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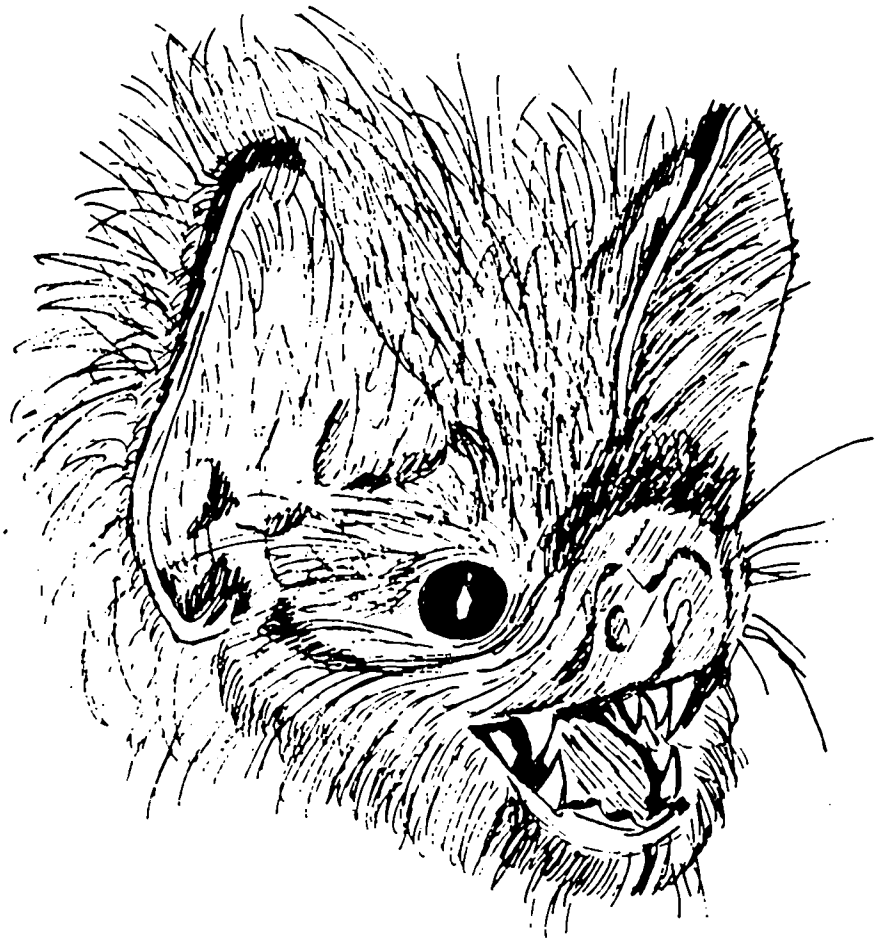
EVALUATION OF THE VAMPIRE BAT CONTROL PROGRAM



DANIEL D. BADGER

Project Leader

KARL M. SCHMIDT

Research Associate

DEPARTMENT OF AGRICULTURAL ECONOMICS
OKLAHOMA STATE UNIVERSITY
STILLWATER, OKLAHOMA 74074

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AE 7914

May 29, 1979

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WITH

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Stillwater, Oklahoma 74074

Daniel D. Badger
Project Leader

Karl M. Schmidt
Research Associate

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ABSTRACT

The AID sponsored vampire control program in Latin America was initiated by personnel of the Denver Wildlife Research Center, Fish and Wildlife Service, U.S. Department of Interior. Until now, the control program has had its greatest success in Nicaragua. In fact, this program was the first national campaign by the Ministry of Agriculture (working with farmers) in Nicaragua.

An indication of the success of the national control program in Nicaragua is that 95 percent of the participants and 77 percent of the non participants in the vampire bat control program stated they would participate in a similar service program with the Ministry if provided that opportunity in the future. Also personnel were trained to work with farmers in providing a technical service. The combination of this development of technical expertise and the rapport with farmers gained by the Ministry should lead to a higher level of confidence in the Ministry, and an increased ability to undertake similar nation-wide programs in the future.

The estimated annual economic benefits in 1,918 Nicaraguan herds with 298,919 cattle in the control program were $31,388 (U.S.) from decreased bovine mortality due to paralytic rabies, $1,263,030 (U.S.) from increased meat and $1,119,740 (U.S.) from increased milk production. The four-year control program in Nicaragua (1974-1977) cost $519,000 (U.S.); $482,400 was expended by the Ministry of Agriculture, $6,500 by the cattleowners, and $30,100 of AID expenditures (Tables 9,10, and 11).

The total annual benefits of the vampire bat control program in Nicaragua were estimated to be $2,414,158 (U.S.). The annual costs were estimated at $129,750 (U.S.) ($519,000 ÷ 4 years). The benefit-cost ratio is 18.61 to 1.00, indicating that for every $1.00 spent on control during this four year period in Nicaragua, the benefits were $18.61. Even though the production estimates are subject to some error, the magnitude of the ratio is such that we can state with confidence that there was a high pay-off for this AID-sponsored research and development program. Looked at in a different perspective, AID's total cost for this program over a <u>ten year</u> period was $1.5 million (U.S.). <u>Annual</u> benefits from just one small Central American country were $2.4 million (U.S.).

The control program involved 148,142 cattle being injected and 2,696 vampire bats being captured and treated with diphacinone. The number of people treated nationally for rabies because of vampire bites decreased from 48 cases in 1973 before control to one case annually after control. Fear of being bitten by vampire bats was not changed due to the control program. Owners of small herds received 0.3 percent, intermediate sized herd owners 22.6 percent and owners of large herds about 77.1 percent of the economic benefits of control.

Environmental quality received a positive net impact from diphacinone control, with nontarget species and air and water quality not adversely affected. The diphacinone control strategy had a net overall average impact of +53 compared to a net impact of -11 for the alternative control strategies, when economic impacts, social well-being impacts and environmental quality impacts were aggregated.

The $1.5 million (U.S.) cost to USAID for development and testing of anticoagulant control methods by the Denver Wildlife Research Center was "transferred" as a benefit technology to 16 Central and South American countries where diphacinone has been used. This "transfer" or allocation was on the basis of number of head of bovine animals reported for each country.

For Nicaragua, the inputs by cattleowners, the Nicaraguan government and the USAID transfer of technology were estimated at $6,500, $482,400 and $30,100, respectively. The monetary contributions by the respective segments of control were: cattleowners, 1.3 percent; the Nicaraguan Ministry of Agriculture, 92.9 percent; and, transferred technology from USAID, 5.8 percent. Given the cost distribution situation in Nicaragua as indicative of control programs in other Latin American countries, it could be that any "foot-dragging' in the implementation of the diphacinone vampire bat control program is due to the high cost to the host country government. Certainly, the proportion of AID transferred technology is low compared to the total costs of the control program.

The cost of control application will depend primarily on: (a) the method of diphacinone application; (b) the administrative system and structure of the developing country; and (c) whether the chemical is sold or handled through public or private infrastructure.

This evaluation study looked at the effectiveness of vampire bat control only when implemented by the public sector. Some research is necessary

on benefits and costs when methods are handled within the private sector, i.e., by the ranchers themselves. Data from interviews with Nicaraguan ranchers indicated that 94 of 117 vampire bat control program participants had syringes which were commonly used for other vaccinations. Thus, 80 percent of the participants were capable of doing the injection work themselves. They had been or were buying other vaccines or drugs for injection for their cattle. The technicians were only necessary for the training of correct injection procedures.

Control program personnel in Colombia and Panama preferred the systemic method of control because of personnel problems associated with the topical treatment method (fear of bats, working at night, etc.). Personnel in Venezuela and Trinidad favored the topical application method to avoid possible diphacinone contamination of milk and meat products.

Typically in most countries the effectiveness of the vampire bat control program has been measured by the reduction in the number of bat bites after some specified periods of time, such as 30 days, 90 days, etc. While there is an obvious connection with death of the bovine if bitten by a bat carrying the paralytic rabies virus, a majority of the bats do not carry the virus. Then the effects are based on the connection between the number and frequency of bites on the animal and the age and physical condition of the animal. If the animal is healthy, and is only bitten occasionally, generally milk production and/or amount of weight gained is not adversely affected.

The above statements are not meant to imply that significant losses have not been prevented by the vampire bat control program. What is not known is the direct connection between bites and weight loss or milk production loss. Any future programs involving pest control and agricultural-related losses (in crop yields, meat or milk production) should include control plots or lots of animals, which are not treated, as well as developing methods to measure, weigh or otherwise evaluate the changes which occur between the control and treated animals, fields, etc.. Obviously, in developing countries, the equipment or tools, such as scales, may be difficult to obtain. However, to provide a viable measure of the effectiveness of the control program, justifiable expenses include the purchase of necessary equipment, costs of training personnel to use the equipment, and the salaries and associated expenses of additional technical assistance

personnel for supervision of the experiment. Such costs are an integral part of the technical assistance program.

USAID might well require better accounting records and more of the experimental data sets, even if it means a slightly higher level of funding for the R&D programs. Better records which note more physical and/or economic aspects of pest control will obligate USAID to do a more thorough job of supervision of the project. Such records will greatly improve the quality of data for analysis, for the effort expended.

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INTRODUCTION

The control of the vampire bat population when it exceeds natural-state levels becomes a problem for many cattleowners and people in Latin America. Conventional methods of control involve either: (a) bat habitat or bat destruction that kills non-target wildlife species and also threatens man; (b) killing of individual bats at high cost and with cumbersome techniques; or, (c) the marginally effective repulsion or avoidance of the vampire bat with the burden of the pest being shifted to other hosts.

Vampire bats cause an estimated loss of one million head of cattle each year, primarily from Mexico to Northern Argentina (Centro Pan Americano, 1967, pp. 152-154). The geographical distribution for vampire bats is shown in Figure 1. In addition, other animal production losses are suffered, such as decreased meat and milk production. The United States Agency for International Development (USAID) has sponsored a vampire bat control program since 1967 (AID PASA RA (ID) 1-67), in conjunction with the Denver Wildlife Research Center of the Fish and Wildlife Service, U.S. Department of the Interior.

Personnel of the Denver Wildlife Research Center (DWRC) have been successful in developing methods for vampire bat control. The topical method consists of capturing bats, placing an anticoagulant paste on the backs of the captured bats and then releasing them. The bats return to their roost where grooming among the bats results in ingestion of the paste and subsequent death by hemorrhaging. The systemic method involves the intrarumenal injection of the anticoagulant into the bloodstream of the bovine. When the bovine is fed upon by vampire bats, the ingested anticoagulant causes fatal hemorrhaging in the bats.

Several Latin American countries have initiated vampire bat control programs, some with USAID sponsored technical assistance teams. However, some of the vampire bat control programs have been short-run reactions to outbreaks of bovine paralytic rabies transmitted by vampire bats. An intensive control program has been conducted in Nicaragua in most of the

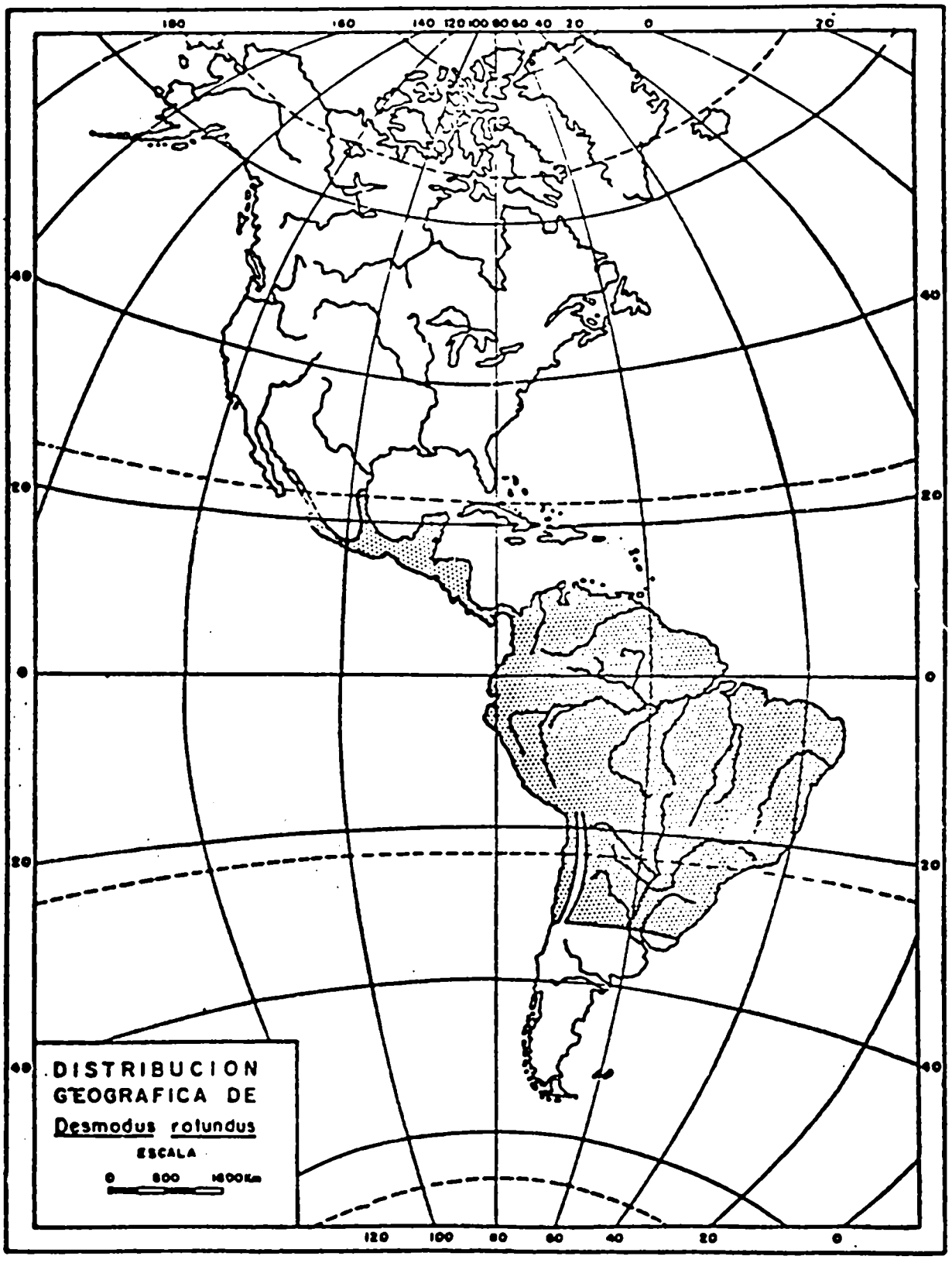

Figure 1: Shaded Area Represents the Geographic Distribution of Desmodus rotundus, the Common Vampire Bat.

livestock regions of the country (Appendix I). Data have been recorded on type and date of the reduction in vampire bat bites. Some records of vampire bat bites on animals and treatment effectiveness have been maintained in other Latin American countries.

There has been no previous socio-economic evaluation of the effectiveness of the vampire bat control program. This is the first study which investigates the socio-economic impact of bat control with diphacinone versus alternative methods of control. It was necessary to compare diphacinone control to alternative control methods because even in the most primitive of economic conditions, some control is attempted.

USAID currently is planning to expand control programs in agriculture with particular emphasis on controlling losses from rodents and birds. An economic evaluation methodology that could be implemented early in those control programs, i.e. incorporated into the treatment programs, would be very useful. The results and methodology of a socio-economic evaluation of the vampire bat control program could be used in developing more effective control programs for rodents and birds.

Objectives

The specific objectives of this study were to:

1. determine costs for research and development (R&D) of the vampire bat control program to AID and the Denver Wildlife Research Center, and the training and implementation costs incurred by the above two agencies, as well as by LDC governments.
2. evaluate direct and indirect economic benefits, and the distribution of these benefits among various groups.
3. evaluate social, environmental, and quality of life impacts both before and after the vampire bat control program was implemented.
4. evaluate effects on small livestock producers, and others in rural areas, who have not directly participated in the vampire bat control program.
5. estimate a benefit-cost ratio of the vampire bat control program to date, and extrapolate future benefits and costs, assuming the program is implemented nationwide in additional Latin American countries.

Area and Scope of Study

Data were obtained from Ministries of Agriculture from several other Latin American countries and the Island of Trinidad. Personal visits were made with extension specialists in vampire bat-infested areas, and with the specialist team personnel who are involved in the treatment program in Venezuela, Colombia, Trinidad, and Nicaragua.

Data on human bat bites and rabies deaths also were obtained, where available, in each of these countries. Data on hide values and the effect of vampire bat punctures on hide values were obtained.

The primary effort in vampire bat control, using the techniques developed by the Denver Wildlife Research Center, has occurred in Nicaragua. The Ministry of Agriculture in Nicaragua implemented a control program in 1974. Thus it was decided that the major evaluation effort should take place in Nicaragua.

The estimated economic costs and benefits that accrued due to the Bat Control Program between January, 1974 and January, 1978 are presented in this study. Costs to the producer, to small rural communities and to the Nicaraguan Ministry of Agriculture are included. Benefits to participating as well as non-participating cattle producers were estimated.

METHODOLOGY

It was decided by the authors in coordination with AID and Denver Wildlife Research Center personnel that the primary data effort for the evaluation of the vampire bat control program would be made in Nicaragua. This country was selected since it had implemented the most intensive control program of any of the Latin American countries. Personal interviews with livestock producers (including dairy cattleowners) and other informed persons was the technique selected to obtain information.

Secondary data were to be obtained by personnel in Nicaragua and several other countries to aid in the evaluation. Also many references on vampire bats and vampire bat control programs were researched to gain insights into the program.

General Experimental Design

Sampling and Interview Procedures

A geographically stratified random sample of 180 livestock producers was selected in two major cattle regions in Nicaragua. Ninety of these producers were to be personally interviewed in the Boaco-Chontales Region in the central highlands and 90 producers were to be interviewed in the Managua-Masaya-Carazo-Granada-Rivas Region along the Pacific Coast.

Sixty of the personal interviews would be with small producers, those having 10 or less head of cattle, 60 interviews with medium size producers (11-100 head of cattle), and 60 of the personal interviews would be with large producers, those having more than 101 head of cattle. Ten in each group would be with those who had not participated in the vampire bat control program, but who may have received indirect benefits from their neighbors' participation in the program. A summary indicating the number of personal interviews to be taken is presented in Table 1.

Table 1: PARTICIPANT AND NON PARTICIPANT CATTLEOWNERS TO BE INTERVIEWED, NICARAGUA, 1978

Size of Herd	Total Interviews	Treatment Program		Not in Treatment Program	
		Pacific Coast	Central Highlands	Pacific Coast	Central Highlands
Small (1-10 head)	60	20	20	10	10
Medium (11-100 head)	60	20	20	10	10
Large (101+ head)	60	20	20	10	10

The sample of participant livestock producers was randomly selected from the list of names and addresses of those who had participated in the vampire bat control program administered by the Ministry of Agriculture in Nicaragua. The Ministry maintains these lists by Department (State), by month and year of visit. The number of cattle examined and number treated are recorded for each farm.

The sample of non participants (non-vampire bat control program livestock producers) interviewed was randomly selected from a list developed through visits with extension agents of the Ministry of Agriculture, The National Agricultural Bank, and through contacts with mayors and other leaders of the communities in the two regions. Also the participants interviewed were asked for names of their neighbors who had not been participating in the program. Some of the producers on this second sample list were those who refused to participate in the vampire bat control program for various reasons--lack of confidence in the treatment process, fear of losing cattle due to the treatment, and possibly for cultural or other attitudinal reasons. Some of these producers did not wish to be interviewed about the indirect effects of the vampire bat control program on their operation.

Three questionnaires or survey forms were developed: Livestock producers, Medical personnel, and Townsfolk (See Appendix I, II and III for forms). Questions were asked on the adverse effects of vampire bat bites on cattle and other livestock (horses, pigs) including death losses due to paralytic rabies. Information on gain rates, birth rates, extraction rates[1)] and cattle market values also were requested for analysis purposes, if the producers could provide those data. Related impacts, such as effect on

[1)] Percentage of cattle in herd marketed each year.

bat bites on humans, and the quality of life aspects (fear of bats) also were obtained. Improvements or changes in the above parameters after treatment were obtained for both the short run (30 days after treatment to 2 years) and the long run (2 years or more after treatment). At least some of these producers became involved in the treatment program in 1974.

Questions were structured to get at any indirect effects on the non-participating producers. Some of these effects depended on the proximity of their farms to those farms which had participated in the vampire bat control program. Similar questions on extraction rates, gain rates, cattle market values, hide values, physical and quality of life effects on humans were also included in the survey form.

