UNIFORMED SERVICES UNIVERSITY OF THE HEALTH SCIENCES
F. EDWARD HEBERT SCHOOL OF MEDICINE
4301 JONES BRIDGE ROAD
BETHESDA, MARYLAND 20814-4799

GRADUATE EDUCATION
(301) 295-3913
FAX: (301) 295-67772

APPROVAL SHEET

Title of Dissertation: "A Prevalence Study of Intestinal Parasites in Southern Belize"

Name of Candidate: Pote Aimpun
Doctor of Public Health
15 November 2000

Dissertation and Abstract Approved:

Donald Roberts, Ph.D. — 15 November 2000 (Date)
Department of Preventive Medicine and Biometrics
Committee Chairperson

John Cross, Ph.D. — 15 November 2000 (Date)
Department of Preventive Medicine and Biometrics
Committee Member

Patrick Carney, Ph.D. — 11/15/00 (Date)
Department of Preventive Medicine and Biometrics
Committee Member

Susan Langreth, Ph.D. — 15 Nov 2000 (Date)
Department of Microbiology and Immunology
Committee Member

Paul Hshieh, Ph.D. — 15 Nov. 2000 (Date)
Department of Preventive Medicine and Biometrics
Committee Member

COL Gary Gackstetter, USAF — 15 Nov 2000 (Date)
Department of Preven ive Medicine and Biometrics
Committee Member

The author hereby certifies that the use of any copyrighted material in the thesis manuscript entitled:

"A Prevalence Study of Intestinal Parasites in Southern Belize"

is appropriately acknowledged and, beyond brief excerpts, is with the permission of the copyright owner.

Pote Aimpun
Department of Preventive Medicine and Biometrics
Uniformed Services University of the Health Sciences

Abstract

Title of Dissertation: A prevalence of intestinal parasites in southern Belize

Pote Aimpun, Doctor of Public Health, 2000

Thesis directed by: John H. Cross, Ph.D., Professor,

Department of Preventive Medicine and Biometrics

A biomedical survey of stool specimens from 82% of the population (n=672) of 5 villages in Toledo District, Belize were examined by the formalin-ethyl acetate concentration technique for the prevalence of intestinal parasitic infections. Seventy-six percent of the population was infected. The most common infection was hookworm (55%), followed by *Ascaris lumbricoides* (30%), *Entamoeba coli* (21%), *Trichuris trichiura* (19%), *Giardia lamblia* (12%), and *Entamoeba histolytica* (6%). The mean age of infected persons was 19 years. The frequency of infections was higher in younger age groups. Females had higher prevalence of hookworm infection than males. The living conditions of 111 surveyed households were characterized as 60% with dirt floor, 43% without toilets, 35% in overcrowded living condition, 10% using stream water and 16% drinking untreated water. A cross-tabulation and logistic regression analysis was used to identify risk and protective factors of the parasites. The risk factors for intestinal parasites were

Mayan Ketchi [1.6(1,2.4)], houseworker [2.4(1.2,4.6)], and use of stream water [2.3(1.2,4.5)]. The protective factors were drinking treated water [0.4(0.2,0.9)], and wearing shoes [0.6(0.4,1)]. Prevention and control programs focusing on significant factors associated with parasite infections could save time and money by targeting populations by risk characteristics.

A Prevalence Study of Intestinal Parasite in southern Belize

By

Major Pote Aimpun

Dissertation submitted to the Faculty of the Department of Preventive Medicine and Biometrics Graduate Program of the Uniformed Services University of the Health Sciences in partial fulfillment of the requirements for the degree of Doctor of Public Health, 2000

Acknowledgements

Special thanks to Dr. John H. Cross for taking good care, invaluable advice and support during this study. My thanks are also to committee members (Dr. W. Patrick Carney, Dr. Donald R. Roberts, Dr. Paul B. Hshieh, and Dr. Susan Langreth) who reviewed my work and provided many recommendations. For supplies and logistics, I thank Ms. Tina Brackins and Ms. Maggie Pickerel for helping to ship items to the Malaria unit. I also thank Ms. Yvette Alonso and Miss. Aretha Hyde and USMLO, LTC. Rogelio Diaz, and Ms. Mary Mccullough who allowed me to put my supplies in their storage. While I was in Belize, I was helped by Dr. Jorge Polanco, Deputy Director of Health Services with points of contact and permission to do this study. Colonel Dr. Peter Craig, the Belize Defense Force medical doctor arranged for my accommodation at Rideau Camp in Punta Gorda. Major Boran, the commandant of the camp allowed me to stay and have meals with them and also provided Medic, Corporal Navaro, to help me with this survey. In Punta Gorda, Mr. Manga, a health educator, introduced me to villagers at Golden Stream, Medina Bank, San Marcos, Bladden, and Tambran. In the villages, I was assisted by Mr. Ignacio Sho, Mr. Benedicto Chun, Miss. Manuela Tzub. These individuals helped me communicate with all the villagers.

