha, 7,201-14,400 ha, and greater than 14,401 ha, respectively (Table 4). Information for holdings of less than 1,000 ha was not provided.

Table 4 - Features of Pantanal region, Brazil cattle ranches, by ranch size

Feature	Size of ranch (ha)				
	Regional mean	1,000-3,600	3,601-7,200	7,201-14,400	>14,401
Cattle/ranch	2,558	726	1,491	3,012	6,918
People/ranch	12	7	9	12	25
Horses/ranch	43	22	23	61	90

Source: Calculated from IBGE, 1990 and Cadavid Garcia, 1985, 1986.

Cadavid Garcia (1986) reported one working animal per 66 head of cattle on holdings of less than 3,600 ha. Since holding size and the number of horses per holding are correlated, this implies a maximum of 2,049 horses (less than 1 per property) should be found on all holdings of less than 1,000 ha. Therefore, it is unlikely that agricultural properties of less than 1,000 ha are cattle ranches requiring working animals. As a result, the smallest holding size category was truncated to 1,000-3,600 ha for this analysis. We arrived at a total estimate of 48,958 horses on cattle ranches in the Pantanal (Table 3).

RESULTS AND DISCUSSION

The distribution of costs and benefits of *T. evansi* control

The strategies recommended to combat *T. evansi* in the Pantanal consider the distribution of costs and benefits derived from the use alternative strategies across ranch size. Analogous to the regional analysis, the adoption of a year-round curative strategy is superior on financial grounds to a seasonal curative strategy, independent of ranch size. The seasonal cure is financially superior to the imported preventive strategy and prevention is preferred to no treatment throughout all ranch size categories. (Table 5).

Table 5 - Net benefits of *T.evansi* treatment to Pantanal, Brazil ranchers, financial terms (US$), by ranch size

Ranch size (ha)	Year-round cure			Seasonal cure			Prevention		
	Total (%)	Per ranch	Rtrn/ Invst	Total (%)	Per ranch	Rtrn/ Invst	Total (%)	Per ranch	Rtrn/ Invst
All	2,083,977 (100.00)	1,843	24.5	1,875,579 (100.00)	1,658	24.5	1,241,319 (100.00)	1,098	1.05
1,000-3,600	377,433 (18.11)	925	18.7	339,699 (18.11)	833	18.7	227,584 (18.33)	558	1.05
3,601-7,200	262.384 (12.59)	968	19.1	233.146 (12.59)	871	19.1	158.036 (12.73)	583	1.05
7,201-14,400	622,838 (29.89)	2,606	27.0	560,554 (29.89)	2,345	27.0	378,001 (30.45)	1,582	1.05
>14,401	821,312 (39.41)	3,856	29.4	739,181 (39.41)	3,470	29.4	486,051 (39.16)	2,282	1.05

However, based on property size, our results indicate substantial differences in the expected annual, per ranch, financial net benefit from use of each alternative treatment strategy. Although the mean net benefit from the adoption of a year-round curative strategy is US$1,843, smaller ranches can expect net benefits of less than US$1,000, while large ranches can expect almost US$4,000 (Table 5). The investment required to earn these returns is also skewed. Smaller ranches can expect to invest on average about US$50 annually, while large holdings will be investing almost three times this amount (Table 6).

Table 6 - Estimated investment requirements of *T. evansi* treatments to Pantanal region, Brazil ranchers, by ranch size (US$)

Ranch size	Required investment (US$), by treatment					
(ha)	Year-round cure		Seasonal cure		Prevention	
	Per ranch	Per horse	Per ranch	Per horse	Per ranch	Per horse
Mean	75.14	1.74	67.62	1.56	1,045.18	24.15
1,000-3,600	49.55	2.25	44.59	2.02	531.20	24.15
3,601-7,200	50.75	2.21	45.68	1.99	555.34	24.15
7,201-14,400	96.44	1.58	86.79	1.42	1,437.90	24.15
>14,401	131.30	1.46	118.17	1.31	2,173.07	24.15

Estimated differences in net benefits are not, simply, due to having more exposed animals. Rather, there are economies of scale in the diagnostic costs of curative treatments that large ranches enjoy over smaller ones. This can be seen in the returns-to-investment ratios which indicate the estimated dollar return for each dollar invested in treatment. This measure is indicative of the individual incentives motivating ranch owners determined by ranch size. If there were no economies of scale in curative treatments the returns-to-investment would be equivalent across ranch size; however, returns-to-investment increase as ranch size increases (18.7, small; 24.5, mean; and 29.4, large) (Table 5).