The livestock producers' questionnaire was structured so that a comparison could be made between those farms where the following treatments occurred: (1) vampire bats were captured and treated: (2) cattle were examined and injected; and (3) vampire bats were captured and treated and the cattle were given the systemic injection. For non participants interviewed, an analysis of the proximity of their farm to those participant farms for each of the above three treatments would be made assuming sufficient data could be obtained for such analysis.

The livestock producer interviews were taken during the dry season months of April and May. The interviews for the townsfolk and medical personnel questionnaires were also conducted in May, 1978.

Livestock Producer Survey (Form in Appendix II)

The random sample of livestock producers who had participated in the vampire bat control program in the major cattle producing regions of Nicaragua was developed. A total sample of 117 participant cattleowners were interviewed from the Central Highlands, composed of the Departments of Boaco, Matagalpa, and Chontales, and the Pacific Coast region of Managua, Masaya, Carazo, Granada, and Rivas Departments. This represented three fewer participants than had been specified in the statistical sample (Table 2).

The sample was stratified by the number of total head of cattle as was recorded on the form filled out at the time of treatment. Seventeen of the cattleowners were considered small, i.e., with less than 11 head

Table 2: VAMPIRE BAT CONTROL PROGRAM PARTICIPANTS AND NON-PARTICIPANTS INTERVIEWED, BY SIZE OF CATTLE OPERATION, BY DEPARTMENT, NICARAGUA, 1978.

	Participants				Non-participants			
Department	0-10 Head	11-100 Head	101+ Head	Total	0-10 Head	11-100 Head	101+ Head	Total
Boaco	1	11	9	21	4	4	2	10
Chontales	0	3	8	11	1	6	4	11
Matagalpa	0	6	7	13	1	2	2	5
Central Highlands	1	20	24	45	6	12	8	26
Carazo	4	4	5	13	8	4	1	13
Granada	2	5	8	15	1	3	1	5
Managua	5	4	4	13	6	1	1	8
Masaya	3	7	5	15	4	0	0	4
Rivas	2	6	8	16	1	3	1	5
Pacific Coast	16	26	30	72	20	11	4	35
TOTAL	17	46	54	117	26	23	12	61

of cattle, 46 were owners of intermediately sized herds of from 11 to 100 head, and the remaining 54 owners had large sized herds with greater than 101 head.

Another sample of 61 cattleowners was drawn from among the neighboring ranchers to the participants, to gather data on the effects of diphacinone control of vampire bats in a general area. Twenty-six of the non participants owned herds with less than 11 head, 23 were owners of herds with 11-100 head, and 12 were owners of herds with greater than 101 head of cattle.

The sample of non participant cattleowners was taken by choosing at random the neighbors of the participants in the sample. The selection of the non participant was dependent on: (a) that the neighbor lived within 15 kilometers of the participant; and (b) that the participant stated that his neighbor had not participated in the control program.

The surveyed cattlemen which had participated were requested information on the size and type of their farms (Appendix II), the cattle handling facilities and use of veterinary services, the history of the vampire bat problem and control efforts, the cost of their participation, the effects on the cattle and bats from the treatment, the economic value of the service and what future reactions to Ministry of Agriculture programs would be. The neighbor non participants were similarly interviewed, but the questions on cost and effort of diphacinone control were substituted by queries as to the reason(s) for non participation.

Much of the information given by the cattleowners would have to be speculation and approximation because the state of management art is low in rural areas in developing countries. It was assumed that the average of the cattleowners' estimates would exhibit a central tendency as the number of observations increased.

Medical Personnel Survey (Form in Appendix III)

The interviewee of the medical personnel survey was the person in charge of the health center or hospital in the small town. Nineteen towns with health facilities were selected for interviews, with at least two towns in each department. Data were requested on the cases of people who had received treatment at the medical facility for vampire bat bites. Also, the opinion of the interviewee about the feelings and attitudes of the people of the area concerning vampire bats was requested.

Townsfolk Survey (Form in Appendix IV)

A sample of towns close to where vampire bat control had been implemented in the country was drawn. Seventeen towns were chosen for the townsfolk sample, with at least two towns from each department. The sample was restricted to rural towns with less than 10,000 urban inhabitants (Appendix V) so that there would be greater probability that the person interviewed was aware of the attitudes of the townsfolk concerning vampire bats and the vampire bat control program.

A person aware of community awareness and civic action was contacted for the townsfolk survey. The individual was a religious leader, the mayor or rural justice of the peace. Most of the respondents were born in the community or had lived there from ten to twenty years. The person interviewed was asked to give his opinion about townsfolks' feelings and attitudes about vampire bats. Data on participation of the town in vampire control was requested so as to measure the effect of diphacinone control on the socio-economic welfare of rural (non-farm) people.

Environmental Impact Matrix

Vampire bat control deals with a detrimental renewable common property resource. The evaluation and comparison of the respective impacts of diphacinone versus conventional alternative control techniques were accomplished by means of an environmental impact matrix. The use of the matrix facilitates comparison and analysis of strategies and types of impact within a strategy. Qualitative as well as quantitative data are handled in the environmental impact matrix by the assignment of index values to the qualitative and quantitative data to form a common denominator.

The sections on economic parameters, social well-being parameters, and environmental quality parameters were given equal weights. Matrix variables dealing with unique effects of vampire bat control were developed by the authors to show a comparative view of diphacinone versus alternative control methods.

The measurement of the economic social well-being and environmental effects of diphacinone chemical control techniques versus alternative

control methods were based primarily on the Nicaraguan experience. The results of the surveys were combined to form a basis of qualitative and quantitative data which were extrapolated to project an estimate of the national effect of the Nicaraguan control program.

Economic Parameters

The first economic variable listed in the matrix reflects the effect of vampire bat control on the number of deaths to bovines from paralytic rabies. The decrease in loss of production or mortality rate of bovines is a benefit. The maximum known or estimated loss from either strategy of control was assigned a value of zero. Whichever of the two strategies was least effective was assigned a score of zero. The score assigned the other strategy was obtained by dividing the economic loss of that more effective strategy by the corresponding loss of the least effective control strategy. The highest possible score for the better alternative strategy was +100.

The second variable in the economic impact section reflected effect of control on milk and meat production. The scores were assigned similarly to the first variable, with the least effective control method given a score of zero and the score of the other method calculated by dividing the economic loss of the most effective strategy by the respective figure of the least effective strategy. The maximum score for the better strategy was +100.

The cost of control work by the cattleowner and the governmental program agency was included in the matrix as the third variable. The outlay of money and/or time for control is a negative aspect of control, and the strategy which required the most outlay in economic terms was given the lowest value, -100. The index score of the other strategy was calculated in the same manner as explained for the two previous variables.

The last variable in the economic impact section of the matrix was the transfer of technology. The costs of the research and development of technology of the respective control strategies were assigned scores of from zero to 100 to indicate the positive effect of technology transfer. The greater economic transfer was given the maximum value of +100.

Social Well-being Parameter

The first variable in the section on social well-being was the change in human fear of being bitten by bats as a result of vampire bat control. The alternative strategy was given a value based on the percentage of surveyed people who had not participated in the diphacinone control program and who expressed no fear of being bitten by vampire bats in the future. The score of diphacinone control strategy was the percentage of surveyed people who had participated in the control program and who expressed no fear of being bitten in the future by vampire bats.

The situation of people being bitten by, and/or treated for rabies, was considered in the second social well-being variable. The control strategy which was least effective in reducing biting incidences was given a value of -100. The other strategy score was calculated by dividing the number of incidences of the most effective strategy by those of the least effective strategy.

The generation of employment done during control was the third variable. The strategy which generated the least employment was assigned a score of zero, while the other strategy was assigned a value of 100. This is not double counting of the benefits, because only part of the benefits of money invested in pest control is economic return and another distinct part is an improvement in social welfare.

The last variable reflects progress towards equal distribution of service to specified classes of participating cattlemen. An equal distribution of the economic benefits from control was assigned a value of +100. The benefits were distributed on a per head owned basis given that the decrease in economic loss was directly related to the number of cattle bitten before control and that control was equally effective on all bovines treated.

Environmental Quality Parameter

The ability of the alternative strategies to control the vampire bats affecting cattle and/or people was measured by the first variable in the environmental impact. Complete specificity of a control was assigned a value of +100, while destruction of as many non-vampire as beneficial bats was assigned a value of zero. Greater destruction of beneficial bats than vampire bats would result in a negative score.

The second environmental variable was the effect of the control program on biological equilibrium between vampire bats and their natural hosts. Complete return to natural conditions where vampire bats would feed only upon wild animals would be assigned a score of +100. Control which would result in a shift by vampire bats to cattle and/or man from wildlife would be assigned a value of zero.

The third variable was the effect on air and water quality by the control strategies. A control strategy which does not target on the pest or which transforms a pest problem into a pollution problem was assigned a value of -100 if there was any indication that chemicals used in the control strategy could contaminate the milk, or meat consumed from treated animals.

Net Overall Impact

The average score of the sections on environmental quality, social well-being and economics were given equal weight in the overall net impact. The control strategy with the highest overall net impact score is the most desirable.

HISTORY OF VAMPIRE BATS AND OF THE VAMPIRE BAT CONTROL PROGRAM

No previous economic and social evaluation of vampire bat control has been done. Neither has there been any thorough economic evaluation of the losses due to vampire bats. The literature on bats in general, and vampire bats in particular, focuses on both the physical and biological aspects of the problem and the control program.

Background on Vampire Bats

Vampire bats (Desmodontidae) are the only family of bats which subsist solely on the blood of the other vertebrates and are sometimes vectors for the rabies virus. Desmodontidae live only in Latin America and consist of three genera: Desmodus, Diphylla, and Diaemus.

Desmodus rotundus is the most abundant species. Its geographic range extends from 27 degrees north latitude in Mexico to 33 degrees south latitude in Chile and Uruguay (Figure 1). Desmodus rotundus feed either on livestock or wildlife, whereas the genera Diphylla and Diaemus feed almost exclusively on wildlife.

Vampire bats prefer a relatively stable microclimate with a relative humidity of 45 percent and a temperature around 22 degrees C (72 degrees F). They are found from sea level to 3,000 meters altitude. They live in rock crevices, tunnels, caves, hollow trees, mines, abandoned houses and wells. Vampire bats primarily feed on cattle, although they will also attack horses, poultry, hogs, sheep and humans. The female of the species produces one and sometimes two offspring each year (Constantine, 1970). The annual population increase in the absence of control was estimated to be 33 percent. Vampire bats may live longer than 15 years but the average age of Desmodus in a colony has been estimated at 3.4 years by Lord, Muradali and Lazaro.

Death and Damage Caused by Vampire Bats

The literature on the damage caused by vampire bats focuses on human and livestock deaths caused by rabies. A UN/FAO survey team in 1966 studied

the paralytic rabies problem in Latin America and estimated that one million head of cattle died annually in Latin America from rabies transmitted by vampire bats. The direct economic losses, for 1965, were estimated at more than $100 million. Adding indirect losses, including malnutrition, the annual total economic loss in Latin America was estimated at $350 million (CPAZ, 1967). A 1969 UN/FAO report documents some of the paralytic rabies death losses associated with vampire bats (FAO). Constantine has reviewed various diseases which might be transmitted by vampire bats to humans and livestock. Eighty-nine human deaths due to vampire bat transmitted rabies were recorded in Trinidad during the period 1925-1937. In 1960 there were 22 deaths in Central and South America (Malaga-Alba). Five deaths were recorded in Argentina in 1965 (Constantine, 1970). The percentage of vampire bats which may have rabies has been observed to vary from 0-3 percent in an outbreak area to 14.3 percent when an outbreak has passed (Baer). Vampire bats carry the rabies virus and although humans seldom contact rabies from vampire bats, many people, particularly children, are fed upon by the bats.

There is high probability that vampire bats may transmit many other diseases besides paralytic rabies. In addition, they have transmitted foot and mouth disease, yellow fever, and trypanasomiasis to their feeding victims in experiments (Constantine, 1970). No estimates have been made of the economic loss incurred by vampire bat transmitted diseases, other than paralytic rabies.

Effect of Blood Loss on Bovine Weight

Cattle fed upon by vampire bats sustain a loss of blood of between 20 and 30 milliliters per feeding (Lord), with an average 25 milliliter feeding weighing 23.8 grams (McNab). There is an additional loss of blood from the bite wound after feeding of an estimated 25 milliliters. The feeding loss and the post-bite loss would, if sustained every day for one year, total 17 kilograms or 38 pounds.

The effect on the retardation of growth of a bovine due to blood loss from vampire bats has not been researched. However, from data of an experiment in Australia on cattle ticks, it was shown that an infestation of 50 ticks would in one year consume an estimated 20 pounds of bovine blood and

cause a weight loss of 82 pounds. Estimates by Australian cattleowners put the average estimated weight loss at 64 and 54 pounds annually for fat and store cattle, respectively (Commonwealth).

Assuming that the retardation in growth of 4.1 pounds of bovine weight for each pound of blood loss to parasites as suggested by the study of ticks can be applied to the vampire bat situation, the estimated annual retardation in growth of a bovine from one vampire bat would be 155 pounds or 70 kilograms. Estimates by cattleowners could be expected to be lower than the scientifically measured loss.

Economic Loss Due to Vampire Bats

The annual direct losses from vampire bat borne paralytic rabies is estimated to be 1,000,000 head of cattle in Latin America. The annual mortality of bovine cattle in the Americas was estimated by Acha (1967) to be 514,500 head for an estimated annual economic loss of $47,592,000 (U.S.). These figures include only the domesticated cattle that might have died from paralytic rabies. In addition, horses, sheep, pigs, poultry and wildlife succumb to vampire bat transmitted rabies.

Methods of Vampire Bat Control

Conventional Methods of Vampire Bat Control

The conventional methods of vampire bat control most frequently used on the farm or ranch are: (1) lights in the house or around the corral; (2) wire screens around the corral; (3) traps to catch bats; (4) killing of bats with firearms; and, (5) application of repellents or poison on or near the wound of the bitten animal (Mitchell and Burns). These conventional methods are only partially effective, with a danger often present to the livestock owner and/or to the animals.

Common methods of destruction are: (1) burning out of caves or trees; (2) gassing of caves and wells; (3) dynamiting to destroy caves and/or bats; (4) insecticides and other pesticides to kill or repel bats; and, (5) poisoning of caves or trees (Piccinini; Constantine, 1970; Mitchell and Burns). The destruction of vampire bat refuges also kills beneficial

bats, and it is difficult to locate the bat roosts. Almost all of the conventional methods are expensive and/or impossible to implement when cattle herds are large (Mitchell and Burns). No information on the cost of or extent of application of the above mentioned conventional control measures was presented in the Mitchell and Burns study.

The destruction of vampire bats by means of traps, firearms, gas, fire, dynamite, and insecticides has been detrimental to other bat species and to wildlife habitat for other animals. Examples of roost destruction which killed nonhemotaphagous species are presented by both Greenhall and Constantine (1970). Hollow trees also are frequently burned out or chopped down in an effort to control the vampire bat population, causing a loss of habitat to birds as well as bats. No data were available as to the type or number of bats or other animals killed or deprived of habitat with the destruction of the roosts.

Considerable time and money has been expended in the control of rabies in cattle by means of antirabies vaccination. Generally, the cost of the vaccine is considerable, the protection is short-termed, and few poor ranchers and farmers are able to buy the vaccine. Moreover, use of the antirabies vaccine does not stop the spread of rabies by the infected vampire bat. In 1973, antirabies vaccine cost from $.75 to $1.25 (U.S.) per dose (DWRC, 1973).

An estimated 2,724,790 cattle in Latin America were vaccinated annually against rabies according to Acha (1967). The vaccination, at an average cost of $1.25 per dose, would have required an estimated outlay of $3,406,000 in Latin America. The estimated annual cost of the national antirabies vaccination program of 8,000 head in 1964 in Nicaragua (Acha, 1967) would have been $10,000 (U.S.), using a cost figure of $1.25 per dose.

Diphacinone Control of Vampire Bats

An effort has been made by USAID to increase agricultural production by providing adequate protection to both animals and humans from vampire bats. A PASA agreement was negotiated in 1967 with the Denver Wildlife Research Center (DWRC) of the Bureau of Sport Fisheries and Wildlife (now U.S. Fish and Wildlife Service), and USAID. The agreement initiated a program of developing means of reducing vampire bat populations by control

methods that are safe, effective, and adaptable to the social and economic conditions of lesser developed countries (LDC's).

Personnel of the DWRC, together with Mexican government counterparts, were involved in the development of chemical control of vampire bats. Work was first done in 1968 in a laboratory at Palo Alto, Mexico, where drugs and treatment methods were tested. After basic research, diphacinone was selected as the control compound and field tested in several Latin American countries.

There are three methods of getting the anticoagulant to the vampire bats. The methods are: (a) topical application to the bat; (b) topical application around the wounds of previously attacked animals, and (c) systemic application (injection) of the chemical into the rumen of the bovine.

The topical treatment of bats involves using a mist net around the corral at night to capture the vampire bats, and a paste of diphacinone is spread on the back of the vampires. The bats are then released to return to their roost (e.g., cave, well, hollow tree). Through the "grooming" process, other bats ingest the paste. Death is caused by internal hemorrhaging. Estimates are that one vampire bat treated topically will cause the death of from 15-20 vampires in the cave. The topical method is more efficient for absolute control, and therefore preferred when there are rabies outbreaks. The treatment of one captured bat, for $.03 in material costs, could under ideal circumstances kill up to 20 bats (Mitchell and Burns; DWRC, 1976).

The same paste can be spread around the wound of previous vampire bat bites to control vampires which return to previous victims, and which often will reopen a closed wound from a previous feeding. This method of chemical control can be used on all types of bitten livestock.

The systemic, or intrarumenal method involves injecting the anticoagulant into the rumen of the bovine which at the recommended rate is not toxic to the bovine. The anticoagulant is quickly absorbed into the bovinal bloodstream but passes out of the bovinal system in three days. Any vampire bat which feeds upon the treated animal within a 72 hour period following injection will suffer fatal hemorrhaging within 48 hours.

However, the systemic method was developed only to be used with cattle that are: (1) three months of age or older; (2) preferably on

green pasture, and (3) not to be slaughtered within 30 days (EL GANADERO, #15). The cost per dose per animal was approximately $.10 in 1974, and $.50 in 1978, if the chemical was purchased directly by the cattleowner (EL GANADERO, #17). The anticoagulant is stable to heat of 145 degrees C and does not decompose readily. The antidote in cattle is Vitamin K_2 (Mitchell and Burns). A single injection will kill all bats which feed on the bovine (usually from one to five vampire bats) (Mitchell and Burns). The systemic treatment of cattle is an effective measure of contacting the vampire bats because the bats usually feed once a night (Wimsatt and Guerriere) and the estimated longevity of a fasting vampire bat is only 70 hours (McNab).

The systemic method is preferable in the absence of trained vampire control technicians, as it can be applied during the day and involves the use of only normal veterinary tools. Piccinini concluded that the best control came from use of all three types of treatment methods, but that the single best control method was systemic (Piccinini, p. 27).

Effect on Milk Production

Two experiments utilizing the systemic method of control were conducted to measure the effect of vampire bat predation on milk production. In Nicaragua, the control program in one herd resulted in a 16 percent increase in milk production (Thompson, Elias, and Mitchell). The number of vampire bites decreased from an average of 2.09 bites per cow prior to treatment to zero. In a similar study of vampire bat control on a dairy farm in Ecuador, there was no significant change in milk production even though the average number of bat bites per cow dropped from 3.95 to 0.12. The level of management of the Ecuadorian herd was superior to that of the Nicaraguan herd and the Nicaraguan herd was under more tropical stressful conditions than was the Ecuadorian herd. No other parameters of the effectiveness of vampire control were measured (factors such as change in the weight of the livestock, quality of the milk and feed consumption).

Vampire Bat Control in Latin America

The countries which have used the systemic and/or topical method of vampire bat control are: Argentina, Belize, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Guyana, Mexico, Nicaragua, Panama, Surinam, Trinidad, Uruguay and Venezuela. French Guayana, Guatemala, Honduras, Paraguay and Peru have expressed interest in vampire bat control, but have no known national control program.

Argentina

Chemical control of vampire bats in Argentina is being done by a veterinarian trained in bat control. Rabies control was limited to injection of cattle in affected areas in 1970. About 15 percent of the country was affected, with an annual loss of cattle estimated at 5,000 head (DWRC, 1970).

The cyanide gassing technique has also been successfully used to block a large migrating epizootic transmitted by vampire bats. Unused wells in the path of the epizootic were gassed and regassed for a period of one year by two technicians well-trained in vampire bat control (Lord).

Belize

There had not been a confirmed case of rabies transmitted by vampire bats in Belize. Still, the Belizian Ministry of Agriculture has been interested in reducing the vampire bat populations before rabies can enter from neighboring countries (DWRC, 1970).