To all individuals listed above I express my sincere thanks. I also thank HM2. Kenny Stone who helped me with some samples while I was working in the parasitology lab. Finally, I thank all the Belizian people who participated in this study and provided me their stool specimens and I thank members of the Preventive and Biometrics and the USUSH family who supported me during my stay at USUHS. Last, my thanks are second to none for my parents, who support and encourage me all the time.

Table of Content

Content **Page**

List of tables

List of figures

Figure	Name of figure	Page

Figure	Name of figure	Page

Introduction

Intestinal parasitoses are the most common group of parasitic diseases infecting the human population worldwide. The number of people infected is currently estimated to be over two billion (Smith, 1998). Although the prevalence of intestinal parasitic infections varies markedly, even in developing countries, they are the most common diseases of humans in Africa, Asia and Latin America (Pawlowski, 1984).

The human is a habitat of 399 species of parasites (Ashford and Crewe, 1998). Three hundred and forty-two are helminths and, of these, 197 species are reported to live in the alimentary tract (Crompton, 1999). About 50 species of worms commonly infect humans worldwide (Garcia and Bruckner, 1997).

Intestinal parasites of humans are a very diverse group of animals, ranging from single celled protozoans to multicellular worms that inhabit the gastrointestinal tract. Infections vary clinically from asymtomatic to symtomatic, that can cause a myriad of conditions including dysentery and life-threatening anemia.

In 1947, an estimated 1,367 million or 62% of the world's population were infected with one or more species of helminthic parasites. Of those, 460 million persons were infected with hookworm, 650 million with *Ascaris lumbricoides*, 355 million with *Trichuris trichiura*, and 200 million with *Schistosoma spp.* (Stoll, 1947). By 1994, the estimated number of intestinal parasitic infections had increased. There were an estimated 1,050 million persons with hookworms, 1,470 million with *A. lumbricoides* and 1.3 million with *T. trichiura* (Chan *et al.*, 1994). More recently, Crompton (1999) estimated 4,457 million helminthic infections in the world population of 5,753 million individuals. Additionally, significant numbers of the world's population are infected with other helminths, not mentioned above.

In 1987, the World Health Organization (WHO) estimated that each year there were 3.5 million cases of clinical disease due to nematode infections. Most of these infections have public health consequences, such as causing nutritional deficiencies in school age children (Bundy *et al.*, 1992). An estimate by the World Bank in 1993 suggested that intestinal helminthic infections were a major source of morbidity in developing countries. For example, although a hookworm consumes a small amount of blood (Chitchang, 1982), the intensity of infections and prevalence rates are very high. On a daily basis an estimated 9 million liters of blood are lost as a result of hookworm infections (Plorde and Ramsey, 1991).

Many organs can be effected by spurious parasites infections including: eyes, brain, spinal cord, heart, vascular, lung, stomach, small and large intestine, liver, gall bladder, kidney, urinary bladder, skin, muscle, and bone (Muller, 1981). The pathology of a helminthic infection depends on its life cycle, the numbers of worms and general health of the patient.

Unfortunately, intestinal parasitic infections have had a low priority in public health programs of many developing countries (Ananthakrishnan *et al.*, 1997), and this remains one of the major unresolved public health problems in many parts of the world (WHO, 1981). Even though there are effective and inexpensive drugs for treatment of intestinal parasites (Anderson *et al.*, 1993), many prevention and control programs are not staffed with skilled diagnostic personnel and receive limited government support (Pawlowski, 1983).

Japan is the only country that successfully controlled and eradicated oriental schistosomiasis (Ebisawa, 1998; Tanaka and Tsuji, 1997). However, eradication was possible only after intensive research on the parasite's biology, lifecycle, intermediate hosts, environmental factors, human behavior, clinical aspects, treatment and understanding the epidemiology of the parasites. Once these factors were well understood, programs to prevent and control schistosomiasis were developed. Accurate information on intestinal parasitic infections and risk factors for infection (e.g., poor sanitary conditions, eating habits, contaminated food and water, inadequate education, low socioeconomic status) are needed to control and/or eradicate these parasites.