Expected net returns using a seasonally adopted curative strategy will be smaller per ranch due to lower levels of investment (US$45, small; US$68, mean; US$118, large) (Table 6). At a regional level, the difference in expected regional net benefits from use of a year-round curative strategy and benefits obtained from use of a seasonal strategy is more than US$200,000 annually. However, the return on investment derived from the wet season adoption of a curative strategy are equivalent to the year-round strategy across ranch sizes. From a regional policy perspective, an adjustment in credit availability or increased use of public relations techniques may be needed to entice the seasonal strategist to adjust to year-round *T. evansi* control.

Results indicate no economies of scale in the preventive treatment of *T. evansi*, since it does not require a costly veterinary visit. The

preventive strategy demands a far greater investment in order to reduce disease risk to zero (US$531 small, US$1,045 mean, US$2,173 large), but results in no animal deaths due to *T. evansi* (Table 6). The returns-to-investment derived from use of the preventative strategy, while lower than the curative strategies, are financially feasible and equivalent across ranch size. Although the returns-to-investment differ substantially between preventive and curative strategies, the proportion of net benefit accruing to large versus small ranches is quite similar across strategies; each large ranch stands to garner about four times the net benefits of each small ranch on average across treatment strategies (Table 5).

In general, results indicate that those who have more to gain have more to lose. Logically, the more land a ranch has, the more animals it will have, the greater the gross financial impact of a disease outbreak will be, and the greater the cost of mitigating these damages on a ranch by ranch basis. The costs and the benefits of all strategies increase as ranch size increases on a category and a per ranch basis. The larger ranches garner 60% of the net benefits from any strategy adopted.

Policy implications

On a policy level, if changes in treatment behavior are desirable at the municipal or regional level, it is necessary to look to the incentives which motivate each ranch size, the expected behavior based on those incentives, and the potential impacts of manipulating private incentives to achieve the broader objectives of the municipality or region.
Suppose that the region has as its objective minimizing the number of horses killed by the disease and to do so for a minimum cost. On animal welfare grounds, regardless of ranch size, the preventive strategy saves the most animals, followed by the year-round, and then the seasonal control strategy (Table 7). Results indicate the year-round and the seasonal curative strategy are economically equivalent; the net returns for each dollar of additional investment are equivalent (Table 5). However, the year-round curative strategy is superior on regional financial and animal welfare grounds as it provides a regional net benefit of US$208,398 and 579 horses relative to the seasonal strategy.

Currently, ranchers adopt a wet season strategy for *T. evansi* control. Our results indicate that it should be possible to change rancher behavior

to a year-round control strategy using the financial incentives in place provided ranchers are not too liquidity constrained to invest nominal additional funds. Information about the cost effectiveness of the strategy may be sufficient to entice change, or it may be necessary to provide financing (e.g., grants or loans) to alleviate liquidity problems at expected treatment times.

Table 7 -Net benefits from *Trypanosoma evansi* control in the Pantanal, Brazil, number of horses, by ranch size

Size (ha)	Control strategy					
	Cure—year-round		Cure—seasonal		Prevention	
	Region	Mean	Region	Mean	Region	Mean
1,000-3,600	1,061	2.6	954	2.3	1,185	2.9
3,601-7,200	736	2.7	662	2.4	823	3.0
7,201-14,400	1,722	7.2	1,550	6.5	1,924	8.1
>14,401	2,264	10.6	2,038	9.6	2,530	11.9
Region	5,783	5.1	5,204	4.6	6,462	5.7

A scheme to induce this change in behavior could focus on any aspect of the treatment process (i.e., treatment costs, diagnostic costs, the rancher and ranch management, or the horses themselves). Typically, inducements are offered by ranch or by treatment (or per horse treated). These distinct policy options are not equivalent on either efficiency or equity grounds.