A veterinarian was trained how to capture and treat vampire bats and ten agricultural extension workers were to be trained in 1971 to assist in an expanded program. In 1975, a Peace Corps biologist was selected to develop a control program in Belize. The program was based on education and investigation, as well as control (DWRC, 1975 and 1976).

Bolivia

Paralytic rabies was probably the most serious animal health problem before 1972. Therefore, the World Bank financed field demonstrations in

regions where rabies was a problem. Veterinarians from the Bolivian Ministry of Agriculture and the Banco Agricola de Bolivia were trained by DWRC and the Pan American Health Organization (PAHO) personnel in the topical method of control.

In 1974, a United Nations Animal Health Team assisted the Bolivian Ministry of Agriculture veterinarians located in Santa Cruz and Trinidad in treating bats at ranches which requested such assistance (DWRC, 1975). Most of the control work has been done in only the lowlands of the southeast of Bolivia. Transportation difficulties limit control work in northern Bolivia (Lord). The UN project in 1975 sent a man to Mexico to be trained in vampire bat control, and to Nicaragua, to observe field control work.

Brazil

A total of 39,281 livestock deaths in Brazil were attributed to rabies from 1966 to 1974. The annual economic loss was estimated at $20 million (U.S.) (Piccinini, p. 5 and 6). Annual bovine mortality in Brazil was estimated to be 200,000 head by Acha (1967), and 215,000 head by DWRC (1970), with an economic loss estimate of $9 million (U.S.) (DWRC, 1970).

The Brazilian government attempted to combat bovine rabies in 1972 by means of antirabies vaccines. The Ministry of Agriculture purchased 2,500,000 units of the ERA brand vaccine. In 1972, field demonstrations were conducted in northeastern Brazil by DWRC personnel. Also, the Brazilian government initiated pilot control campaigns in 1972 in the zone where the control demonstration had been made (DWRC, 1972). The DWRC sponsored several workshops in Brazil in 1973, where 125 Brazilians were trained in the control techniques. The Pan American Zoonosis Center in Argentina trained 12 Brazilian veterinarians in 1974 (DWRC, 1974).

From 1973-1974, 12,690 vampire bats were captured and treated in 3,062 caves in Brazil as part of a national rabies control program (DWRC, 1976). No nonhematophagous bats were found killed. Vampire bat control and research had been initiated by the Brazilian Ministry of Agriculture with approximately $65,000 (U.S.) allotted to the program. Plans were to increase funding in 1975 (DWRC, 1974).

Colombia

In 1971, an outbreak of paralytic rabies killed over 800 head of cattle valued at $175,000 (U.S.) in northeastern Colombia. Personnel from DWRC trained 45 people in vampire bat control in 1973 (DWRC, 1973). The Colombian Ministry of Agriculture planned for a regional control program for the departments of Guajira and Cesar in 1975, because cattle producers in the region had lost cattle valued at an estimated $420,000 (U.S.). The control program utilized the systemic method of vampire bat control (Piccinini). Direct losses caused by bovine rabies and indirect losses from loss in weight, decreased milk production, and secondary infections have been estimated by the Instituto Colombiano Agropecuaria (ICA) to have exceeded $2.5 million (U.S.) annually (Cadena and Perez). In 1975, $40,000 (U.S.) was budgeted by the Colombian government to create a buffer zone in front of the advancing epizootic (DWRC, 1974). USAID loaned $25,000 (U.S.) to Colombia for use in the vampire bat regional control programs (Cadena and Perez, pp. 13-14). Problems in obtaining the diphacinone hampered the development of the control program in Colombia until an agreement was reached whereby the chemical could be purchased through the Centro Internacional de Agricultura Tropical (CIAT).

Costa Rica

Vampire bats were not considered a serious problem in Costa Rica until 1972, though Costa Rica lies between Panama and Nicaragua, countries in which there were large vampire bat populations (DWRC, 1972). In 1975, personnel from the Nicaraguan Ministry of Agriculture gave four demonstrations to some 295 cattlemen.

In 1978, the vampire control program was being implemented by use of the systemic applied diphacinone. The chemical control was sold to all cattleowners under the trade name, DIPHACIN. The cost per dose was $20 colones, ($2.20 U.S.). Previous to the availability of diphacinone, ranchers had been combating the vampire bat with NEGUVON[a] mixed with burned oil (Umaña).

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[a]NEGUVON is an insecticide/pesticide used to control ticks and grubs.

Ecuador

Field demonstrations on chemical vampire bat control were given in 1974 by DWRC personnel for Ecuadorian veterinarians. A national control program was planned pending an evaluation of the bat situation (DWRC, 1974). The director of the World Bank in Guayaquil asked the Ecuadorian Ministry of Agriculture for vampire bat control in problem areas in 1975 (DWRC, 1975).

El Salvador

Though vampire bats attack cattle in all of El Salvador, rabies is only a problem in one department. A pilot program on topical vampire control was set up in 1975 in the department after consultation with DWRC personnel (DWRC, 1975).

Guyana

Demonstrations on vampire bat control were given in 1974 to cattle-owners and veterinarians by DWRC personnel. The presentations were funded by the World Bank, the Guyanan Ministry of Agriculture, and the AID mission in Guyana. A regional control program also was initiated in 1974, with a nationwide program to begin in 1975 (DWRC, 1974).

Mexico

The Mexican government has been very cooperative in the vampire bat control program. The control chemical, diphacinone, was field tested and evaluated in Mexico from Palo Alto. Research on vampire bats and the methods of control were begun there in 1968 by DWRC, and even earlier by FAO/UNDP.

In 1972, personnel from AID/Instituto Nacional de Investigaciones Pecuarias (INIP), of Mexico, and the FAO/UNDP trained four Mexican veterinarians in vampire bat control. Subsequently, each newly trained veterinarian went to work on a control project in different parts of the country, assisting other local government veterinarians. A nationwide control program was begun in 1973. In addition, the production of vaseline-based diphacinone was begun in Mexico by INIP in 1972 (DWRC, 1972).

Vampire bats were a serious problem in Mexico prior to the implementation of chemical control, with 4,244 cattle deaths reported in 1972. From 1973 to 1976 rabies deaths among cattle had dropped from an estimated

100,000 head annually to 309 head (Piccinini; and DWRC, 1978). From 1972 to 1976, 29,574 vampire bats were topically treated with diphacinone (Manriquez), together with the vaccination against rabies of 5,540,100 head of cattle (DWRC, 1976).

Nicaragua

The annual loss of bovines to vampire bat borne rabies was estimated to be 0.5 percent of the national herd (CPAZ, 1977). The total estimated cattle population was 2.6 million head in 1974 (UNASEC) for an estimated loss of 13,000 animals in 1974. The average price for a beef animal weighing 320 kilograms was $128 (U.S.); for a dairy cow the value was $189 (U.S.); and a newborn calf was valued at $14 (U.S.). The annual economic loss without the control program was estimated at $214,300 (U.S.) (CPAZ, 1977). The cost for a unit of antirabies vaccine was $1.30 (U.S.) in 1973 (DWRC, 1974). No estimate on the economic aspect was given in the Centro Panamericano study (CPAZ, 1977) concerning meat and milk production losses from cattle fed upon by bats without rabies.

A workshop on vampire bat control was presented by DWRC personnel to 61 Nicaraguan veterinarians and cattlemen in 1973. The following year a five-year program, costing an estimated $520,000 (U.S.) was begun (DWRC, 1975). According to the proposed budget for Nicaragua in 1975, the Ministry of Agriculture budget was $3,561,228 (U.S.), 1.33 percent of the national budget. The control of vampires was provided a 1974 allocation of $114,285 (U.S.), or 3.2 percent of the Ministry of Agriculture budget (Gonzales and Mitchell, p. 25). Since 1974, no confirmed case of vampire bat borne rabies has been recorded in Nicaragua (Gonzales and Mitchell).

Through the efforts of the control program, according to the 1977 Centro Panamerica de Zoonosis study, it was estimated that in five years the annual bovine loss could be reduced by $1,542,857 (U.S.).

Vampire control treatment noted among other things: date; location of the ranch; name of the owner; total cattle owned and/or treated; method of treatment; number of fresh bites on the animals; and the number of fresh bites 30 days after control was applied.

In 1977, 661 ranches in the Central and Pacific regions of Nicaragua were visited by technicians from the Nicaraguan Department of Animal Health

to measure the extent of the vampire bat problem. There was evidence of fresh vampire bat bites on cattle on 606 ranches (92 percent). However, assuming one bite per bovine, only 11 percent of the cattle had been bitten (Appendix VI).

Panama

A vampire bat control program was begun in 1974 with an appropriation of $37,000 (U.S.) by the Panamanian Ministry of Agriculture. Previously in 1973, DWRC personnel had assisted in training 94 Panamanians (DWRC, 1973). Ten teams, consisting of one veterinarian and two assistants, were assigned to seven agricultural sectors in Panama and the Darien Strip along the Colombian border.

The control teams treated 2,000 head of cattle and 1,400 vampire bats between May, 1975 and May, 1976. An 85 percent reduction in the number of fresh bat bites was recorded. A lack of adequate cattle handling facilities hampered a more thorough control effort. Some ranchers with herds larger than 1,000 head were being trained to implement systemic vampire bat control on their own cattle (Boyd, 1977).

Surinam

In Surinam, the topical method of control was employed, with the cattle first being moved and corralled away from the site where they were bitten. The bats are netted, however, at the site where the cattle were last pastured because the bats return to the area where they were accustomed to finding cattle. The men applying the control were trained by personnel of the Pan American Health Organization (PAHO).

Trinidad

Rabies and vampire bat control has been very successful in Trinidad with an estimated 2,000 bats killed per year by conventional methods in a control program which employs 15-16 men full-time (Piccinini). It was reported by Malaga-Alba that the cost of bat destruction in Trinidad averaged the equivalent of $10 (U.S.) per vampire in 1962.

The use of diphacinone via the topical method was begun in 1974 in Trinidad. There were 992 vampire bats captured in mist nets, treated with

the anticoagulant paste and released in 1976-1977 (Muradali). Data from the Trinidad Department of Public Health indicated that a continuous program of control by means of traps has been employed against vampire bats, in addition to the diphacinone method, to halt the spread of paralytic rabies and incidences of humans bitten by vampire bats.

Uruguay

A surveillance program was begun in Uruguay in 1975. Personnel in the program tested 99 vampire bats in 1975, but found none positive for rabies. Rabies, however, was a serious problem in bordering southern Brazil (DWRC, 1975).

Venezuela

Annual rabies losses among cattle in 1970 were an estimated 15,000 (DWRC, 1970). In 1973, four Venezuelans participated in a workshop on chemical control methods presented by DWRC personnel, and in 1974, a regional control program was begun (Rhoad).

Other Countries

Ministry of Agriculture personnel in Guatemala, Honduras, Paraguay, and Peru have received information on vampire bat control from either the DWRC or PAHO. No known programs exist in these countries, though interest has been expressed and cases of bovine rabies have occurred (DWRC, 1970 and 1975). Paraguay, for example, lost 17,043 cattle in 1975, for an estimated economic loss of $1.7 million (U.S.).

Comparison of Programs of Various Countries

A comparison of the vampire bat control program in the countries of South and Central America was made in the areas of: (a) type of method(s) used; (b) whether private or public funds financed control; (c) whether bovine rabies and/or production loss motivated control; (d) whether vampire bat rabies control involved more than diphacinone application and/or conventional methods; and, (e) whether the programs were long-run nationwide projects or only applied sporadically following rabies outbreaks.

The use of the two alternative diphacinone methods was known to have been implemented in 16 countries. Five other countries had not initiated

national control programs by 1978. The systemic method alone was used in two countries, the topical method only in five countries, and both methods were used together in six of the countries. The type of method used in three countries was not specified. Conventional methods were employed along with the diphacinone methods in national control campaigns in two countries.

Control of paralytic rabies in livestock was the factor noted for having motivated control work in all 16 countries, although two countries also controlled vampire bats to decrease non-rabies losses. Long-run continuous control programs using diphacinone were conducted in three countries. In the remaining 13 countries, control was implemented only in response to sporadic outbreaks of rabies in specific regions. No coordinated programs between two bordering countries were encountered.

The national governments of the respective countries were all involved in the control work. Application of diphacinone by the cattleowners in conjunction with the national government program was encouraged in three countries. The extent to which individual cattleowners might be acquiring and applying the diphacinone, either systemic or topically, was not researched in this study. The future sale of the chemical to individual cattleowners was planned in three of the four countries personally visited during this study.

THE NICARAGUAN VAMPIRE BAT CONTROL PROGRAM

History of Control Program

Information about the Nicaraguan vampire bat control program obtained by surveys is presented in this section. The general areas considered are: (1) history of the control work; (2) distribution of the control service; and, (3) accounting history of the program from 1974-1977.

The program started with a 1-2 weeks training session for the technicians. Training was given by DWRC personnel, in the classroom and the field. Twenty men received basic instruction on the vampire bat, the purpose and application of the anticoagulant drug, the methods of handling the injection and vampire capture equipment, and pre-and post-treatment evaluation procedures. DWRC personnel accompanied the men for one month in the field, working with them as well as instructing them, both initially and during the post treatment examination of the cattle. The men were assigned in teams of two after training to work in different Departments of Nicaragua, with major attention given to the Departments of Granada, Carazo, and Boaco. Only the trained technicians applied the control techniques.

The Department of Animal Health selected the Departments where the control of vampire bats was implemented and the teams of technicians themselves selected the ranches for control work. The plan of the work week was made up by each team on Friday, according to one technician, and Monday through Thursday were dedicated to actual control work. One technician said that the team planned for the injections to be done in the afternoon, and when necessary, the team captured bats for topical treatment on the same ranch that night.

Implementation of Cattle Inspection and Treatment

Each team of technicians was responsible for the pre-and post-treatment evaluation of the cattle they had treated. According to two technicians,

treatment inspection work was at the beginning of the program done judiciously, but as the second year commenced, the inspections became sporadic. The number of cattle inspected after treatment was often less than those initially inspected and/or treated, as can be seen from data in Table 3. The reasons given by the technician for the difference were: (1) the sale of the treated or initially inspected cattle soon after the control treatment; (2) the cattleowner or ranch foreman not receiving any valuable information from the post treatment inspection, reduced his cost in time and manpower by only presenting some of the treated animals for inspection; (3) the cattle had been moved to other pastures sometimes inaccessible to the technicians; and, (4) there was fear that a too exact tally of the cattle on the ranch would be economically detrimental (some taxes are based on number of cattle owned).

The men agreed that when implementing the topical method of control, there was a considerable problem with fruit bats getting caught in the net. The fruit bat would struggle and destroy a portion of the net by biting it with his teeth. Thus, the teams found it advisable to only pitch the net in open pasture, corrals or pens, and away from fruit trees.

Some of the ranches on which cattle had been bitten by vampire bats were not treated; those cattleowners resisted because they were afraid that the drug injected in the cattle would kill the cattle, or because of poor relations between the Ministry of Agriculture and the cattlemen.

There were a total of 148,142 bovines injected with diphacinone and 2,696 vampire bats captured, treated with diphacinone paste, and released during the course of the four year effort. The yearly progress of the control program is recorded in Table 3.

The efficiency of control decreased as time progressed and is attributable to the effectiveness of diphacinone control. In 1974, for example, 908 vampire bats were treated and 31,577 bovines were injected. There were 42,436 less bites recorded 30 days after treatment was implemented, for a ratio of 47 bites reduced for every vampire bat captured, or 1.3 bites reduced for every bovine injected. In 1976 there were 18,335 less total bites after treatment, for a reduction of 22 bites for every bat treated and/or 0.6 bites reduced for every bovine injected. The proportions were 17 bites reduced for every bat treated and/or 0.5 bites reduced for every bovine injected in 1977.

Table 3: ANIMALS EXAMINED AND FRESH VAMPIRE BITES BEFORE AND 30 DAYS AFTER DIPHACINONE CONTROL, VISITS TO RANCHES MADE AND NUMBERS OF VAMPIRES CAPTURED AND CATTLE TREATED IN THE NICARAGUAN VAMPIRE BAT CONTROL PROGRAM, 1974-1977

	Pretreatment and Treatment				Post Treatment		
Years	Bovines Examined	Fresh Vampire Bites	Bovines Treated	Vampires Captured and Treated	Animals Examined	Fresh Vampire Bites	Decrease in Bites (Percent)
1974	59,980	46,452	31,577	908	48,669	4,016	90
1975	112,355	50,070	73,088	622	97,625	2,815	92
1976	75,632	20,704	32,343	850	67,810	2,369	87
1977	22,698	6,071	11,134	316	20,892	548	91
TOTAL	270,665	123,297	148,142	2,696	234,996	9,748	91

Source: Vampire Control Campaign, Dept. of Animal Health, Ministry of Agriculture, Managua, Nicaragua

The number of beef and dairy cattle treated, the estimated number of cattle bitten, and the number of vampire bats captured and treated, based on the number of cattle in the herd, also were analyzed.

A total of 298,919 cattle were among the 1,918 herds which received treatment. A distinction between dairy and beef-type animals for each herd size strata is presented in Table 4. There were more dairy animals than beef animals in the small sized herds, about as many beef as dairy animals in the intermediate sized herds, and considerably more beef than dairy cattle in herds with greater than 101 head.

There were 945 (0.6 percent) cattle treated from herds with less than 11 head. Another 24.9 percent (36,830) were from intermediate sized herds, and the balance of 74.5 percent were from large herds.

The number of cattle bitten was estimated to be 41 percent of the cattle owned, since 123,297 bites were recorded on 270,665 animals examined prior to treatment. This assumed that the 28,254 other cattle on the ranches which were not examined in the control program had received no bites. For example, of the 491 beef on the small size ranches, an estimated 201 head were bitten.

There was some repetition of treatment among herds and animals. Program level data by the Ministry of Agriculture indicated that 2,126 ranches had received treatment. However, close inspection of the data revealed that only 1,918 different herds received treatment although 2,126 separate ranch treatment visits were made. Assuredly, some animals received more than one injection during repeated systemic treatments, but no estimate as to the extent of duplication was possible from the control program records.

The 20 men on the 10 control teams worked 1,551 days treating cattle and 455 nights in the capture and treatment of vampire bats. There were an estimated 95.5 cattle injected per day via the systemic method and 5.9 vampire bats captured per night. It is assumed that the 30 day post inspection of the cattle took as much time as that required to do the initial day work, i.e., another 1,551 days. Thus, an estimated 3,102 days and 455 nights of technician time was required to implement the Nicaraguan control and post treatment inspection. No estimate was possible on the number of administrative and clerical days expended during the course of the program, because the administrative personnel were assigned to several projects simultaneously.

Table 4: TOTAL BEEF AND DAIRY CATTLE IN TREATED HERDS, NUMBER OF CATTLE INJECTED AND VAMPIRE BATS CAPTURED, BY SPECIFIED HERD SIZE, NICARAGUAN VAMPIRE BAT CONTROL, 1974-1977

	Range of Herd Size			
	1-10 Head	11-100 Head	101+ Head	Total
Cattle Owned				
Beef	491	35,290	154,401	190,182
Dairy	524	32,170	76,043	108,737
Total	1,015	67,460	230,444	298,919
Percent of Total	.3	22.6	77.1	100.0
Vampire Bats Captured	170	510	2,020	2,696
Cattle Injected	945	36,830	110,380	148,142
Estimated Number of Cattle Bitten[a]				
Beef	201	14,469	63,304	77,974
Dairy	215	13,190	31,178	44,583
Total	416	27,659	94,482	122,557[b]
Herds Treated	176	981	761	1,918[c]

[a] Assuming a ratio of 0.41 animals bitten for each animal owned.
[b] Will not be equal to 123,297 recorded bites in Table 3, col. 3 because of rounding error on ratio of bites per animal.
[c] 2,126 separate visits to do control work were made on the 1,918 farms or ranches.

Effectiveness of Control

The effectiveness of diphacinone control of vampire bats was measured in this study by: (1) the reduction in the number of fresh bites 30 days after treatment; (2) the length of time from date of treatment until a recurrence of fresh bites was noted; (3) the eagerness of cattleowners to repeat treatment; and, (4) the existence of freshly bitten cattle on farms adjacent to the treated herds. The harm done to livestock per vampire bite was assumed constant for all numbers of bites on all animals, i.e., two bites were twice as bad as one bite, regardless of whether the two bites occurred on one animal or if two animals each suffered one bite each. The number of fresh bites was assumed to be directly proportional to the number of deaths due to paralytic rabies, or to the loss of meat or milk production.

Data provided by MAG indicated that 30 days after topical and/or systemic treatment, the intensity of fresh vampire bat bites was reduced by 91 percent (Table 3). No distinction was made as to the comparative effectiveness of the systemic or topical methods.