Recent surveys of Central America estimate 14 million people infected with intestinal parasites (Martin, 1998). In a 1993 survey in Guatemala, the prevalence of parasitic infections ranged from 11%-37% (Anderson, et al., 1993). In another study, the prevalence of *A. lumbricoides* ranged from 36%-74% and the prevalence of *T. trichiura* in school children was 88% (Watkins *et al.*, 1996). In Honduras, 96% of those surveyed were infected with at least one intestinal parasite (Sanchez *et al.*, 1997). In Mexico, mortality in 1993 due to infectious and parasitic diseases was estimated at 5.7% (WHO, 1996).

Information on intestinal parasitic infections in Belize populations is limited and dated. The only published study on the prevalence of intestinal parasites was conducted in the mid-1960s. It showed that 74% of those surveyed were infected with at least one intestinal parasite (Petana, 1968). In the 1980s, gastrointestinal infectious diseases, including intestinal parasites, were among the leading causes of death in Belize. In 1986, intestinal infectious diseases were the ninth leading cause of death, but in 1987, they were the seventh leading cause of death (Macedo, 1990).

Since there is a paucity of information on the prevalence of intestinal parasitosis in Belize, a stool survey was conducted to obtain a better understanding of the extent of the problem.

Background

Belize (17°15'N, 88°45'W) is geographically diverse. Nestled between Mexico to the north, Guatemala to the south and west, and the Caribbean to the east, the land area is slightly smaller than Massachusetts, only 22,800 km^2, making it the smallest country in Central America, (Figure 1). There are two distinct geographic areas. Most of northern Belize consists of lowland areas, with many swamps. The Maya Mountains are in the south where Victoria peak is the highest point (1,200 m) (CIA, 1999; Mahler and Wotkyn, 1995).

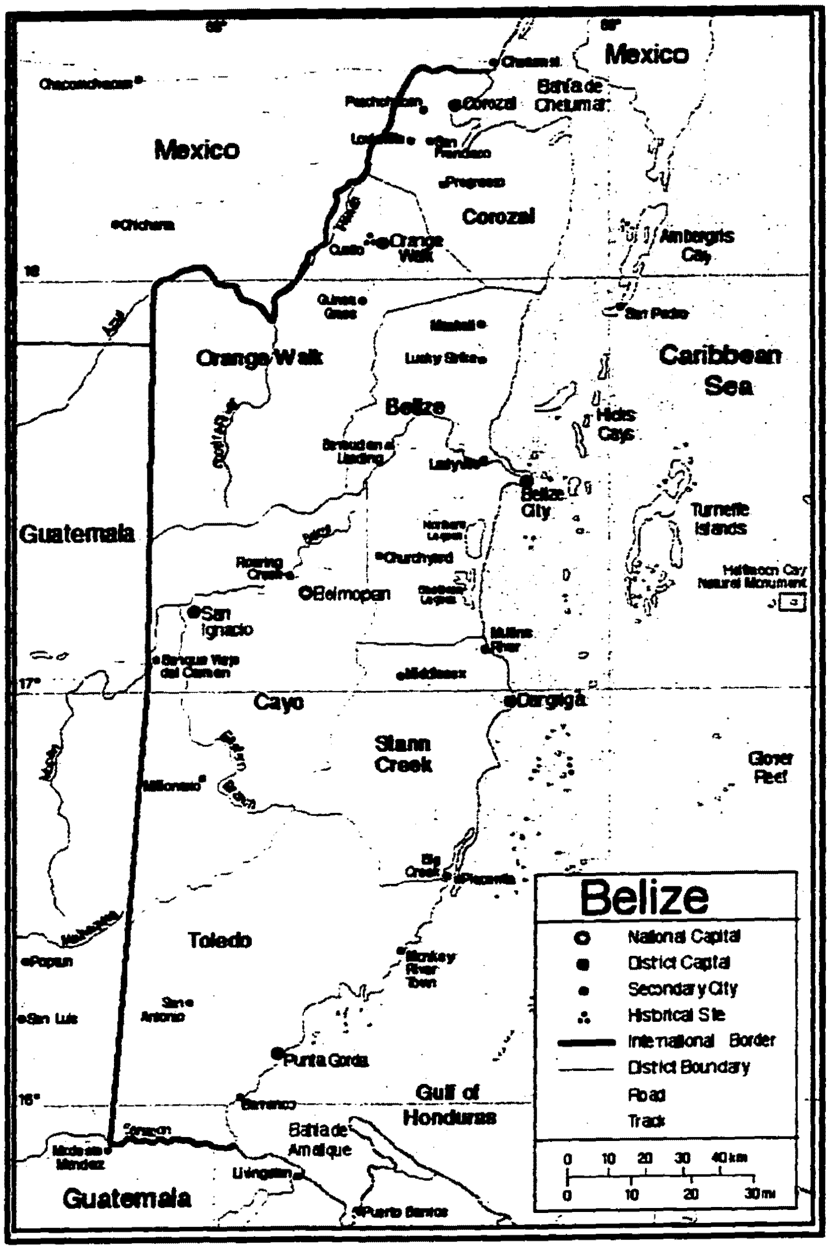

Figure 1.