The year-round strategy requires an additional investment of 11% relative to the seasonal strategy, or US$4.96 per smallest ranch category, US$5.07 per ranch 3,601-7,200 ha, US$9.65 per ranch 7,201-14,400 ha, and US$13.13 per ranch of the largest size category. If financial inducements were offered based on the additional investment required of the regional mean ranch size (US$7.52) to the 1,131 Pantanal ranches, only the 679 ranches of the two smallest size categories would be enticed to comply (Table 6). This result is expected because the inducement is greater than the difference in per ranch net benefits from changing strategies for the smaller ranches, but less than that difference for larger ranches; it's a good deal for small ranches and a bad deal for

large ranches. The annual cost of the program would be US$5,106 (679 x 7.52). It would result in additional regional net benefits of US$66,972 (377,433 + 262,384 - 339,699 - 233,146), 181 horses would be saved (1,061 + 736 - 954 - 662), and the return to investment would be 12.1:1 ((66,972 - 5,106) / 5,106). The cost of the program per horse saved would be US$28.20 (5,106 / 181).

In order to expect full compliance, financial inducements would need to be offered equivalent to the maximum required additional investment for a ranch to change from the seasonal to the year-round curative strategy (US$13.13, Table 6). This program would cost US$17,213 (1,131 x 13.13), result in additional regional net benefits of US$208,398 (2,083,977 - 1,875,579), save 579 horses (5,783 - 5,204), and have a return to investment ratio of 11.1:1 ((208,398 - 17,213) / 17,213) due to the economies of scale on the larger ranches. The cost of the program per horse saved is US$25.73 (17,213 / 579).

If the inducement policy were to be made based upon horse treated rather than by ranch, the difference in required investment between the two strategies on a per horse basis need to be used. For the year-round strategy, the mean Pantanal ranch would invest US$1.74 per horse versus US$1.56 per horse for the seasonal strategy; a differential of US$0.18 per horse per year. The smallest ranches have a differential of US$0.23 per horse; the small ranches show a difference of US$0.22 per horse; ranches 7,201-14,400 ha have an investment differential of US$0.16 per horse; and the largest ranches have the least differential in investment between the two strategies on a per horse basis (US$0.15)(Table 6).

A regional policy offering the mean required inducement to all Pantanal ranches (US$0.18) could expect compliance from the 452 (239 + 213) largest ranches. These ranches account for 69% (33,749 / 48,958) of all horses in the region. The program would cost US$6,075 (0.18 x 33,749), result in regional benefits of US$144,415 (622,838 + 821,312 - 560,554 - 739,181), save 398 horses (2,264 + 1,722 - 2,038 - 1,550), and provide a return on investment of 22.8:1 ((144,415 - 6,075) / 6,075). The cost per horse saved would be US$15.27 (6,075 / 398).

An inducement of US$0.23 per horse could be expected to result in full compliance among the region's 1,131 ranches. The program

would cost US$11,260, result in regional benefits of US$208,398, save 579 horses, and provide a return on investment of 17.5:1. The expected costs per horse saved are US$19.45. Thus, for either partial or total compliance with policy we find that a per horse inducement is superior to a per ranch inducement based on efficiency and efficacy grounds; more horses are saved for less cost.

This preventive strategy requires the same level of investment per horse regardless of ranch size, and treatment offers no economies of scale. Prevention carries the promise of saving an additional 679 (6,462 - 5,783) horses relative to the year-round strategy and 1,258 (6,462 - 5,204) horses compared to the seasonal strategy at the regional level. The per horse inducement necessary to expect rancher behavior to change from seasonal cure to prevention at the mean Pantanal ranch size (US$22.59), would result in probable compliance by the 452 largest ranches in the region at a programmatic cost of US$762,390 (22.59 x 33,749) and saves about 866 horses at a financially unjustifiable cost of US$880 per horse saved (more than twice the price of a horse). Providing a per horse inducement sufficient to expect total compliance (US$22.84) results in annual programmatic costs of US$1,118,201 (22.84 x 48,958), or a financially unjustifiable US$890 per horse saved.

CONCLUSIONS

This study illustrated some of the potential difficulties policy makers might have in manipulating economic incentives in order to achieve broader social objectives. We have also demonstrated the potential pitfalls of making regional policy based upon mean values. We explored the distributive and policy implications of three proactive treatment strategies for the horse disease *Trypanosoma evansi* used in four ranch size categories. This study supports the recommendations of Seidl *et al.* (1998b) by finding that the best available technology is a year-round curative strategy, a seasonal strategy ranks second, and an imported preventive strategy ranks third as economically justified strategies to mitigate the impact of the disease.