The Nicaraguan Ministry of Agriculture conducted a survey of 661 ranches in 1977 to determine the extent of the national vampire bat problem 3 1/2 years after the control program had begun. As presented in Appendix VI, only 55 of the 661 ranches were completely free of vampire bats. The ranches were situated close to where control had been implemented in the previous 3 1/2 years; little crossover protection from participant to nonparticipant herds was noted.

VAMPIRE BAT CONTROL PROGRAMS IN COLOMBIA, PANAMA, VENEZUELA, AND TRINIDAD

Information on the extent of diphacinone use in the control of vampire bats in Latin American countries other than Nicaragua was sought by personal consultation with knowledgeable program spokesmen of each country. The information was sought to facilitate a comparison of the Nicaraguan experience to the general methodology and impact in all of Latin America. It was expected a priori the consultations, that considerable data would be available on: (1) the number of deaths of cattle to rabies transmitted by vampire bats; (2) the number of cattle and/or bats treated via the techniques which employ diphacinone; (3) related costs of conventional and diphacinone control; (4) the number of humans bitten and/or treated for bat bite; and (5) effects on the environment from the use of diphacinone. The list of interviewees was developed from published data on vampire bat control and from suggestions of the authors of the aforementioned data.

Colombia

Vampire bats caused the greatest damage in the Departments of Magdelena, Guajira, and Cesar. Paralytic rabies killed many cattle in those Departments in 1973, 1976, and 1978 according to Marique and Valdez. Due to the cattle loss, the Instituto Colombiano de Agropecuario (ICA) began very effective inoculation of cattle against rabies, using the CEPA-ERA type of vaccine made in Canada. In the Department of Magdelena, 7,022 head of cattle were treated by ICA. The vaccine was paid for by the cattleowners at a price of $2.00 (U.S.) per dose.

Another antirabies vaccine, VECOL, which is made in Colombia, is marginally effective, but costs only $ .50 (U.S.) per dose. According to veterinary advisor, Mason, the shipping and handling of the antirabies vaccines has been at times poorly conducted, such that the treatment is ineffective in controlling rabies.

The ICA personnel estimated that 10,000 bovine deaths were attributable to rabies between 1969 and 1976, but some of the deaths could be attributed to other causes as well. An estimated 300 head of cattle, 45 mules, burros and horses, as well as other minor farm animals died from paralytic rabies in 1977 in the Santa Marta region on some 146 ranches. The estimated 1978 livestock population of the area was 20,000 head of cattle. The value of a cow weighing 560 kilograms was an approximate $310.00 (U.S.), while a breeding heifer was worth $380.00, at June, 1978 prices.

The chemical method of vampire bat control is not the only method used in the region. Around 1974, a cave in San Juan de Cesar was gassed, killing 2,500 bats of all types, including vampires, according to the ICA personnel visited.

Diphacinone was first used in a regional control effort following a serious outbreak of paralytic rabies in the Department of Cesar in 1976. The systemic method was employed with an 85 percent reduction in bat bites observed. An estimated 80 percent of the cattle of the area had been bitten.

According to Marique and Valdez, 50 veterinarians were trained by the Denver Wildlife Research Center personnel around Santa Marta in 1977. The personnel of the ICA vampire bat control service only used the systemic method because the technicians don't like to work at night or go into caves to count or handle dead bats. Incidents of people of the region having been bitten by vampire bats have created superstition and bat phobia.

The control chemical, diphacinone, is provided free by ICA and only the technicians from ICA may apply the control. When more than 20 percent of the livestock on a farm show vampire bat bites, the ICA personnel implement the systemic control.

Weak animals and calves are more frequently bitten by vampire bats than are healthy or older animals, respectively. The reason put forth for this by Rodriquez, Waked, and Obando is that the weak animals do not resist the vampire attack and that calves sleep more soundly than do older animals. The men also stated that cattle will become anemic if bitten often, but observed that if the animal is strong and is not bitten much, that the adverse effects on milk production or the loss in weight is slight.

Panama

Boyd related that the Ministerio de Desarrollo Agropecuaric (MDIA) divided Panama into eight regions, and assigned a veterinarian and two assistants to each region for the purpose of combating vampire bat transmitted paralytic rabies. The rabies control personnel were assigned the additional work of combating brucellosis, tuberculosis and parasites in 1977, whereupon the rabies control declined. The topical method was used but the men did not like the night work (Boyd, 1978).

The Panamanian government vaccinated 75,996 head of cattle against rabies from 1972-1977. The ERA strain of vaccine was used, at a cost per dose to the cattleowner of $.50 (U.S.). DDT was also regularly used in 1977 in the Canal Zone to destroy bat colonies in buildings, according to Dr. Gale. The people in the Canal Zone think all bats are vampire bats because bats, sickened by DDT, have bitten people when handled.

The movement of some cattle from Santo Province to better pasture during the dry season in 1976, resulted in 78 people being bitten by vampire bats which had depended on the cattle for blood. Thirty unused wells which housed the vampire bats were sealed, eliminating the problem. Most of the people which had been bitten were afraid to take antirabies treatments. However, nobody died from rabies so rabies was apparently not prevalent in the vampire of the area at that time.

The estimate by Acha (1967) of 8,000 cattle rabies deaths in Panama each year from paralytic rabies is unaccountable by known facts, according to Boyd, who suggested Acha may have estimated ten rabies cases for each recognized case.

Trinidad

The control of vampire bats on Trinidad is conducted as part of a plan to control rabies. Vampire bat bites have been observed on bovines, swine, oxen and horses. Paralytic rabies claimed the lives of 151 horses between 1969 and 1975. From 1970 to 1976, 67 people were bitten by bats, and 7,828 cattle were observed with fresh bites also.

The control of bovine rabies by means of mandatory vaccination is conducted by the government. The vaccine is effective for up to four years,

but cattle are inoculated every three years according to Moe. The government of Trinidad pays for the cost of treatment of the 26,584 cattle (in 1975) in Trinidad and Tobago.

The control of vampire bats by conventional methods using mist nets, poison and firearms killed 19,166 bats from 1968-1976. A detailed and growing listing of bat roosts assists the capture of the vampire bats done almost exclusively at roost sites. The number of vampire bats caught annually remained relatively constant from 1969-1977.

Diphacinone control methods were implemented beginning in 1974. Twelve people employed in the program captured and treated 443 vampire bats in 1974 and 529 in 1976. Cattle are not injected intraruminally with diphacinone because of concern that problems might result from human consumption of milk from the treated cattle (Moe and Muradali).

Venezuela

Marsiglia explained that the Venezuelan plan was to have five teams, composed of one veterinarian and two technicians, with each team having its own equipment and assigned area. Each team was to give priority to controlling outbreaks of rabies expected each year in each area, but when not combating a rabies outbreak, the men would engage in vampire bat control to advance meat and milk production. Although thirteen veterinarians have been trained in bat identification and vampire control, only Drs. Davila and Pascal are actively engaged in research and control of vampire bats.

Eight bovine rabies outbreaks have been eliminated in Venezuela since May, 1975. The topical technique of vampire bat control and the application of the diphenadione paste to recent vampire bat bites, has been effective. The control work is done in a 15 kilometer deep zone in advance of the moving epizootics. Even owners of a few animals use the topical application method of vampire bat control. Trapping and treating bats is being done primarily in areas where outbreaks of paralytic rabies have occurred (Marsiglia and Lord).

Summary

There was no central data gathering authority able to divulge complete data on the history of vampire bat control in either Colombia, Panama, Trinidad or Venezuela. What data were available for the most part were produced by control personnel on scattered cases of observed control. None of the countries visited had pursued vampire bat control consistently for more than an average of one year at a time. The use of antirabies vaccination was not always used in conjunction with diphacinone application although all of the countries used both methods. The control of rabies was the motivation for the use of diphacinone control techniques. Difficulty in obtaining and maintaining an effective quality vaccine in Colombia resulted in the vaccine only being effective from six months to two years. In Trinidad, the antirabies vaccine was considered effective for four years, but livestock were still vaccinated every three years. In several of the countries, the control of vampire bats with diphacinone methods began as a separate and unique operation. However, the effectiveness of the work declined when additional work responsibilities were assigned to the control personnel.

ANALYSIS OF SURVEY DATA

The results of the evaluation of the economic impacts of vampire bat control in Nicaragua are presented in this section. Available data on the social and environmental impacts of vampire bat control also are presented in this section to show the contrast between pre- and post-diphacinone control. This method was used in the absence of data from a nationwide control versus no-control experiment. Primary data on the herd-level impact of vampire bat control was gathered by a survey of 117 cattle producers whose herds were treated in that country's control program from 1974 to 1977.

The benefits of vampire bat control to nonparticipant cattleowners or rural residents also were studied in this socioeconomic evaluation. Cattleowners of 61 nearby herds were interviewed to determine the extent of the indirect or "third-party" effects of the vampire bat control program. Although benefits could also result indirectly to future residents or cattleowners in an area where control was effected, sufficient time has not elapsed since treatment to measure such benefits.

Primary data on the impact of the control program on rural residents of the area were gathered by interviewing civic leaders and medical personnel in small towns in the treatment area, i.e., municipalities within 15 kilometers of where vampire bat control was done.

Cattleowners whose herds might have received some benefit were selected from among the neighbors of the interviewed participant cattleowners. The majority of the nonparticipant interviewees occupied land which bordered the participant herd grazing area and the remainder were situated up to 15 kilometers from known participants. The indirect benefits to nonparticipant cattleowners is presented in the section on Economic Impact, and the benefits received by rural nonfarm people are presented in the Social Well-Being section.

Characteristics of the Sample Farms and Ranches

The amount of land owned appears proportional to the number of cattle owned, indicating a strong dependence by all agricultural operations on cattle (Table 5). The average acreage per farm/ranch often includes land used for cultivation as well as grazing. The size of land holdings by nonparticipants was greater than that owned by participants only in the case of the 1-10 head herd size. The acreage of the farms with from 11-100 head was only slightly greater in the Central Highlands than in the Pacific Coast region, for both participants and nonparticipants. The opposite was true for herds greater than 101 head, with more than double the acreage in the Pacific Coast region compared to the Central Highlands participant ranch/farms.

Table 5: AVERAGE ACREAGE FOR SAMPLE PARTICIPANT AND NONPARTICIPANT FARMS, BY SPECIFIED RANGE OF HERD SIZE, BY REGION, NICARAGUA, 1978[a)]

Status in Program	Range of Herd Size		
	1-10 Head	11-100 Head	101+ Head
		acres	
Participants			
Central Highlands	b)	149	850
Pacific Coast	41	139	2,036
Weighted Regional Average[a)]	41	144	1,509
Nonparticipants			
Central Highlands	144	162	787
Pacific Coast	142	153	839
Weighted Regional Average[a)]	143	158	804

[a)] The averages weighted by number of farms or ranches in each region. See Table 2, page 8.

[b)] Insufficient data

The number of people who lived and/or worked on the farm was considered in this study to more fully categorize the type of agricultural operation which did or did not receive benefits from the vampire bat control program. There were more people living and working on the participant than on the nonparticipant forms (Table 6). The average number of people on the small herd participant farms is more than half that of the participant farms

with 101+ head. The average number of people on the nonparticipant farms decreases as herd numbers increase. The number of people on the farms with intermediate sized herds was smallest in both participant and nonparticipant cases, indicating some efficiency of size.

Table 6: AVERAGE NUMBER OF PEOPLE ON SAMPLE FARMS, BY SPECIFIED RANGE OF HERD SIZE, BY REGION, FOR PARTICIPANTS AND NONPARTICIPANTS IN NICARAGUAN VAMPIRE CONTROL PROGRAM, 1978[a)]

Status in Program	Range of Herd Size		
	1-10 Head	11-100 Head	101+ Head
Participants			
Central Highlands	5.0	13.1	15.8
Pacific Coast	10.1	6.5	19.6
Weighted Regional Average[a)]	9.8	9.4	18.0
Nonparticipants			
Central Highlands	6.3	4.3	9.6
Pacific Coast	10.6	7.1	5.6
Weighted Regional Average[a)]	9.6	5.7	8.3

[a)] The averages are weighted by the number of farms or ranches in each region. See Table 2, page 8.

Farm Livestock Populations

The range of herd size by sample strata was decided before the initiation of the survey to accentuate the distribution of the costs and benefits of the vampire bat control program. The average number of beef and dairy cattle is presented by region for participants and nonparticipant herds in Table 7.

There were about the same average number of beef as dairy purpose cattle on the farms with 10 animals or less. The number of beef and dairy cattle was equal or almost equal in all regions for both the small and the intermediate sized herds. There were considerably more beef than dairy animals reported in the large-sized herds in the Pacific Coast region for both participants and nonparticipants, with more than five times as many beef as dairy animals in the Central Highlands region participant herds.

The similarity in the numbers of beef and dairy purpose cattle in the small and intermediate size herds is explained by the fact that cattle owned by smaller sized operations are usually dual purpose animals. The categorization of the animal as dairy or beef is dependent on the viewpoint of the cattleowner and the point in the production cycle when the question was asked. Thus, the views of the livestock owners towards function of their cattle tended toward a balance between dairy and beef as the sample size increased.

Table 7: AVERAGE NUMBER OF BEEF AND DAIRY CATTLE PER HERD IN THE SAMPLE PARTICIPANT AND NONPARTICIPANT HERDS OF SPECIFIED SIZES, BY REGION, NICARAGUA, 1978

	Specified Herd Size Range		
Region	1-10 Head	11-100 Head	101+ Head
Participants			
Central Highlands			
Beef	3	26	395
Dairy	3	25	78
Total	6	51	473
Pacific Coast			
Beef	3	16	487
Dairy	4	16	355
Total	7	32	842
Nonparticipants			
Central Highlands			
Beef	1	24	118
Dairy	5	24	173
Total	6	48	291
Pacific Coast			
Beef	3	17	123
Dairy	4	13	30
Total	7	30	153

Effectiveness of Control on Participant Farms

Vampire bat control on the sample farms was 100 percent effective in 63 of the herds. An average of 30.2 months had elapsed from date of treatment until the time of the interviews with participants. On the remaining 54 control program farms in the sample, a recurrence of biting was noted an average of 9.4 months after treatment. For the 117 herds in the participant sample, the cattleowners estimated an average respite from bat bites of 19.9 months resulted from diphacinone control. The intensity of biting upon renewal of biting was not quantified, but was declared to be much less than at the time of first treatment.

The participants were asked whether participation in the control program should be voluntary or obligatory. This question was asked to determine the general attitude of the cattleowners towards the control program, and to determine to what extent a recurrence in the bat bites was due to the intensity and coordination of the control work. Eighty-nine percent or 93 of the 105 participants who responded to this question felt that participation should be obligatory. Fifty of those 93 herdowners claimed that bat biting of their livestock recurred within a few months after treatment[1]. Only three of the 12 herdowners who said participation should be voluntary claimed that treatment was less than 100 percent effective. Thus, a positive relationship exists between attitude towards obligatory participation and the recurrence of vampire bat bites after treatment. The herdowners had confidence in the treatment methods, explaining the recurrence of the bat problem as being due to lack of control in other herds of the area.

The sample participants and nonparticipants were asked whether they would collaborate in another vampire bat control program or in a similar pest control program. There were 92 participants and 47 nonparticipants who responded to the question of whether they would participate in a similar service if offered by MAG. Eighty-seven (95 percent) of the participants and 36 (77 percent) of the nonparticipants stated they would participate if a similar service was offered. Evidently, even the nonparticipants had heard good comments about the control program.

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[1] Responses ranged from 10 days to one year.

Indirect Effects on Nonparticipant Farms

The extent that nonparticipating cattleowners received benefit from vampire control on neighboring ranches closer than 15 kilometers also was investigated. Both participant and nonparticipant cattleowners were asked if they were aware of neighbor participation and then were requested to quantify the effect of such participation.

Awareness of Neighbor Participation

A greater proportion of participants than nonparticipants claimed their neighbors had collaborated in the control effort. In the Central Highlands, 58 percent (26 of 45) of the interviewed participants claimed neighbor participation had also occurred, while only 35 percent (9 of 26) of the nonparticipants said their neighbors had been in the program. Participation by the sample participant neighbors was 51 percent (37 of 72) in the Pacific Coast, while 43 percent of the nonparticipants (15 of 35) claimed that their neighbors had received the control service.

Only 24 of 58 (41 percent) of the nonparticipant neighbors were aware that vampire bat control had been carried out in the area. This follows the fact that only neighbors to actual participants in the sample were considered as nonparticipant candidates and, assuredly, other neighbors besides those known to the interviewers had also participated.

Indirect Effects

A decrease in vampire bat bites due to control treatment effected on neighboring herds was noted by owners or managers of seven of the 168 ranches (four percent) in the survey. Two of those seven were participants whose cattle had been treated either before or after the treatment of neighboring herd. The one nonparticipant who claimed that there was a complete cessation of biting on his nontreated animals lived within one-half kilometer from a large herd where the topical method of control had been employed. Another rancher said his herd was not treated, though cattle of all of the herds within six kilometers had been treated and that the result was a 60 percent reduction in the number of bites for a time span of two years on his own cattle.

Neither the participant nor the nonparticipant interviewees could give more precise information as to the indirect effect of vampire control on adjacent herds. The lack of awareness could be attributed to general lack of communication between cattleowners, a history of erratic fluctuation in production, or to the fact that there was no notable indirect effect.

An indirect benefit or effect was noted on five of 24 nonparticipant haciendas (21 percent) which were aware of control efforts in neighboring herds. Indirect benefits to livestock owners were marginal, with the benefits from vampire bat control going mostly to the owners of those herds which were actually treated. The extreme specificity of the diphacinone strategy limited the extent of indirect benefits.

Reasons for Nonparticipation

The reasons given by the 61 nonparticipants for their not having participated in the control are listed in Table 8. There were 35 cattleowners (57 percent) who had either not heard of the control program administered by the Ministry of Agriculture or who had heard of the program but had not been visited by control personnel. Another 20 percent (12) of the cattleowners had either no cattle or no cattle being bitten by vampire bats at the time treatment was offered. There were 8 cattleowners who claimed that control work had been done on their haciendas, but no record of said control could be found in MAG files, and precise details by the cattleowners as to the treatment could not be recalled. Only two cattleowners refused to let their cattle be treated (systemically) due to fear of harm coming to the livestock. Among other reasons given for nonparticipation were that cattle handling facilities were inadequate, and the price for control was too high. In proportion to the number of candidates interviewed per zone, more nonparticipant cattleowners claimed ignorance of the control program in the Pacific Coast than in the Central Highlands. A much larger proportion of Central Highlands than Pacific Coast cattleowners did not participate because the control personnel never made it to the ranch site.

Table 8: REASONS GIVEN BY NONPARTICIPANTS FOR NOT PARTICIPATING IN THE VAMPIRE BAT CONTROL PROGRAM, NICARAGUA, 1978

Reason	Central Highlands	Pacific Coast	Total
Had not heard of control program	6	12	18
Control personnel did not arrive	11	6	17
No problem with vampire bats	3	6	9
Claimed participation[1)]	3	5	8
No cattle at the time	2	1	3
Lack of confidence in treatment (systems)	1	1	2
Other reasons (lack of facilities, etc.)	0	4	4
Total	26	35	61

[1)] MAG did not have a written record that the livestock producer participated in the control program.

ECONOMIC IMPACTS OF THE NICARAGUAN VAMPIRE BAT CONTROL PROGRAM

Effect on Value of Cattle Hides from Bat Bites

Administration personnel at three slaughter houses and two tanneries were consulted concerning the effect of vampire bites on the value and quality of cattle hides. The men were asked whether the bites decreased the value of the hides, either through damage of holes, loss of hair or uneven hair surface.

Personnel at three slaughter houses in Nicaragua (IFAGAN, CARNIC, and the Public Rastro) were visited. One of the men was a cattlebuyer and the other two were quality control men. One man claimed that in 1976 there were cases of cattle brought in for sale which were streaked with blood from vampire bat bites. The number of noted cases of bat bite had decreased considerably by 1978 to about 100 fresh bites on 10,000 animals per month. The same spokesman claimed that the value of the hide would decrease from $10.70 (U.S.) with no bites to $7.90 (U.S.) with bites, a reduction of $2.80 (U.S.). The other two slaughterhouse spokesmen stated that no bites had been observed in the last three years and 16 years, the respective lengths of the men's experience. All three of the men said that screw worms cause far greater damage, decreasing the value of a hide from $6.00 (U.S.) to $10.70 (U.S.).

Personnel consulted at two tanneries claimed there was no noticable evidence of damage from bat bites on the hides bought from the slaughter house's cattlemen, or from butchers throughout Nicaragua. Both of the men consulted at the tanneries said that they would have no knowledge of vampire bat bites because they received the hides already washed or steam-cleaned. Thus the bite of the vampire bat apparently does not deeply penetrate the hide. Both men stated that grubs and ticks were a tremendous problem at times making it impossible to get top-grade hides.

The decrease in the price paid for the hides does not appear to be based on real damage to the hide from the bite, but is rather a judgment on the value of the total animal. Only one in five hide industry spokesmen claimed that the bite had been a problem.

Secondary Infestations From Bat Bites

The cattleowners were requested to provide information on losses due to secondary infestations or infections, i.e., health problems which developed due to the introduction of disease via the break in the skin caused by the vampire bat bite. An infestation was caused by fly larvae such as screw worms hatching or being deposited live in the vampire bat caused wound, a condition known as myiasis.

The problem is usually controlled where close attention is given to the animals. Thus, on the smaller ranches, with less than ten head, where the animals generally are observed daily, there was no reported incidence of myiasis. Conversely, the cases observed on large cattle herds was due to the fact that these herds, consisting mostly of beef cattle, graze unobserved for extended periods of time in pasture accessible only by horse. Thus the ranchers do not notice the infestations, nor can they always treat the open wound as quickly as the smaller operators.

There were 11 cases of myiasis caused by vampire bats in the Central Highlands, and 17 cases in the Pacific Coast, as reported by program participants. All of the 28 cases occurred on five ranches, each having more than 100 head of cattle. Only two cases were reported on the nonparticipant neighbor ranches. Both occurred on a ranch with between 11 and 100 head of cattle, located in the Department of Granada.

There was an average of one case of myiasis in every 1,063 head of cattle on both the participant and nonparticipant farms. On participant ranches, there was one case in 814 and 1,118 head of cattle on the Central Highlands and Pacific Coast ranches, respectively. On nonparticipant ranches, there was one case in 920 cattle in the Pacific Coast, with no cases reported in the Central Highlands.

The cattleowners could not quantify the physical or economic loss due to myiasis. The loss was therefore included in this study in the section on production loss by assuming that the general physical loss due to vampire bat biting included loss due to myiasis.

Cost of the Vampire Bat Control Program

The cost of vampire bat control was categorized to reflect the input of cattleowners, national government agencies, and foreign government or international agencies. The focus of this section of the study was on the cost to Nicaraguan cattleowners, the Nicaraguan Ministry of Agriculture, and the Denver Wildlife Research Center.

Cattleowner Costs

The cattle either injected or protected by the topical method of vampire control costs owners the following: (1) time for the movement and assembly of the cattle; (2) materials for construction of a temporary corral; and, (3) loss of calves by induced abortion of pregnant cows due to improper handling of these pregnant cows during treatment. The value placed on the cattleowner or worker's time was $.25 (U.S.) per hour; the cost of materials for each corral was valued at $14.00 (U.S.); and, the value of a live newborn calf at $14.30 (U.S.).

The amount of time needed for the treatment program was estimated by the participant cattleowners to be 1.2 man hours on a small herd ranch, 6.2 man hours on an intermediate sized ranch, and was 11.9 man hours on ranches with more than 101 head. The cost in time per farm was estimated to be about $.30 (U.S.) for a small herd, $1.60 (U.S.) for the intermediate sized herd, and $3.00 (U.S.) for large herds.

None of the owners of small herds in the sample claimed that any additional cattle handling facilities were necessary. Most of the animals of small herds were taken by their owners to a site near the farm where systemic treatment was implemented on many cattle in the area. Corrals were constructed on two of the 46 farms with intermediate sized herds and on nine of 57 farms with large herds . The greater number and proportion of corrals on large versus intermediate or small herd farms is because with fewer animals to treat, the cattle could be roped and treated. Also, on smaller and intermediate sized ranches, more of the cattle are dairy type, thus facilities for handling and containment already existed.

Only one herd of the 117 program participants' herds in the sample reported a loss due to the diphacinone treatment process. Two abortions

by cows after systemic treatment caused a loss of two calves estimated by the owner to have a total value of $29.00 (U.S.). Thus the probability of a loss of animals was estimated to be 0.01 percent of all animals treated by the systemic method.

The extrapolation of the costs of the vampire bat control program to cattleowners was done by multiplying the estimated average cost per farm by the number of farms (Table 9). Where data by herd size was available, a corresponding division was made in the presentation of aggregate impacts.

The owners of large herds shouldered 64 percent of the participants' cost, emphasizing the fact that cost of participation was positively related to the number of animals treated. The movement and handling of the livestock was 60 percent of the cost of the participants' collaboration.

TABLE 9: TOTAL COSTS OF THE VAMPIRE BAT CONTROL PROGRAM TO PARTICIPANT CATTLEMEN IN NICARAGUA, BASED ON 1978 COST DATA

Size of Herd	Number of Herds	Time Cost b)	Corral Construction Cost b)	Death Loss Cost b)	Total Cost b)
1-10 Head	176	$ 50.00	a)	a)	$ 50.00
11-100 Head	981	1,570.00	$ 690.00	$ 50.00	2,310.00
101+ Head	761	2,280.00	1,700.00	160.00	4,140.00
All herd sizes	1,918	$3,900.00	$2,390.00	$210.00	$6,500.00

a) less than $10.00 (U.S.)
b) Cost data rounded to nearest $10.00 (U.S.)

Nicaraguan Ministry of Agriculture Costs

The Nicaraguan government budgeted $114,285 (U.S.) to the Ministry of Agriculture in 1974 for the initiation of a program to control vampire bats. An estimated $73,600 was spent in the acquisition of vehicles, and laboratory and office equipment. The balance of $40,700 was distributed to various personnel and supplies expense accounts (Table 10).

Details on actual expenses for 1975-77 were unavailable, so salary and wage expense was substituted from the control program annual proposed budget. The materials and depreciation expenses were estimated by extrapolation of the 1974 cost of $52.40 (U.S.) per ranch visited.

Table 10: ESTIMATED EXPENSES OF VAMPIRE BAT CONTROL PROGRAM FOR 1974 in NICARAGUA

Item	Annual Expenses 1974	Equipment Acquisition
Salary Expense a)	$ 10,285	--
Wage Expense b)	51,430	--
Per Diem c)	13,405	--
Office Expenses:		
Office Equipment Depreciation d)	715	$ 7,840
Office Supplies	715	--
Laboratory Expenses:		
Laboratory Equipment Depreciation e)	75	730
Laboratory Supplies	110	--
Vehicle Expenses:		
Vehicle Depreciation	12,260	65,000
Maintenance	601	--
Gasoline f)	10,210	--
Other Vehicle Expenses	265	--
Topical Method Supplies Expense g)	3,665	--
Systemic Method Supplies Expense h)	1,260	--
Diphenadione Expense i)	7,820	--
TOTAL	$112,816 (U.S.) j)	$73,570 (U.S.)

Source: Department of Accounting, Ministry of Agriculture, La Calera, Managua, Nicaragua.

a) Includes one medical coordinator, one administrator and one secretary
b) 20 technicians paid $214.30 per month = $4286x12=$51,430
c) $4.30 per day for 18 men, $5.00 per day for the remaining 2 men
d) 10 year life, no salvage value - straight line depreciation
e) 5 year life, no salvage value
f) $0.40 per gallon for 25,525 gallons
g) Nets, gloves, lanterns, electric corral materials
h) Syringes, needles and boots
i) Form of the chemical not recorded
j) This is slightly less than the $114,285 (U.S.) budgeted for the Vampire Bat Control Program in 1974.

Total salary and wage expenses for the 1974-1977 program were estimated at $318,270, depreciation of vehicles and other equipment at $52,180, and all supplies, gasoline and diphacinone expenses were estimated at $111,940. The total expenditure for the four year period was estimated at $482,400. Salaries and wages constituted 66 percent of total expenses, not including the per diem for the technicians. Depreciation expenses were 10.8 percent and the expense of diphacinone was estimated at $31,300 (U.S.) or 6 percent of total expenses.

Denver Wildlife Research Center Costs

The Denver Wildlife Research Center (DWRC) spent $1,462,240 from 1968 through fiscal year 1978 on the testing of various vampire bat control methods and chemicals, the study of vampire bats and the training of control personnel in Latin America. From 1968 through 1975, the DWRC research effort at Palo Alto, Mexico cost $639,934 of the total of $1,462,240. The scientific effort in Palo Alto was 14.7 man years. A total of 47.1 man years went into the DWRC effort at Denver and Mexico. From DWRC records, it was impossible to allocate to specific countries the cost of control personnel training in other countries. No money was spent by DWRC on actual control work in Latin America.

Transfer of Technology

The cost of the research and development of diphacinone control by DWRC was allocated as a transfer of technology to those countries (see section on Vampire Bat Control in Latin America) which were known to have utilized the chemical control measure. The basis for allocation of the DWRC research and development expense was estimated annual mortality of bovines from vampire bat transmitted paralytic rabies; it was assumed that the severity of the rabies problem would motivate proportional utilization of control methods. The countries known to have utilized diphacinone are listed in Table 11 together with the estimated annual precontrol bovine deaths and the portion of the technology transfer corresponding to each country.[1] The allocation in this manner assumes that control would be employed at similar levels in all designated countries, and that no other countries would utilize the diphacinone control methods in the future.

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[1] For example, for Argentina, $\frac{50,000}{485,000} \times \$1,462,240 = \$150,600$ (U.S.)

Brazil and Mexico would have received 60 percent of technology transfer according to this method of allocation. Argentina, Bolivia and Colombia, together would account for another 31 percent. Nicaragua would have received only $30,100 (U.S.) or two percent of the technology transfer from the USAID/DWRC research.

Table 11: ESTIMATED POTENTIAL TECHNOLOGY TRANSFER TO SPECIFIED LATIN AMERICAN COUNTRIES FROM UTILIZATION OF DIPHACINONE VAMPIRE BAT CONTROL

Country	Estimated Annual Pre-Control Mortality a)	Portion of Technology Transfer
	head	
Argentina	50,000	$ 150,600
Belize	2,000	6,000
Bolivia	50,000	150,600
Brazil	200,000	602,300
Colombia	50,000	150,600
Costa Rica	10,000	30,100
Ecuador	5,000	b)
El Salvador	3,000	9,200
Mexico	90,000	271,000
Nicaragua	10,000	30,100
Panama	8,000	24,000
Surinam	2,000	6,000
Trinidad	500	1,500
Venezuela	5,000	15,000
TOTAL	485,500	$1,462,240 c)

a) Acha, 1967
b) Ecuador did not have a control program at the time of this evaluation.
c) May not sum due to rounding. This is the estimated AID cost for the Vampire Bat Control Program.

Economic Loss to Paralytic Rabies Prior to Diphacinone Control

There were 170 cattle deaths attributed to vampire bat-borne paralytic rabies on the 178 ranches of the sample, from 1970 until control was implemented between 1974 and 1977. A reported 105 of the deaths occurred in participant herds between 1970 and 1974; 65 of these deaths were in non-participant herds. Three of the deaths occurred in small herds, 46 in intermediate sized herds and 121 in the large herds. The probability of

an animal dying from rabies transmitted by vampire bats in the participant herds prior to treatment was thus one in 357 animals and in the nonparticipant herds one in 58 animals.

No cattle died from bat-borne rabies in participant herds after control of vampire bats was implemented. Sixty-five cattle on nonparticipant ranches succumbed to the virus in 1977-1978, of which 35 died in the six months following the close of the control program in December, 1977.

There were 146 beef-type cattle and 24 dairy animals reportedly killed by the rabies virus on the 178 sample ranches with 31,889 total head of cattle. An estimated 0.28 percent (89) of the cattle on the participant ranches died from paralytic rabies prior to vampire bat control. The large herds suffered 72 percent, the intermediate size herds 26 percent, and the small herds two percent of the death loss. The death loss for the nonparticipant farms from paralytic rabies was 1.7 percent for the same period.

Assuming a mortality rate of 0.28 percent for the control program participant farms, the estimated number of deaths which occurred on these farms in the four years prior to control was 836, of which 532 were beef type animals and 304 dairy type cattle. The estimated annual mortality rate was 209 bovines per year from 1970-1973. This figure would equate to an estimated 1,820 deaths per year among the estimated Nicaraguan herd in 1974 of 2,600,000 cattle (UNASEC).[1] We realize these death loss estimates are much lower than the CPAZ (1977) and Acha (1967) estimates. However, our estimates are based on field survey data.

The economic loss to the owners of the large herds of beef animals was estimated to be $55,337 (U.S.), assuming: (1) a value per head of $128; (2) the large herd beef cattle population is as shown in Table 4; and, (3) the ratio of loss as calculated in the section on rabies deaths was 0.28 percent. The estimated annual economic loss of beef and dairy animals to paralytic rabies in the program participant herds for the four year period (1970-73) before the control program was implemented, was $31,387.50 ($125,550÷4) (Table 12).

Production Loss to Vampire Bats Prior to Diphacinone Control

The 117 cattleowners in the control program were asked what weight loss could be attributed to the loss of blood, secondary infection and general discomfort caused by a vampire bat bite. Seventy-five cattlemen volunteered their estimates of what the loss had been. All but 9 of the cattlemen said

[1] 2,600,000 head x .0028 = 7,280 deaths for 4 years (1970-73); 7,280 ÷ 4 = 1,820 deaths per year.

that continuously biting by bats would decrease the weight of the beef animals, the production of the milk cows, or the strength of their draft animals. However, 42 of the cattleowners interviewed could give no estimate of the physical quantity of the decrease in production. No cattleowner had actually measured the decrease in milk or beef production.

Twenty-seven cattleowners whose beef animals had been treated claimed that the average increase in production after control was implemented was 44.5 kilograms (99 lbs.) per year. Another 28 owners of predominantly dairy animals estimated that milk production increased an average of 1.9 liters per day or 69 gallons per year following control, based on about a 165 day milking period per year.

Table 12: ESTIMATED PRECONTROL ECONOMIC LOSS DUE TO DEATHS OF BEEF AND DAIRY CATTLE FROM VAMPIRE BAT TRANSMITTED PARALYTIC RABIES ON CONTROL PROGRAM PARTICIPANT FARMS, NICARAGUA, JAN. 1970 - JAN. 1974a/

Type of Animal	Range of Herd Size 1-10 Head	11-100 Head	101+ Head	Total
Beef b)	$128	$12,672	$55,296	$ 68,096
Dairy c)	189	17,010	40,257	57,456
TOTAL d)	$320	$29,680	$95,550	$125,550

a) Number of deaths by herd size was obtained by multiplying .0028 death loss by data in Table 4, page 32.
b) $128 (U.S.) per beef animal (see page 24).
c) $189 (U.S.) per dairy animal (see page 24).
d) $189 rounded to recent $10 (U.S.)

Non participant cattleowners whose animals were being bitten by the bats claimed the cattle were losing an estimated 24 kilograms of weight per head per year. Twelve nontreated dairy cows-herds were losing an estimated 0.9 liters of milk per day per bitten cow due to loss of blood and to bother by vampire bats.

Estimated production loss was greater in participant than in nonparticipant herds. The loss was also greater in the Central Highlands in all cases except nonparticipant dairy herds. The difficulty of accurate estimates is compounded by the fact that many of the livestock were dual purpose. An estimate of weight loss only partially indicates the detriment caused by feeding vampire bats when the animal also produces milk. Many cattleowners

stated that a nursing beef cow would show no ill effects herself from the bite but that the loss would appear as reduced gain in the suckling calf. Other aspects to keep in mind is that few scales for weighing beef animals are available at the farm level and the milk production is very seldom weighed at the dairy farm.

Economics of Production Loss

The estimated annual loss in weight or decrease in the rate of gain of a beef animal was valued at $.40 per kilogram, for a loss of $17.80 (U.S.) per head. Assuming as many beef cattle lost weight before control as there were beef animals bitten, and that each animal received 0.41 bites per night (about one bite every two nights), the estimated number of beef animals which were suffering weight loss due to vampire bat bites was 77,975 head.(Table 4) The estimated aggregate loss on beef animals before treatment in the program was $1,387,940 (U.S.). A gross benefit of $1,263,030 (U.S.) in increased beef production resulted from the program, with a continued loss of $124,910 assuming a 91 percent effective control program.(Table 13)

The loss in milk production per year of 69 gallons per dairy cow was valued at $.40 (U.S.) per gallon, for a yearly economic loss of $27.60 (U.S.) per dairy cow. Again, assuming as many dairy cattle were suffering a decrease in production as were recorded as having been bitten, then there were an estimated 44,582 dairy cows bitten, and an estimated decrease of milk production of 3,076,158 gallons. The estimated value of the loss of milk production before treatment was begun would have been $1,230,480 (U.S.), and after treatment would have been reduced by 91 percent to $110,740 (U.S.). The net savings due to vampire control among dairy animals would thus be an estimated $1,119,740 (U.S.).

The distribution of these benefits by size of beef or dairy herd is presented in Table 13. The loss before and after treatment was distributed among the specified herds sizes on a per head basis. For example, there were an estimated 416 cattle bitten among the 1,015 head from the small size herd (Table 4). There were 201 beef animals losing weight and 265 dairy cows with decreased production prior to the vampire bat control in Nicaragua. The economic loss to cattleowners with small herds was estimated to be $3,580 (U.S.) from beef weight loss and $5,930 (U.S.) from decreased milk production prior to control.

Table 13: ESTIMATED ANNUAL ECONOMIC LOSS IN SPECIFIED SIZED HERDS OF BEEF AND DAIRY CATTLE FROM VAMPIRE BAT CAUSED DECREASE IN PRODUCTION[a] WITH AND WITHOUT DIPHACINONE CONTROL ON CONTROL PROGRAM PARTICIPANT FARMS, NICARAGUA[b]

Type of Animal	1-10 Head	11-100 Head	101+ Head	Total
Without Chemical Control				
Beef	$3,580	$257,550	$1,126,810	$1,387,940
Dairy	5,930	364,040	860,510	1,230,480
TOTAL	$9,510	$621,590	$1,987,320	$2,618,420
With Chemical Control (91% reduction in Losses)				
Beef	$ 320	$23,180	$ 101,410	$ 124,910
Dairy	530	32,760	77,450	110,740
TOTAL	$ 850	$55,940	$ 178,860	$ 235,650

[a] This is the economic loss associated with the weight loss and milk production loss caused by vampire bat bites.

[b] Figures rounded to nearest $10

Non-quantified Economic Parameters

Additional parameters may have had an economic impact but were not quantified in this study due to lack of data. Questions on the cost of prediphacinone control of vampire bats by cattleowners and other rural residents were asked, but few responses were given in economic terms. The use of NEGUVON, garlic water, CRIOLIN, and red clothes was frequently mentioned, but no information on the cost of their use was obtained.

The cost of antirabies vaccination of cattle was not revealed by either cattleowners or government officials. Some 700 head of cattle had been treated against rabies by personnel of the Vampire Control Program at government expense. The use of antirabies vaccine by ranchers in cases other than those recorded in Vampire Control files was unknown by government officials. It was suggested to the interviewer that use of antirabies vaccine was done by private cattleowners with the vaccine being purchased outside of government channels.

The cost of antirabies vaccinations of humans bitten by bats is borne by the Ministry of Health. The actual cost per does was not obtained. Also,

the cost to individuals in terms of time spent seeking medical assistance for bites or recuperating from vampire bat feeding was not considered in this study.

The cost of training the technical personnel was partially included under the cost to the Ministry of Agriculture in that the time spent by the trainees was paid at working salary levels. The salary expense for the personnel who conducted the technician training was part of the Denver Wildlife Research Center/USAID budget. Not quantified for paucity of data and lack of methodol[illegible]s the economic loss caused by the destruction of beneficial bats.

Total Economic Impact of the Vampire Bat Control Program

Total impact of vampire bat control is found by summing of the annual impacts that would result in years following the initial control efforts. The impact in the years following control decrease at a rate equal to the rate that the vampire bat population increases. Given that female vampire bats greater than one year of age produce one offspring per year, the estimated rate of increase in the population of vampires is 30 percent per year. A vampire bat population of an area which has been decreased by control to nine percent of its original level (as in the Nicaraguan control program), would in 10 years return to 95 percent of original level. Conversely, the extent of control in the tenth year would be five percent of what it was in the first year following control. The accumulated impact is the sum of the impacts of all of the 10 years following control. The impact of year two, for example, found by dividing the extent of control in year two (88.3 percent) by the amount of control in year one (91.0 percent) for a net impact of 97 percent. The accumulated net impact for the 10 years over which a net impact would result is the sum of the yearly net impacts, or 680 percent of the net impact of year one.