We found that the greatest potential benefits and the greatest

potential costs fell to the largest properties with the most animals. Expected net benefits from the alternative strategies were lower on small holdings than large ranches, both on a per horse and per ranch basis. Returns on investment for treatment strategies were greater on larger ranches than on smaller ones. Moreover, economies of scale determined by the number of animals treated existed in curative strategies that did not exist in the preventive strategy.

From a regional policy perspective, while the preventive strategy was financially justifiable and preferable in animal welfare terms, the costs of converting ranchers from the prevailing seasonal curative strategy were unjustifiable. Policies that could be expected to induce both partial and total conversion to a year-round curative strategy were financially justifiable on both a per ranch and a per horse basis. Inducement policies based upon a per horse incentive should be expected to be more efficient and effective than those based upon per ranch incentives. These conditions exist due to economies of scale in curative treatments and the distribution of net benefits across ranch size. The optimal policy depends upon whether animal welfare or budgetary concerns take precedence in decision-making and the existence of alternative investment opportunities. The policy expectation of partial compliance produces greater financial returns to investment than enticing total compliance. The policy enticing total compliance saves more horses.

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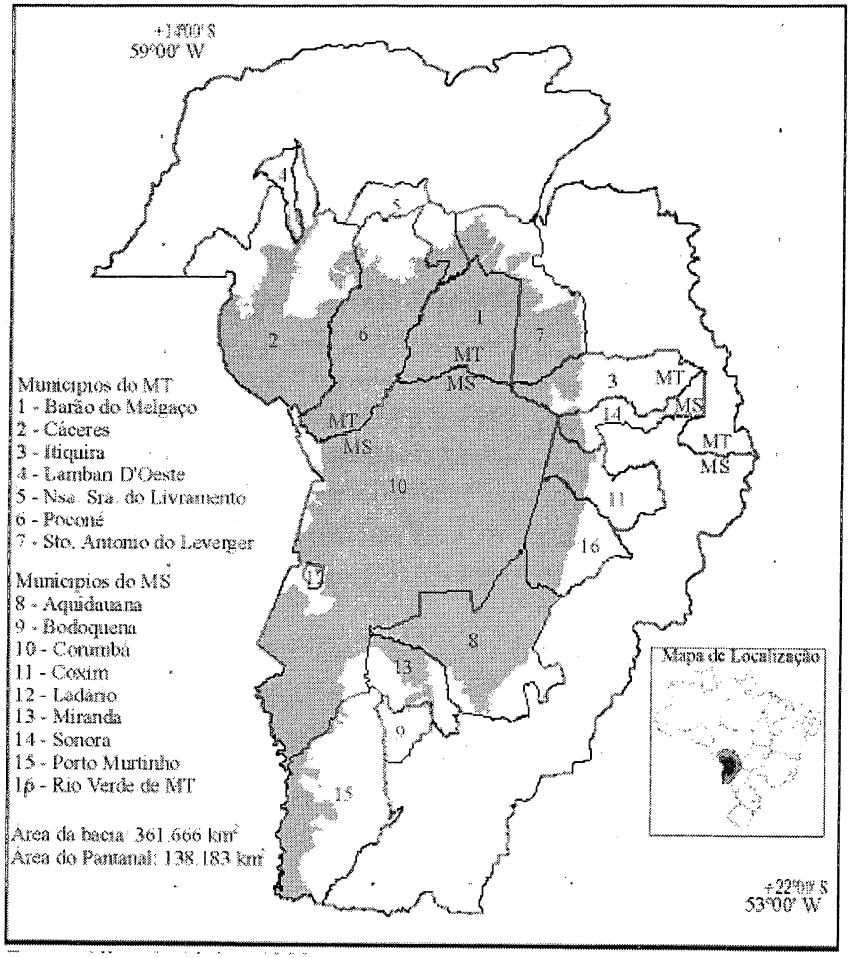
FIGURES

Figure 1: Municipalities of the Pantanal region, Brazil



Source: Silva & Abdon, 1998

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