The loss of bovines from paralytic rabies was decreased to zero cases among the treated herds in the Nicaraguan program. The value of the 209 cattle saved annually in the participant herds in the control program was an estimated $31,388 (U.S.) in the initial year following control. The decrease in the loss of beef and milk production in the first year following control was an estimated $2,382,770 (U.S.) with annual losses of $235,650 (U.S). still being sustained by livestock in the control program even after control was implemented. Thus, initial year total benefits are $2,414,158 (U.S.).

The accumulated gross benefit was an estimated $16,416,274, found by multiplying the initial year benefits by 6.8. The cost of control on the part of the cattleowner, the Nicaraguan government, and the DWRC (technology transfer) was subtracted from the accumulated gross benefit to obtain the estimated net economic impact from diphacinone control of $15,897,274. The costs of alternative conventional control prior to and in conjunction with diphacinone control were not determined in this study, but would have been subtracted from gross benefits of the respective strategies had they been known.

Index of Economic Impact

The index values placed on the parameters of economic impact detailed in the previous section are discussed here (Table 14). The estimated annual death loss from rabies of $31,388 without diphacinone control was given a value of 0. The complete cessation of rabies deaths among the treated herds after diphacinone application was given a value of 100. The annual estimated pre-control loss of milk and meat production of $2,618,420 was given a value of 0. The 91 percent decrease in production loss of $235,650 after diphacinone application was given a value of 91.

Table 14: MATRIX OF INDEXED IMPACTS OF DIPHACINONE AND ALTERNATIVE CONTROL STRATEGIES BASED ON THE NICARAGUAN CONTROL PROGRAM, 1974-1977

Parameter	Without Diphacinone Control	With Diphacinone Control
Paralytic Rabies Loss	0	100
Production Loss	0	91
Cost of Vampire Bat Control	no data	a)
Cost of Rabies Control by Vaccination	no data	b)
Technology Transfer	0	100
Average Index Value	0	+ 97

a) was $482,400 (U.S.) for 4-year program
b) an estimated $373,650 (U.S.) every three years

The cost of both conventional and diphacinone vampire bat control are not rated in the matrix, because although costs of the monetary outlay for

diphacinone control was known, no corresponding value for the conventional method was encountered. Likewise for lack of precise data, the parameter on the relative impacts of rabies control by vaccination were not given a value in the impact matrix for the diphacinone strategy. The estimated annual outlay for rabies vaccinations for the 298,919 head in the herds treated in the vampire control program would have been $124,550 (U.S.). This is based on vaccination costs of $373,650 (U.S.) every three years. The average values of the three comparable economic parameters were zero for the alternative strategy and 97 for the diphacinone control strategy.

SOCIAL WELL-BEING IMPACTS

Various parameters impact on social well-being due to the development of diphacinone and its implementation in vampire bat control. Some of these social well-being parameters are personal hardship of rural people (the human aspect) and distribution of income among socioeconomic strata (the society aspect).

The Human Aspect

In addition to specific agency interviews, several questions on the surveys were directed towards obtaining data on the number of people in Nicaragua who had been bitten by vampire bats and who had received antirabies treatments as a consequence. Information also was obtained concerning the fears of rural people of being bitten by vampire bats, community awareness of the hazards to people from vampire bats, and the community efforts which had been made to combat vampire bats.

Cattleowner Survey

The participant and nonparticipant cattleowners of the sample were asked to furnish information on the number of people on the farm who had been bitten since 1958 on the 178 ranches. Seventeen people had been bitten on as many ranches (Table 15). There was an estimated population of 2,040 people on the farms in the sample, so one of every 120 people on the farms had been bitten. Of those bitten, twelve were on participant farms and five on nonparticipant farms. Four of the cattleowners admitted having been bitten once themselves; five people bitten were ranch or farm workers; and, the remainder were children, four of whom had been bitten more than once.

None of the farm people received or sought medical care after having been bitten. However, neither these people nor others on neighboring ranches had ever succumbed to rabies for lack of antirabies vaccination.

Table 15: INCIDENCE OF HUMANS BITTEN BY VAMPIRE BATS, AND EXISTENCE OF FEAR OF FUTURE BITES ON PEOPLE, ON PARTICIPANT AND NONPARTICIPANT FARMS, BY REGION, NICARAGUA

	People Bitten on Farm		Bitten			Have Fear of Future Bites on Humans	
	Yes	No	Owner	Workers	Children	Yes	No
Participants							
Central Highlands	5	41	0	1	4	10	35
Pacific Coast	7	66	2	2	3	19	53
Subtotal	12	107	2	3	7	29	88
Nonparticipants							
Central Highlands	1	25	0	1	0	6	20
Pacific Coast	4	29	2	1	1	7	26
Subtotal	5	54	2	2	1	13	46
TOTAL	17	161	4	5	8	42	134

The fear of being bitten by vampire bats was not decreased as a result of diphacinone control, when compared between the participant and nonparticipant groups. After control of vampire bats was implemented, 29 of 117 participant respondents (25 percent) experienced fear of being bitten. For those nonparticipants with previous experience with vampire bats biting the cattle, 26 percent expressed fear of being bitten.

Since none of the previously mentioned 17 victims had received medical care for the bites, it is concluded that the fear of being bitten was not due to fear of getting rabies. On the contrary, the effect of the vampire control program may have been an increase in fear of being bitten, due to education of the nature and history of vampire bats. Nine of ten nonparticipants whose cattle had never been bitten did not express fear of being bitten.

Continued effective control could be expected to result in decreasing fear of being bitten, however, the short-run effect of the control program was mixed. Some participants and nonparticipants were less fearful following control. Other cattleowners and their families were more fearful following the implementation of the vampire bat control program because the possible

consequences of vampire bat bites became known at the time control was implemented.

Rural Community Survey

The leaders of 17 rural communities were interviewed concerning the effect of the vampire bat situation on the citizens of their respective towns. The towns selected (see list in Appendix V) were located in areas where the Ministry of Agriculture had implemented the vampire bat control program.

The civic leaders in two of the 17 municipalities stated that in their respective areas, people had been bitten by vampire bats. Eight people were reported to have been bitten in those two towns; five of those bitten took antirabies treatments. In the municipality where the bite victims were given antirabies shots, the respondent was certain that the townsfolk would collaborate financially in vampire bat control.

Five of the 17 civic leaders interviewed had knowledge of the vampire bat control program. Two of those five leaders had cattle which were experiencing problems with bats; one claimed there was no problem with bats; and, two civic leaders gave no response. Nine of the 17 civic leaders believed there was no problem with bats biting people, while three of the civic leaders believed bats were biting only the cattle.

Medical Facility Personnel Survey

The personnel of 18 medical facilities were interviewed to obtain recent rural level data on the effect of the Nicaraguan Vampire Bat Control Program. Questions were asked concerning: (1) the incidence of humans bitten by vampire bats; (2) the attitude of the community towards the local vampire bat situation; and, (3) the measures which typically had been employed to control the vampire bats. The average length of experience at the medical facility was 4.7 years. Six of the 18 interviewed had worked in their rural medical position prior to 1974. Twelve of the people interviewed were nurses, three were rural health investigators, and three were doctors or medical students.

Nine persons in six towns who had been bitten by vampire bats subsequently had been treated for rabies. All nine reported cases occurred since

1975, with five of the cases occurring in 1978. All cases had been recorded on the standard report form of the Ministry of Health. There were no instances remembered of individuals who had reported being bitten but who had not been treated for rabies.

The Ministry of Health provides the antirabies vaccine free to the clinic upon request, which in turn provides the vaccination at no charge to the patient. Either an eight- or a 14-dose treatment was given. Three of the nine people had been bitten in a rural area; the other six victims lived in small towns. One person who was treated had been bitten by a fruit bat.

No analysis had been made to determine if the bats were rabid, but rabies treatments were given as a precautionary measure. Further questioning of medical personnel revealed that no known human deaths from vampire-borne rabies had occurred in the communities.

According to the medical personnel in five of the communities, the people of their respective areas were aware of the vampire bat rabies hazard to humans. In ten communities, the people were considered worried or very scared. In five other communities, the people were not thought to be scared, while in two communities, the people were judged to be not aware of any vampire bat problem. The community attitude was unknown by the medical personnel of two facilities.

According to the medical personnel in five of the communities, the most common method of combating the vampire bat problem was treatment of cattle in the country. Conventional methods (firearms, red cloth repellants, slingshots) were used in three rural communities. In nine other towns no known method of bat control was practiced.

Ministry of Public Health Data

Eighty-one people had been given antirabies treatments after having been bitten by bats in 1973, 1974, 1976 and 1977, according to the records of the Zoonoses Department of the Nicaraguan Ministry of Health. No data were available for 1975. No confirmation was possible as to whether the people bitten actually had been bitten by vampire bats or whether other species of bats were responsible for the bites. There was no confirmation as to the existence of rabies in the treated cases; the Ministry of Health paid for the costs of these treatments.

Twenty-six vampire bats were analyzed in 1973 and 1974 to determine if they carried rabies. Only the vampire bats tested in 1973 were positive. Since 1973, no cases of rabies in humans from vampire bats have been noted or confirmed.

In summary, 48 persons were treated by the Ministry of Health for bat bites in 1973. Another seven rural people in the cattleowners' sample and give in the rural community leader survey also were bitten, but did not seek treatment. After control was begun in January, 1974, and until June, 1978, the Ministry of Health indicated that 33 people were treated for bat bites. Five cases of treatment were recorded by local rural health facilities, four untreated cases were recalled by cattleowners interviewed and three untreated cases were mentioned in the civic leaders' survey.

Distribution of Economic Benefits

The progress towards more equal distribution of income among socioeconomic strata was measured by comparing the distribution of the costs versus benefits of the program between herd size categories. The data on costs and benefits of diphacinone control to the participants are summarized in Table 16. No corresponding data were available for the alternative strategies.

The small herd owners received 0.3 percent of the estimated economic benefits of $16,416,274 (U.S.) provided by vampire bat control. The cattleowners in the medium size herd strata and the owners of the large herds received 22.6 percent and 77.1 percent, respectively. The estimated benefits were $16,632 (U.S.) per herd in the large herd group, $3,782 (U.S.) per intermediate sized herd and $280 (U.S.) per small herd. The equality of benefit distribution was derived by dividing the percent of benefits (0.3) received by the owners of small herds by the respective percent (77.0) received by the owners of large herds. The result of the calculation is an index of -99 (Table 17).

Index of Social Well-Being Impact

The impact of the human aspect parameters of human fear from vampire bat bites, and cases of people bitten and/or treated for vampire bat bite are presented in this section. The data from the cattleowners, rural community (civic leaders), and medical facility surveys were not extrapolated

Table 16: DISTRIBUTION OF PARTICIPANT COSTS AND ESTIMATED TOTAL PROGRAM BENEFITS FROM PARTICIPATION IN THE NICARAGUAN VAMPIRE BAT CONTROL PROGRAM, BY SPECIFIED RANGES OF HERD SIZE, 1974-1977

Parameter	Range of Herd Size 1-10 Head	11-100 Head	101+ Head	Total For All Herd Sizes
		($U.S.)		
Participant Costs	50	2,310	4,140	6,500
Benefits of Participation	49,249	3,710,078	12,656,947	16,416,274
Percent Per Strata	0.3	22.6	77.1	100
Herds in Strata	176	981	761	1,918
Net Benefit Per Herd	280	3,782	16,632	8,559

Table 17: IMPACT ON SOCIAL WELL-BEING PARAMETERS DUE TO DIPHACINONE VAMPIRE BAT CONTROL AND ALTERNATIVE CONTROL STRATEGIES

Parameter	Alternative Control Strategies	Diphacinone Control Strategy
Human Fear Aspect	74	75
Human Bite Cases	-100	-23
Employment Generation	0	100
Distribution of Benefits a)	No data	-99
Average Index Value	-9 b)	+13 c)

a) estimated as percent of total benefits received by small herd owners (see discussion in text)
b) calculated by dividing -26 by 3 parameters
c) calculated by dividing +53 by 4 parameters

to the national level. The use of an "indexing" system to value the different parameters is an attempt to place a quantitative score on some variables which may not be amenable to quantitative measurement.

The fear of being bitten by vampire bats was slightly lower among participants (with control) than among nonparticipants (without control). The human fear aspect without control was given an index value of 74, indicating 26 percent of the people were afraid. The index value with control was 75, indicating 25 percent of the people were afraid, even with control (Table 17).

The actual incidence of people bitten by vampire bats decreased from 48 treated cases and 17 untreated cases before control in 1973, to 33 treated and five untreated cases after the vampire bat control program was implemented in 1974. The five untreated cases after control having occurred on nonparticipant farms. The situation before control was given a value of -100 and the annual average of 8 cases per year following control an index value of -23. These index values are listed with other social well-being scores in Table 17.

Generation of Employment

The work of vampire bat control generated 20 technician jobs for four years. Some administrative and clerical employment also was generated, but at an unspecified level. The time spent by the administrators and secretaries who were assigned to several projects simultaneously was not estimated for the vampire control program.

The generation of the employment in the vampire control program was assigned a score of 100, while the negligible wage-compensated employment produced in control by alternative strategies was given a value of zero (Table 17).

Nonquantified Social Well-Being Variables

The availability of trained technicians, an ongoing or existing organization, and learning from experience were nonquantified social well-being variables. Due to lack of time and data, no quantitative measurements of these parameters were made during this evaluation.

Twenty technicians in the Ministry of Agriculture in Nicaragua were trained and effectively contributed to the vampire bat control program. These same technicians also were used in subsequent programs to control swine cholera encephalitis and coffee rust. Since the termination of the intensive vampire control program by the government, the men have been actively employed in other disease control work. An organization with trained staff as well as technicians is now available for animal health work.

Social well-being impacts may result where diphacinone control is implemented on bats which roost in wells used for human drinking water. There is harm caused by the excreta of the bats falling into the water before control; adverse effects may occur also if the bats die due to control and fall into the well water. The precontrol problem is daily and constant, while the immediate postcontrol problem could be remedied by retrieval of the dead bats from the water.

Net Impact on Social Well-Being

The social well-being impact of diphacinone control was an average of the scores of the four social well-being parameters or +13. The alternative control measures were estimated to impact comparatively on social well-being at a level of -9. The different scores which were assigned to the different variables for each strategy of control are presented in Table 17. The net impact is the simple average of the four scores for the diphacinone strategy and for three variables for the alternative control strategy.

ENVIRONMENTAL QUALITY IMPACTS

The impacts on the environment from diphacinone control of vampire bats were estimated from both primary and secondary data. Published literature and observations of governmental agency personnel in Venezuela, Colombia, Trinidad, and Panama, as well as comments by the individuals interviewed using the three types of survey forms (civic leaders, medical clinic personnel and livestock owners) provided data on the environmental quality analysis. The parameters of environmental impact discussed are: (1) effect on nonvampire bat species and other wild animals in the bat roost (nontarget wildlife); (2) biological equilibrium; and, (3) air and water pollution. Aggregation of these parameters provided an estimation of the environmental impact of diphacinone control of vampire bats. Very limited quantitative data were available. If a specific parameter for the strategy had no impact on environmental quality, it was assigned a value of zero. If the impact was known to be able to harm environmental quality, a maximum negative score of -100 was assigned.

Effect on Nonvampire Bat Species and Other Wildlife

The use of diphacinone by the systemic method (intraruminal injection of the bovine) is species (Desmodontindae) specific as well as bat specific, since only vampire bats which feed on the treated cattle are killed. Vampire bats which feed on wildlife hosts are not affected.

The topical method of diphacinone control is also species specific. The bats which have been treated return to a specific section of the roost and are groomed (also called preening) only by other vampire bats. Neither nonvampire bat genera nor other wildlife cohabitants of the roost are affected. The topical control of vampires in 3,062 Brazilian caves was not observed to have killed any nonhematophagous bats (DWRC, 1976). Thus, the diphacinone control strategy had high selectivity of control between species.

This study did not detect any negative effects on wildlife which might eat the dead vampire bats killed by diphacinone, and falling to the floor of the cave, etc.. Since no negative effects on other wildlife which might cohabit the refuge with the vampire bat were found, a rating of +100 was given for the diphacinone method of control for the effect on nontarget wildlife parameter (Table 18).

The alternative control strategies were assigned a score of -100 because of umerous observed cases where nonvampire bat species have been killed in attempts to control vampire bats. Most alternative strategies also damage wildlife habitat and kill other wild animals.

Biological Equilibrium

The diphacinone control of vampire bats which feed on cattle readjusts the balance of nature hwich has been upset by the introduction of livestock. However, the alternative conventional control methods also pursue this objective of reducing the proportion of vampire bats which depend on man-introduced species. Thus, a value of +100 was given to both the diphacinone control strategy and the alternative strategy (Table 18).

Air and Water Quality

The use of diphacinone in the systemic and topical control methods causes no measurable harmful effects on the quality of air or water. The quantity of chemical used and the preciseness of application merited a score of zero (0) for the change in air and water quality impact. The alternative control strategies were assigned a score of -100, because many of those methods use chemicals and/or explosives that contaminate both air and water (Table 18).

Food Quality

A value of zero (0) was assigned to the diphacinone strategy in the parameter of food quality since scientific studies have shown that negligible or no residue from diphacinone treatments remains in the meat tissue or is passed on in the milk. The alternative control methods were assigned a value of zero (0) also, since there was no evidence available to show that

food consumed by humans had been adversely affected by the alternative methods of control (Table 18).

Experiments by DWRC personnel were conducted in 1973 to measure diphacinone levels in the milk of cows treated systemically. More than 30 gallons of milk from cows overdosed at five times the normal rate of 1 mg./kg. of weight would have to be consumed to receive the minimum dose of 2.5 mg. of anticoagulant used in human anticoagulant therapy (DWRC, 1975).

Blood and tissues from cattle treated with diphacinone were tested at 30 days after treatment to determine levels of residual anticoagulant Detectable levels (> 0.01 p.p.m.) could not be found in blood, brain, fat and muscle tissue. Rats fed for 14 days on the liver of treated cows showed no change in prothumbin clotting time and diphacinone residue was not encountered in the liver or blood of the rats (Bullard, et. al.).

Nevertheless, scientists Muradali in Trinidad and Lord in Venezuela fear there are some long range effects from the accumulation of diphacinone in humans which continuously eat meat or drink milk from cattle injected with diphacinone (systemic method). Neither scientist consequently recommends the systemic method of vampire bat control. Their apprehension is based on the fact that some individuals in Trinidad subject to blood clotting and strokes take anticlotting or blood-thinning medicines. The hypotheses is that (in Trinidad) any diphacinone in the meat tissue or milk may upset the delicate balance in the human body and cause hemorrhaging (personal conversation by senior author with Dr. Muradali). Research data were not available to the authors of this report. Lord and Muradali do however recommend the topical method of vampire bat control.

Control agencies in Nicaragua, Colombia and other countries which are using the systemic method of diphacinone application in vampire bat control, as well as the Denver Wildlife Research Center personnel, are opposed to systemic treatment of cattle which will be butchered within 30 days from the date of treatment. Hopefully, ranchers who are buying the diphacinone and treating their own cattle follow this recommendation.

When the impacts of the four parameters considered under environmental quality are averaged, the diphacinone control strategy has an average score

of +50 while the alternative control strategies have an average score of -25 (Table 18). This simply means that as far as environmental quality impacts, the diphacinone control strategy is significantly better for use in controlling vampire bats.

Table 18: IMPACTS ON ENVIRONMENT QUALITY DUE TO THE DIPHACINONE VAMPIRE BAT CONTROL STRATEGY AND ALTERNATIVE (CONVENTIONAL) CONTROL STRATEGIES

Parameter	Alternative Control Strategies	Diphacinone Control Strategy
Effect on Nontarget Wildlife	-100	100
Biological Equilibrium	100	100
Air and Water Quality	-100	0
Food Quality	0	0
Average Index Value	- 25	+ 50

ANALYSIS OF NET IMPACTS FROM THE DIPHACINONE CONTROL STRATEGY

Environmental Impact Matrix

The economic impacts, social well-being impacts, and environmental quality impacts can be displayed together in an Environmental Impact Matrix. The scores derived for each of the three major parameters of the environmental impact matrix were averaged together. The alternative control strategies had a net economic impact of zero (0), a social well-being impact of -9 and an environmental quality impact of -25. In contrast, the net economic impact of the diphacinone strategy was +97, the social well-being impact was +13 and the impact on environmental quality was +25. Assuming that the best strategy is the one with the greatest overall positive impact, the diphacinone method strategy with a net environmental impact of +45 is better. The scores of all parameters are presented in Table 19.

Benefit Cost Analysis

The estimated annual economic benefits in 1,918 Nicaraguan herds with 298,919 cattle in the control program were $31,388 (U.S.) from decreased bovine mortality due to paralytic rabies, $1,263,030 (U.S.) from increased meat and $1,119,740 (U.S.) from increased milk production. The four-year control program in Nicaragua (1974-1977) cost $519,000 (U.S.); $482,400 was expended by the Ministry of Agriculture, $6,500 by the cattleowners, and $30,100 of AID expenditures (Tables 9,10, and 11).

The total annual benefits of the vampire bat control program in Nicaragua were estimated to be $2,414,158 (U.S.) The annual costs were estimated at $129,750 (U.S.) ($519,000 ÷ 4 years). The benefit-cost ratio is 18.61 to 1.00, indicating that for every $1.00 spent on control during this four year period in Nicaragua, the benefits were $18.61. Even though the production estimates are subject to some error, the magnitude of the ratio is such that we can state with confidence that there was a high pay-off for this AID-sponsored research and development program. Looked at in a different perspective, AID's total cost for this program over a <u>ten year</u> period was $1.5 million (U.S.) <u>Annual</u> benefits from just one small Central American country were $2.4 million (U.S.).

Table 19: COMPARATIVE NET ENVIRONMENTAL IMPACT MATRIX OF THE DIPHACINONE CONTROL STRATEGY VERSUS ALTERNATIVE CONTROL STRATEGIES FOR VAMPIRE BAT CONTROL IN NICARAGUA

Parameter	Alternative Control Strategies	Diphacinone Control Strategy
Economic Impacts		
Paralytic Rabies Loss	0	100
Production Loss	0	91
Cost of VB Control and Antirabies Vaccinations	---	---
Technology Transfer	0	100
Economic Impact Average	0	+ 97
Social Well-Being Impacts		
Human Fear Aspect	74	75
Human Bite Cases	-100	- 23
Employment Generation	0	100
Distribution of Benefits	No data	- 99
Social Well-Being Impact Average	- 9	+ 13
Environmental Quality Impacts		
Effect on Nontarget Wildlife	-100	100
Effect on Biological Equilibrium	100	100
Air and Water Quality	-100	0
Food Quality	0	0
Environmental Quality Impact Average	- 25	+ 50
OVERALL IMPACT AVERAGE	- 11	+ 53

Potential Latin American Economic Impact

The part of the evaluation dealing with actual benefits and costs of diphacinone utilization in vampire bat control in other countries in Latin America is full of data gaps. Data which does exist are from experiments by the Denver Wildlife Research Center, Piccinini's research in Brazil, and some data from publications on cattle health from Panama and Costa Rica, together with ICA and Trinidad data obtained by the senior author of this study. No country has provided data on the economic benefits resulting from control. No country, other than Panama and Nicaragua, has cost of control for all cattle treated, and Panama only lists data for 1974.

In the face of such an incomplete data base, it was felt necessary to use the data base of estimated bovine mortality by Acha (1967) (Table 20). The annual mortality of bovines was listed for almost all countries in Central and South America. The exceptions were Peru, which may have experienced paralytic rabies loss, and Chile, which according to the literature, has not yet had paralytic rabies problems from vampire bats, although the bats feed on livestock. Acha did not list losses to horses, sheep, swine, or poultry.

The Acha data base is good in that it presents an estimate of the vampire bat-borne paralytic rabies situation before diphacinone was implemented. Thus a good estimate of the potential economic benefits of control is possible for all countries. Barring the existence of data on the extent of diphacinone use to date, the next best basis for evaluation of potential control is from the standpoint of before control.

The estimated value of annual loss to vampire bat-borne paralytic rabies was found by multiplying the estimated bovine mortality (Acha's data) by the value per head of cattle, the export or import price, whichever was lower. The results of this mathematical exercise are presented in Table 20. The estimated value of annual loss due to deaths caused by vampire bat-borne paralytic rabies for these Latin American countries is estimated at $148,146,000 (U.S.).

Using the Nicaraguan sample results as a model, an estimate of what benefits and costs would be in each and all Central and South American countries (listed by Acha) was made.Data on the cost per head saved from paralytic rabies in the Nicaraguan case indicated that the Nicaraguan

Table 20: ESTIMATED BOVINE MORTALITY FROM VAMPIRE BAT TRANSMITTED PARALYTIC RABIES, VALUE PER HEAD IN 1974-1975 AND ESTIMATED ECONOMIC ANNUAL LOSS OF CATTLE

Country	Estimated Annual Mortality a)	Value per Head Import	Value per Head Export	Estimated Value of Annual Loss g)
				($U.S.)
Argentina	50,000	$1,400	$ 600	30,000,000
Belize	2,000	600	200	400,000
Bolivia	50,000	110	313	5,500,000
Brazil	200,000	320	360	64,000,000
Colombia	50,000	2,040	190	9,500,000
Costa Rica	10,000	1,450	490	4,900,000
Ecuador	5,000	1,110	550	2,750,000
El Salvador	3,000	200	53	159,000
French Guiana	1,000	770	(d)	770,000
Guatamala	12,000	1,250	155	1,860,000
Guyana	3,000	237 c)	121 d)	363,000
Honduras	6,000	770	150	900,000
Mexico	90,000	601	200	18,000,000
Nicaragua	10,000	1,000	55	550,000
Panama	8,000	1,080	700	5,600,000
Paraguay	5,000	380	90	450,000
Surinam	2,000	302	e)	604,000
Trinidad	500	1,140	960	480,000
Uruguay	2,000	5,990	156	310,000
Venezuela	5,000	210	e)	1,050,000
USA	-0-	207	468	-0-
Peru	b)	230	170 f)	b)
TOTAL	514,500	---	---	$148,146,000

a) Acha, 1967
b) No data indicated by Acha on deaths to paralytic rabies
c) 1973 price FAO, Trade Yearbook
d) 1972 price FAO, Trade Yearbook
e) No data, indicating neglible exports. Venezuela had imports of 155,000 head per year in 1974
f) 1971 price FAO, Trade Yearbook
g) Export or import price per head (whichever was lower) times estimated annual mortality

government spent $482,400 (U.S.) in four years or $120,600 each year to save 209 head annually. Thus, the cost per head saved was $577. The market value of a bovine saved from paralytic rabies was $150.[1)]

A proxy for the value of meat and milk production not lost after diphacinone control was $11,400 for each head saved from paralytic rabies. This was found by dividing the economic benefits in the first year following control of $2,382,770 from increased milk and meat production, by the estimated annual number of head which died from paralytic rabies before control, i.e., 209 head.

The "equivalent" per head economic loss of meat and milk production without control would equal $11,400, while the loss of one head from paralytic rabies is an immediate loss of $150. Thus the estimated loss to production of meat and milk in the other Latin American countries is estimated to be 76 times greater than the immediate loss to paralytic rabies (11,400 ÷ 150 = 76). This study did not consider the cost of maintaining the animal during ten years of production. The proxy for economic loss of meat and milk production in the specified countries of Central and South America listed in Table 21 was found by multiplying the economic loss from deaths due to paralytic rabies by the factor of 76.

Accumulated benefits over a ten year period, shown in Table 21 (Column 3), were calculated by multiplying the sum of the figures in columns 1 and 2 by the factor of 6.8. The explanation for this factor is presented on pages 58-59. The total accumulated potential benefits projected for the Latin American countries shown in Table 21 are $77,572.1 million (U.S.). The estimated costs of diphacinone control (Column 4 in Table 21) were computed by multiplying the number of annual deaths (Table 20) by $577. The explanation of how this figure was derived is presented on page 77. The total estimated costs of diphacinone control for these countries are $297.2 million (U.S.).

We realize it is quite different to project potential costs and benefits instead of comparing actual costs and benefits. The true evaluation of the benefits realized from diphacinone control of vampire bats must come from realized application of the USAID/DWRC research. At this point, we have scraped the barrel for more data, but have dim hopes of finding any.

[1)] The average value per head was computed based on the mix of beef and dairy animals in the herd. Beef represented 63.6% and dairy 36.4% of the total numbers. Thus, .636 x $128 =$81.40 for the beef share and .364 x $189 = $68.80 for the dairy share. The total value is $150.20, rounded to $150 (U.S.).

Table 21: ESTIMATED BENEFITS FROM VAMPIRE BAT CONTROL ACCUMULATED FOR 10 YEARS FOLLOWING CONTROL, AND ESTIMATED COSTS OF VAMPIRE BAT CONTROL IN SPECIFIED LATIN AMERICAN COUNTRIES

Country	Initial Year after Control: Decreased Bovine Mortality[a]	Initial Year after Control: Decreased Production Loss[b]	Accumulated Benefits in Ten Years[c]	Estimated Costs of Diphacinone Control[d]
	$ million (U.S.)			
Argentina	$ 30.0	$ 2,280.0	$ 15,708.0	$ 28.9
Belize	0.4	30.4	209.4	1.2
Bolivia	5.5	418.0	2,879.8	28.9
Brazil	64.0	4,864.0	33,510.4	115.4
Colombia	9.5	722.0	4,974.2	28.9
Costa Rica	4.9	372.4	2,565.6	5.8
Ecuador	2.8	209.0	1,440.2	2.9
El Salvador	0.2	12.1	83.6	1.7
French Guiana	0.8	58.5	403.2	0.6
Guatemala	1.9	141.4	974.4	6.9
Guyana	0.4	27.6	190.4	1.7
Honduras	0.9	68.4	471.2	3.5
Mexico	18.0	1,368.0	9,424.8	51.9
Nicaragua	.6	41.8	288.3	5.8
Panama	5.6	425.6	2,932.2	4.6
Paraguay	0.5	34.2	236.0	2.9
Peru	Data Not Available			
Surinan	0.6	45.9	316.2	1.2
Trinidad	0.5	36.5	251.6	0.3
Uruguay	0.3	23.6	162.5	1.2
Venezuela	1.1	79.8	550.1	2.9
TOTAL	$ 148.1	$ 11,259.2	$ 77,572.1	$ 297.2

a) Data calculated in Table 20, p. 76.
b) Figures obtained by multiplying figures in column 4 of Table 20 by factor of 76. See text for explanation.
c) Obtained by multiplying the sum of Columns 1 and 2 by 6.8
d) Obtained by multiplying annual cattle deaths from Table 20 by $577 (U.S.). See pages 75 and 77 for explanation.

A recommendation comes from this predicament: that funds invested in vampire bat control, tetse fly control, etc., should be appropriated after an economic justification is produced of the harm caused by the pest and the extent to which control will actually be implemented. The scarcity of data on diphacinone control work, benefits and costs is due to the fact that little implementation of the diphacinone control method has occurred other than in Nicaragua. The existence of a control method is no justification that it has been used. The sale of Difenadione and Velsicol should be recorded. Perhaps the administration of the diphacinone should have been through the AID offices or PAHO's offices, or in some other way, so records could be kept.

We can develop ways of measuring the physical loss from pest molestation. Perhaps sales of the control substance or the quantity manufactured could be recorded. The real stickler is the effect that results when the control is applied. We are unable to get a very exact handle on that aspect, so have had to rely on estimates.

The reader also may question the extent of time over which the return is computed. In this study, the situation after 1 and 10 years was estimated. The benefits could continue for many years, perhaps till infinity if control was 100 percent effective.

The situation in which an agency finds itself when it must present a benefit-cost ratio automatically sets up a barrier to work in developing countries with poor or nonexistent accounting systems. Benefits and costs must be approached from the direction of the engineering method, simulation and modeling. Actually, if records already had been kept in the developing country, the necessity as shown by the benefit-cost ratio would long ago have motivated national research and implementation, such that AID would be without a job.

SUMMARY

The overall objective of the vampire bat control program was to reduce the economic loss and improve the social well-being of cattleowners in Latin American countries without decreasing the quality of the environment. This study represents the first socioeconomic evaluation of diphacinone vampire bat control.

The comparative environmental impacts by diphacinone control methods versus alternative control methods were evaluated in this study by means of an environmental impact matrix comparing diphacinone control methods and alternative control methods.

An indexing system and a weighting scale were used to compare various subparameters under economic, environmental quality, and social well-being impacts. The data for the evaluation were obtained in surveys in Nicaragua of 178 cattleowners, civic leaders of 17 small rural towns, medical personnel of 19 rural health facilities and five livestock marketing businessmen. Vampire bat control program personnel of Colombia, Nicaragua, Panama, Trinidad and Venezuela also were consulted to determine progress and efficiency of the control programs of the respective countries.

The estimation of diphacinone control effectiveness and extent and type of implementation in Latin America was based on published literature. Production loss and livestock deaths due to vampire bat feeding and transmission of paralytic rabies were estimated from cattleowner observations. Control data were gathered from cattleowners, government control program agencies, the Denver Wildlife Research Center and the United States Agency for International Development.

The junior author of this study and a Nicaraguan University agricultural student interviewed 117 cattleowners or ranch foremen whose herds had received diphacinone control treatment (participants) and 61 cattleowners whose cattle had not received treatment (Table 2). There were from 1 to 10 head in 43 small sized herds, 11 to 100 head in 69 intermediate sized herds and more than 101 head in the 66 large herds. The nonparticipants,

who were interviewed to obtain data on indirect effects of control, all lived within 15 kilometers of the participant cattleowners interviewed.

Economic Impacts

A decrease in production loss and the number of fresh vampire bat bites due to treatment of neighboring herds was noted on four percent (seven) of the 168 sample ranch/farms. However, only 24 of 58 nonparticipants were aware that control was conducted in their area.

A study of the vampire bat problem along the routes where control had been done by the Nicaraguan Ministry of Agriculture 3½ years after diphacinone control had begun indicated that the cattle on only 55 of 66 ranches were observed to be free of fresh vampire bat bites. There were 30 cases of secondary wound infestation (myiasis) observed in five participant herds greater than 100 head and in two nonparticipant herds with from 11 to 100 head.

The loss of weight and/or production due to fly larval infestation of feeding wounds opened by vampire bats was not distinguishable as a separate physical loss. Rather the loss was assumed included in the general physical loss estimated by the cattleowner.

There were 170 cattle reported killed by vampire bat-borne paralytic rabies between 1970-1978 on the 178 ranches of the sample, of which 105 occurred prior to control in diphacinone treated herds and 65 occurred in nontreated herds. There was one bovine death in 89 head per year in participant herds and one in 36 head per year in nontreated herds. Three of the deaths occurred in small sized herds, 46 on intermediate sized and 121 on large sized herds. The rabies virus killed 146 beef type cattle and 24 dairy cows. Assuming a mortality rate of 0.28 percent in all herds treated in the program, the annual mortality among treated herds was 209 animals. Given a value per head for beef cattle of $128 (U.S.) and for dairy cows of $189 (U.S.), the annual precontrol economic loss was $31.388 (U.S.).

An estimated annual loss of beef production of 44.5 kilograms per year on bitten animals was reported by 27 participant cattleowners in the sample. The estimated loss of milk production was 69 gallons per year based on 28 observations by participant cattleowners. Corresponding averages of estimates by nonparticipants of 18 beef and 12 dairy herds were 24 kilograms and 32 gallons, respectively.

Assuming as many beef cattle (77,800) lost the estimated annual average of 44 kilograms prior to control as were observed bitten (see Tables 3 and 4), the estimated annual loss of beef production prior to diphacinone control was 3.4 million kilograms of beef. The estimated 45,240 dairy cows observed bitten prior to control would have suffered an annual loss of 3.1 million gallons of milk. With milk in Nicaragua priced in 1978 at $.40 (U.S.) per gallon and beef at $.41 (U.S.) per kilogram (live weight) the economic losses per year prior to diphacinone control implementation were an estimated $1,387,940 (U.S.) from beef and $1,230,480 (U.S.) from milk. Because diphacinone control had an observed effectiveness of 91 percent, the estimated decrease in loss attributable to application of diphacinone methods was $1,263,030 (U.S.) in beef production and $1,119,740 (U.S.) in milk production. These two benefits (not including reduction in death losses) total $2,382,770 (U.S.).

Nicaraguan cattleowners contributed to the control effort an estimated $6,500 (U.S.) in labor and time, corral facilities and loss of livestock (due to a very few cases of improper diphacinone application). The Nicaraguan Ministry of Agriculture expended an estimated $482,400 (U.S.) for the four-year control program. The cost of research and development allocated to the Nicaraguan effort was estimated to be $30,100 (U.S.). The estimated total cost of injecting 148,142 cattle and capturing and treating of 2,696 vampire bats in Nicaragua from 1974-1977 was $519,000 (U.S.). The annual costs were estimated to be $129,750 ($519,000 ÷ 4 years).

The economic loss of cattle to vampire bat transmitted paralytic rabies in the first year following control decreased from $31,388 (U.S.) (209 head) to zero in the 1,918 herds treated. The annual loss in production of beef and milk due to vampire bat feeding and harrassment was reduced by $2,382,770 (U.S.) in the year following control. Thus, the total annual benefits of the vampire bat control program in Nicaragua are an estimated $2,414,158. A comparison of the benefits and costs results in a benefit-cost ratio of 18.61 ($2,414,158 annual benefits ÷ $129,750 annual costs).

The decrease in loss over the 10 year effective length of control impact was estimated to be $15.4 million (U.S.) The estimated net benefits of control to the Nicaraguan cattle industry after cost were $15.9 million (U.S.). The owners of the 176 small sized herds received $49,249 (0.3 percent) the 981 owners of the intermediate sized herds received $3,710,078 (22.6 percent) and, the 761 owners of herds larger than 101 head received $12,656,947 (77.1 percent).

Social Well-Being Impacts

The control of vampire bats by the use of diphacinone methods slightly reduced the number of people afraid of being bitten by the vampire. However, the very process of control alerted people for the first time to the danger of being bitten and contacting rabies. The overall effect was a very slight increase (from 74 percent to 75 percent) in the people not afraid of being bitten by vampire bats after the control program was implemented. Alternatively, 25 percent of the people were afraid of being bitten by vampire bats, even after the control program.

Actual cases of bat bite and treatment of people for rabies after being bitten decreased from 48 treated and 17 untreated cases in 1973 to an annual average of seven treated cases and one untreated case after control. The treated cases were reported in the surveys. No estimate was made on the number of people nationwide who might have been bitten and who were not treated.

The estimated benefits to the cattleowners were distributed 0.3 percent to owners of small herds ($280 per herd) 22.6 percent to owners of intermediate herds ($3,782 per herd), and 77.1 percent ($16,632 per herd) to large herd owners. The distribution on the basis of head of cattle owned was extremely in favor of the owners of large herds. No estimate was made of the benefits distributed to rural nonfarm people.

Environmental Quality Impacts

The use of diphacinone methods in the control of vampire bats had overall positive impact on environmental quality. Few observations have been recorded concerning the environmental impact of diphacinone control of vampire bats. The environmental impact was approximated from published data.

Diphacinone methods are extremely species specific and cause zero harm to nontarget wildlife habitat. Biological equilibrium is positively affected when vampire bats feeding on man-introduced species is sharply reduced. Air and water quality is not harmed by the proper use of diphacinone. Food quality might be harmed if animals systemically treated are slaughtered too

soon after treatment; however, if proper procedures are followed, there should be no adverse effect on food quality from the use of the systemic method of diphacinone control.

Environmental Impact Matrix

The overall average of the economic, social well-being and environmental quality impacts of the diphacinone control strategy was positive (+53); the overall impact of the alternative control strategies was negative (-11). Thus, diphacinone control is the preferred strategy. All three major parameters for the diphacinone strategy were positive. The economic impact of the alternative control strategies was zero; the social well-being and environmental impacts were negative. No magnitudes of absolute impact were estimated.

Conclusions and Recommendations

Diphacinone control methods for vampire bats are very effective. The overall impact is favorable, with no negative aspects other than the income distribution aspect among small producers, and a potential hazard to food quality should the chemical be misapplied. However, even if total income distribution benefits are relatively small for the very small farmers (1-10 head of cattle), if vampire bats are controlled and one or two head of their herds are saved, the positive net income impacts are significant for those small farmers.

Considerable more and better research needs to be done on the actual physical loss attributable to vampire bat feeding, harrassment and resulting secondary infestations. The method employed in this evaluation, requesting opinions on observed physical production loss is an indication that more scientific research is needed.

A more effective study of a pest control program in a Lesser Developed Country will have to find more complete data sets with which to work. Data sets in turn will be kept in better detail when a value for the data can be shown to those personnel involved in the program. Dairymen and ranchers are the front line of the record-keeping force; however, given the low state

of management art, only a few of the better operations logically could be expected to keep good records. For the poorly managed farms, an outside agent or consultant would need to be employed to assist in the record-keeping of several farm-firms.

The distribution of benefits is skewed in favor of those persons with large herds. In the Nicaraguan control program experience, 76 percent of the cattle were owned by ranches with large herds. A more equal distribution of benefits would necessitate a decisive effort on the part of control program personnel to seek out and treat more of the livestock on small farms. This would be very costly in terms of both personnel and travel time, due to the distances, small size of treatment herds, and conditions of roads.

This study concentrated on the control of vampire bats through governmentally controlled and financed programs. No data were available on the use of diphacinone by private veterinarians or individual ranchers. Fear of contamination of non vampire bat species and the customary methods of allocating new technology in LDC's, precluded the method of diphacinone utilization. Given the state of the infrastructure of agribusiness in LDC's, future technology may well be expected to follow a pattern of distribution similar to that seen in this analysis of vampire bat control.

This study of the development and testing of a pest control method by the DWRC indicates the tremendous scientific ability of the United States. However, the social well-being aspects, as shown via the environmental impact matrix, are still beyond the grasp of present foreign aid methods and means. The cooperation of the national government is the key to technology transfer effectiveness. The equality of distribution within-country will be dictated by sociological conditions and types of agencies associated with foreign assistance programs. More equal distribution of benefits within a country can be accomplished by working with agencies which cut across the grain of the traditional class hierarchy.

Government agency personnel in developing countries have yet to learn the value of keeping records. The urgency of this suggestion is brought out by the fact that the $100,000 (U.S.) plus per year vampire bat control operation in Nicaragua was not recorded as a separate agency operation after the first of four years of control. The records were lumped together with the financial activity of five different control programs.

If the Agency for International Development (AID) wishes to evaluate pest control operations, it should improve the system of recording the money spent in each specific pest control operation. Data obtained on funds allotted to vampire bat control in Bolivia and Colombia could not be confirmed by AID/Washington Agency officials. Rumors in Nicaragua on the monetary role of AID in pest control in that country could not be substantiated by available records. Data on funds expended by the DWRC in the research and development of the Vampire Bat Control Program were not available from AID; however, these data were graciously provided by the DWRC staff. To provide a project-by-project accounting of pest control progress, the accounting system of AID must be improved.

Economic aspects of pest control must be considered before major portions of research and development funds are spent. The effects on the various environmental parameters as presented in this analysis might serve as a basis for pest control planners. Good data by The Denver Wildlife Research Center on the physiological reactions to the control methods were noted. The key issue is what additional data would need to be obtained to make an economic analysis of the technological data. This aspect of the analysis obviously should be planned previous to initiation of the experiment and should be carried through parallel to the research and development operation. While the technological aspects of pest control are being worked out, other disciplines could be employed concurrently in researching the economic and social implications of the various control strategies.

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Appendix I: URBAN AND RURAL POPULATIONS OF POLITICAL DIVISIONS IN WHICH THE VAMPIRE BAT CONTROL PROGRAM WAS IMPLEMENTED IN NICARAGUA, 1974-1975

Department and Municipality	Urban	Rural	Total
Boaco			
Boaco	6,443	13,055	19,498
Camoapa	4,485	11,074	15,559
Las Banderas	---	---	---
San Jose de los Remates	842	3,904	4,746
San Lorenzo	2,102	9,877	11,979
Santa Lucia	727	4,305	5,032
Teustepe	991	11,382	12,373
Carazo			
Concepcion	---	---	---
Diriamba	10,151	15,424	25,575
Dolores	1,230	418	1,648
Jinotepe	12,461	5,651	18,112
La Conquista	537	2,323	2,860
La Paz Oriente	922	843	1,765
La Trinidad	---	---	---
Santa Teresa	2,800	6,537	9,337
Chontales			
Acoyapa	2,853	4,030	6,883
Juigalpa	8,772	9,137	17,909
Libertad	1,361	8,190	9,551
Santo Tomas	2,220	4,597	6,917
Santo Domingo	1,649	5,757	7,406
Villa Somoza	1,473	8,716	10,189
Comalapa	512	4,546	5,058
Granada			
Diriomo	3,621	5,289	8,910
Granada	35,422	9,031	44,453
Nandaime	5,677	8,862	14,539
Diria	1,939	1,261	3,200
Managua			
Chiquilestaragua			
El Carmen	791	6,025	6,816
La Trinidad	---	---	---
Las Banderas			
Managua	375,278	45,786	421,064
San Francisco del Carnicero	685	5,491	6,176
San Rafael del Sur	2,896	15,598	18,494
Tipitapa	5,674	14,641	20,315

Appendix I (continued)

Department and Municipality	Urban	Rural	Total
Masaya			
Cofradia	---	---	---
Los Saltos	---	---	---
Masatepe	7,181	5,409	12,590
Masaya	30,796	14,378	45,174
Nindiri	2,148	6,094	8,242
San Andres	---	---	---
Tisma	1,588	1,235	2,823
Veracruz	---	---	---
Matagalpa			
Ciudad Dario	5,708	17,133	22,841
Esquipulas	2,264	4,874	7,138
El Tuerca	---	---	---
Matagalpa	20,682	39,643	60,325
Muy Muy	1,632	3,981	5,613
San Ramon	595	13,928	14,523
Terrabona	933	7,690	8,623
Sebaco	3,200	6,253	9,453
Rivas			
Altagracia	1,521	5,830	7,351
Escalante	---	---	---
La Virgin	---	---	---
Omatepe (la isla)	---	---	---
Rivas	10,007	10,605	20,612
San Juan del Sur	2,432	4,459	6,891
San Jorge	2,895	1,233	4,128
Sapoa	---	---	---
Tola	987	9,059	10,046

APPENDIX II:

ELABORADO CON DATOS DEL
PROPIETARIO ___ MANDADOR____
FECHA _____

No. de Encuesta _____

EVALUACION DEL PROGRAMA DE CONTROL DE VAMPIROS EN NICARAGUA
POR EL DEPARTAMENTO DE ECONOMIA AGRICOLA DE LA
UNIVERSIDAD DEL ESTADO DE OKLAHOMA EN COOPERACION CON EL
MINISTERIO DE AGRICULTURA Y GANADERIA DE NICARAGUA Y AID

INFORMACION GENERAL

1. Nombre del Ganadero_____ Nombre de la Finca_____
2. Municipio o localidad_____ Departamento_____
3. Edad del Ganadero_____años Casado? Si____ No____ Número de hijos _____
4. Cuantas personas (Incluyendo no Familiares) viven en esta hacienda? _____

INFORMACION SOBRE LA HACIENDA

5. Tamaño de la hacienda_____ Manzanas propias _____ Manzanas Alquiladas_____ Otras _____
6. Años de experiencia en ganaderia _____
7. Principal actividad a que se dedica esta hacienda; Ganaderia_____ Agricola _____
   Ingreso por trabajo fuera de la hacienda _____ Otros ingresos _____
8. Número de cada tipo de ganado; Ganado de carne_____ Caballos _____ Bueyes _____
   Ganado de leche_____ Porcinos _____ Pollos _____
9. Usa Ud. los servicios de veterinaria? Sí____ No____ Cuales usa? _____
10. A qué distancia de la hacienda se encuentra el veterinario? _____ kilómetros
11. Posee Ud. algún instrumento (herramienta) de veterinario? Sí ___ No____; Si posee, cuales_____
12. Usa Ud. los servicios de los extensionistas del MAG? Si ____ No_____
    Si los usa, cuales son? Brucelosis_____ Inseminación artificial_____ Vampiros_____ Otros_____
13. Instalaciones para ganado; Corrales (Tamaño) ___X ____ Varas; Manga Sí____ No____ Bañadero Sí____ No_____
    Cepo Si ___ No ___ Galera Si ___ No ___

INFORMACION SOBRE LA SITUACION DE LOS VAMPIROS EN LA HACIENDA

14. Experiencia de la familia con vampiros;

a. Algún miembro de su familia ha sido mordido por vampiros? Sí___ No___ Cuándo? _____ Quién? _____

b. Tiene temor su familia de ser mordida por vampiros? Sí ____ No_____

15.

Tipo de Ganado	Variación Estacional de las Mordeduras Verano	Invierno	Año	Promedio de Mordeduras Diarias en el Hato
Ganado de Carne	_____	_____	___	_____
Ganado de Leche	_____	_____	___	_____
Caballos	_____	_____	___	_____
Bueyes	_____	_____	___	_____
Porcinos	_____	_____	___	_____
Aves (pollos y otros)	_____	_____	___	_____

16. Número de pérdidas (muertes) ocasionadas por las morderuras de vampiros

Tipo de Ganado	Rabia Paralítica	Otras Infecciones
Ganado de Carne	_____	_____
Ganado de Leche	_____	_____
Bueyes	_____	_____
Caballos	_____	_____
Porcinos	_____	_____
Aves (ponedoras)	_____	_____

17. En su opinión, cual ha sido la pérdida física por animal debido a las mordeduras de vampiros?

_____	Peso por año
_____	Litros por día
_____	Peso por año o días de trabajo
_____	Peso por año o días de trabajo
_____	Peso por año
_____	huevos por año

APPENDIX II: (Continued)

INFORMACION SOBRE PARTICIPACION EN EL PROGRAMA DE CONTROL DE VAMPIROS (PVC)

18. ?Ha participado Ud. en el PCV? Sí____ No____; Si ha participado, ?Cuando?_____?Como se enteró del PCV? _____ Se usó el método tópico o sistémico _____

19. ?Han participado también sus vecinos? Sí___ No____ si han participado, ?viven cerca o viven lejos_____

20. ?Que número de su ganado fué tratado? _____

21. ?Se aplicó algún otro tratamiento a su ganado durante el tratamiento del PCV? Sí__ No___ Si así fue, que tratamiento? _____

22. ?Quien trató a su ganado? Veterinarios locales? Sí____ No___ Personal del MAG Sí___ No____

23. Fué necesario contruir corrales, mangas, cepos, etc. para poder tratar su ganado contra mordidas de vampiros? SI___ No_____; Sí así fué, explicar _____

24. Se capturarón y se trataron vampiros en su finca? Sí___ No_____? Si así fué, cuando? _____

25. Que otro método usó usted para evitar o reducir la incidencia de mordeduras antes que se presentara el Progama de Control de Vampiros por MAG? (Expliquese)_____

RESULTADOS Y BENEFICIOS DE LA PARTICIPACION EN EL PCV

26. Después del tratamiento (tópico) de los vampiros, ?hubo alguna reducción apreciable en el número de mordeduras? Sí ___ No____; ?alguna producción de muertes causadas por rabia paralítica? Sí___ No___; Número_____; %____

27. Después del tratamiento del ganado contra vampiros ?hubo menos mordidas? Sí___ No___ ?Hubo alguna reducción en el número de muertes causadas por rabia paralítica? Sí ___ No____ Número _____

28. ?Que beneficios económicos ha obtenido Ud. del Programa de Control de Vampiros?

a. ?Mayor venta de ganado a causa de reducción de rabia paralítica? Sí___ No___ si así fué, ?Cuanto más se ha vendido? _____

b. ?Más peso por cada cabeza vendido? Sí___ No___ Cuanta más peso por cabeza?_____

c. ?Mayor producción de leche? Sí___ No____; si así fué, ?Cuanto más?_____

d. ?Se ha apreciado alguna reducción en infecciones secundarias? (Gusanera, inflamaciónes, etc) Sí___ No____

e. ?Otros beneficios? Explicar_____

_____

29. Cual fué el costo y el tiempo utilizado en el tratamiento de ganado?

a. Cuanto pagó para cada tratamiento? C$_____ por cabeza

b. Cuanto tiempo se gastó en reunir y movilizar el ganado para tratarlos? _____ horas

c. Otros gastos incurridos _____

30. Tenia algunos problemas con mordeduras en su ganado después del tratamiento intraruminal? Sí__ No___

Si las notó, cuanto tiempo después del tratamiento se notaron?_____ días

Si las notó, que hizo sobre este nuevo problema? _____

31. Experimentó Ud. algún efecto negativo por haber participado en el Programa del Control de Vampiros? Sí___ No___

Si así fué, expliquese; _____

G. FUTURO DEL PROGRAMA- Participantes y No-participantes

32. Cree Ud. que debería ser obligatorio la participación en el Programa de Control de Vampiros? Sí____ No____

33. Si el Tratamiento de Vampiros hubiera sido por Tecnicos particulares, cuanto cree Ud. que le hubiera cobrado (si se usó el metodo sistemico, cuanto por cabeza)? _____ Estaría Ud. dispuesta a pagar el tratamiento de su ganado? Sí____ No_____

34. ?Ha participado Ud. en otros programas del MAG anteriormente al PCV? Sí___ No___; si así fué ?Qué beneficios recibió?_____

35. ?Ha participado Ud. en otros programas después del PCV? Sí____ No____ Si así fué, ?que beneficios recibió?____
_____

36. Participaría Ud. en futuros programas del MAG? Sí___ No___ Explicar _____

37. Comentarios generales _____
_____

INFORMACION SOBRE NO-PARTICIPANTES

38. Razones de la no-participación

a. No se han observado problemas con vampiros Sí_____ No____

b. El ganado se encuentra muy lejos de los centros de tratamiento? Sí___ No____

c. Inadecuadas instalaciones para el ganado; Sí___ No___

d. Desconfianza en el tratamiento; Sí___ No___

e. Alto costo del tratamiento; Sí___ No____

f. Desconocimiento del programa de tratamiento; Sí___ No____

g. Otros _____

39. ?Han participado sus vecinos en el Programa de Control de Vampiros? Sí___ No___; si así fué, marcar cerca o lejas?

40. Si los vecinos han participado en el PCV, han notado Ud. algunas mejoras en su ganado? Sí____ No____

a. Menos mordidas en su ganado? Sí___ No____ Comentarios_____

b. Mayor producción de leche? Sí____ No_____ Comentarios_____

c. Más peso obtenido en el ganado de carne? Sí____ No____ Comentarios _____

d. Menos temor a los vampiros? Sí No Comentarios _____

41. En su opinión, ?Cuales han sido los beneficios recibidos del programa de Control de Vampiros? _____
_____

Abril 12, 1978
DDB/KMS/BG

APPENDIX III

EVALUACION DEL PROGRAMA DE CONTROL DE VAMPIROS
EN NICARAGUA POR LA UNIVERSIDAD DEL ESTADO DE OKLAHOMA,
EL MINISTERIO DE AGRICULTURA Y GANADERIA Y AID

Encuesta Medica No. ____
Fecha _____

A. INFORMACION GENERAL

1. Municipio _____ Departamento _____

   Poblacion urbana _____ Poblacion rural _____

2. Nombre del centro de salud entrevistado _____

3. Nombre de la persona entrevistada _____

4. Desde cuando ha trabajado en este centro de salud? _____

B. INFORMACION SOBRE VAMPIROS EN EL AREA

5. Han tenido algun caso concerniente a vampiros en este centro de salud? Si ___ No ___

6. Historia de los Casos de Personas Mordidas

Numero de casos	Cuando Ocurrieron	Donde Ocurrieron	Severidad de los casos	Tratamiento	Comentarios

APPENDIX III (continued)

C. INFORMACION ECONOMICO DEL TRATAMIENTO HUMANO

7. Costo del tratamiento para casos relacionados con mordidas de vampiros en humanos;

a) Rabia: C$ _____ por tratamiento

Numero de tratamientos por individuo _____

Numero de individuos tratados _____

b) Otros tratamientos; _____; C$ _____ por tratamiento

Numero de individuos tratados _____

D. INFORMACION SOBRE ACTIDUDES

8. Cuan es la actitud de los habitantes de este pueblo sobre vampiros? _____

_____

9. Que medidas se han tomado para el control de los vampiros en este area? _____

_____

10. Informacion general _____

_____

Mayo 30, 1978
DDB/KMS/BG
Total de Copias; 20

Encuesta número _____

Encuesta de
Comunidades

Fecha _____

APPENDIX IV

EVALUACION DEL PROGRAMA DE CONTROL DE VAMPIROS EN NICARAGUA

POR

EL DEPARTAMENTO DE ECONOMIA AGRICOLA DE LA
UNIVERSIDAD DEL ESTADO DE OKLAHOMA
EN COOPERACION CON EL MINISTERIO DE AGRICULTURA
Y GANADERIA DE NICARAGUA Y LA MISION AID

A. INFORMACION GENERAL

1. Nombre de la persona entrevistada _____
2. OCUPACION _____
3. Nombre del pueblo: _____ Departamento _____
4. Hace cuanto tiempo vive usted en este lugar? _____ años
5. Trabajos anteriores _____

_____

_____

B. INFORMACION SOBRE LA SITUACION DE LOS VAMPIROS

6. Conoce Ud. cualquier problema que los habitantes de este pueblo hayan tenido con vampiros? Sí _____ No _____. Sí así es, explicar _____

_____

a) número de personas mordidas _____

b) consecuencias de haber sido mordidas _____

_____

c) ¿son los vampiros un problema en los hogares? Sí __ No __ Explicar _____

_____

d) ¿son los vampiros un problema en el mercado? Sí ___ No ___ Explicar ___

_____

e) ¿en otros lugares? Sí ___ No ___ Explicar _____

_____

APPENDIX IV (continued)

C. INFORMACION SOBRE LA PARTICIPACION DEL PUEBLO EN EL PROGRAMA DE CONTROL DE VAMPIROS

7. Conoce Ud. el Programa de Control de Vampiros del Ministerio de Agricultura y Ganadería? Sí____ No_____ Si así es, ¿conoce Ud. los resultados de los esfuerzos del programa? Sí____ No____ Explicar_____

_____

8. ¿Qué método fue empleado en el control de los vampiros?:

a) Inyectar al Ganado? Sí_____ No____

b) Tratar a las vampiros? Sí____ No_____

9. Comentarios Generales_____

_____

_____

10. ¿Estaría la gente de este pueblo dispuesta a colaborar monetariamente con un programa para la exterminacion de vampiros?

_____

_____

Appendix V.: TOWNS AND RESPECTIVE 1971 POPULATIONS WHEREIN A MEDICAL AND/OR TOWNSFOLK INTERVIEW WAS CONDUCTED, JUNE, 1978

Department; Town	Population a) Urban	Rural	Interview conducted for; Medical Survey	Townsfolk Survey
MANAGUA;				
Managua	375,278	45,786	xx	
Tipitapa	5,674	14,641	xx	xx
Zambrano	---	---		xx
MASAYA;				
Indiri	2,148	6,094	xx	xx
Tisma	1,588	1,235	xx	xx
CARAZO;				
Diriamba	10,151	15,424	xx	
Dolores	1,230	418	xx	xx
Jinotepe	12,461	5,651	xx	xx
Sta. Tetesa	2,800	6,537	xx	xx
GRANADA;				
Diria	1,939	1,261	xx	xx
Diriomo	3,621	5,289	xx	xx
RIVAS;				
Rivas	10,007	10,605	xx	
San Jorge	2,895	1,233		xx
Tola	987	9,059	xx	xx
BOACO;				
San Lorenzo	2,102	9,877	xx	xx
Teustepe	991	11,382	xx	xx
CHON TALES;				
Acoyapa	2,853	4,030	xx	xx
Juigalpa	8,772	9,137	xx(2)	
Sta. Tomas	2,320	4,597		xx
MATAGALPA;				
Ciudad Dario	5,708	17,133	xx	
Las Calabazas	---	---		xx
Sebaco	3,200	6,253	xx	
Terra Bona	933	7,690		xx

a) 1971 Census

Appendix VI : VAMPIRE BAT BITE SITUATION THREE AND ONE-HALF YEARS AFTER CONTROL PROGRAM WAS IMPLEMENTED ON RANCHES ON SPECIFIED ROUTES IN CENTRAL AND PACIFIC REGIONS OF NICARAGUA, 1977

Route	Ranches Visited	Cattle examined	Fresh Bites	With no Bites
Managua - Ticuantepe	33	625	115	9
Managua - San Lorenzo	33	3,854	429	5
Santa Rita - Monte Limar	56	11,850	1,721	1
Managua - Sabana Grande - Tipitapa	13	1,549	69	2
Managua - San Francisco del Carnicero	19	6,892	618	---
Tipitapa - Las Banderas - El Brazil	19	4,313	701	6
Tipitapa - El Hatillo- El Triumfo - San Juan - Tipitapa	13	7,266	479	1
Managua - Masachapa	64	6,133	962	2
San Benito - La Cuesta del Coyol	22	8,195	720	1
Subtotal	272	50,677	5,814	27
La Palma - Las Plazuelas; Tecolostote - El Pugito; Piedra Santa - Juigalpa; La Palma - Santo Tomas	162	49,868	no data	14
Juigalpa - La Palma - El Susto - Betania - San Pedro de Lovago - La Libertad - Santo Domingo	100	15,160	no data	12
Empalme Comalapa - Comalapa; Empalme Cuapas - Llano Grande; Empalme Cuapas Empalme Comalapa; Llano Grande - Cuapas - Llano Grande	127	24,331	no data	2
Subtotal	389	89,359	no data	28
TOTAL	661	140,036	incomplete	55

Source: Vampire Bat Control Program, Department of Animal Health, Ministerio de Agricultura y Ganaderia, La Calera, Managua, Nicaragua.