Map of Belize

In 2000, the total population of Belize was estimated to be 249,183 (126,359 male and 122,824 female)(U.S. Census Bureau, 2000). There are four main ethnic groups: Mestizo (44%) of Spanish and Mayan origin; Creole (30%) of mixed African ancestry; Mayan (11%), the indigenous people of Belize; and the Garifuna (7%), the descendants of African slaves and Carib Indians. Ethnic groups are different between northern and southern areas. In the north, Mestizoes are the majority, while the Mayans prevail in the south (Black World, 1996; Library of Congress, 1992). This ethnic diversity has been shown to influence the disease prevalence in Belize. For example, in recent seroprevalence surveys of hepatitis B virus in Belize, rates of infection varied by ethnicity and geographic location, with the highest rate among the Mayan and Mestizo living in the southern districts. Furthermore, in the southern Stann Creek district, 10% of Mayan and Mestizo children had hematocrit levels below normal compared to 1.7% of the Creole and Garifuna (Chamberlin, 1995). These high rates of anemia warrant further investigation, as common and easily treated intestinal parasites (hookworm) are one of the major causes of iron deficiency anemia worldwide (Hilman, 1998).

Belize has the lowest population density (10.93 persons per km^2)(U.S. Census Bureau, 2000) of any countries in Central American countries. It has the highest literacy rate

(76%) and 60% attend compulsory school for 9 years (U.S. Department of State Beureau of Western Hemisphere Affairs, 2000). The intestinal parasitic infection rate is usually inversely proportional to the literacy rate (Virk *et al.*, 1994).

Belize has large immigrant populations from surrounding countries. Many studies have shown a high prevalence of intestinal parasites in those countries. One study showed 53% of U.S. immigrants from Central America have parasites of which 85% are considered pathogens (Salas *et al.*, 1990). It is reasonable to assume that Central American immigrants are importing their intestinal parasites into Belize.

Although the prevalence of intestinal parasitoses in Belize has not been determined, surveys done in surrounding countries suggest several species of intestinal parasites can be expected. The most likely species of intestinal parasites in Belize are listed in Table 1.

Table 1.

Potential intestinal parasites in Belize
(Ashcroft, 1965; Cross, 1998; Garcia and Bruckner, 1997; Petana, 1968)

Nematodes	**Cestodes**	**Trematodes**	**Protozoa**
Ascaris lumbricoides	*Diphyllobothrium spp.*	*Fasciola hepatica*	*Entamoeba histolytica*
Trichuris trichiura	*Taenia saginata*	*Paragonimus spp.*	*Entamoeba coli*
Hookworms	*Taenia solium*		*Endolimax nana*
Enterobius vermicularis	*Hymenolepis nana*		*Iodamoeba butschlii*
Strongyloides stercoralis	*Hymenolepis diminuta*		*Trichomonas hominis*
	Echinococcus granulosus		*Giardia lamblia*
			Dientamoeba fragilis
			Cryptosporidium parvum
			Cyclospora cayetanensis
			Blastocystis hominis
			Isospora belli

Toledo, the southern most district of Belize, was selected as the site for studying the prevalence and distribution of intestinal parasitoses. The selected villages are located along the southern highway including Bladden, Medina Bank, Tambran, Golden Stream, and San Marcos from north to south, (Figure 2). This district had the smallest population, the lowest population density and the lowest income per household (Library of Congress, 1992; UNICEF, 1997).

The health of Belizeans has improved markedly from its colonial period. The death rate dropped from 11.5 per 1000 in 1950s to 5 per 1000 in the 1990s, while the infant mortality rate declined from 93 per 1000 in the 1950s to 26 per 1000 in the 1990s. However, in the rural areas of Toledo district, the infant mortality rate is more than double that of the national rate (Library of Congress, 1992). More than 45% of children in Toledo district show some degree of malnutrition and growth retardation, and approximately 60% of pregnant women have iron-deficiency anemia. The data from Belize census in 1996 shows 11.2% of the households had no sanitation facilities and 77% of rural households had pit latrines. Seventy percent of wells for drinking water were located within 100 feet of a latrine. Twenty-seven percent of households use streams and creeks as their major water sources (UNICEF, 1997).

Conventional microscopic examination of stool specimens to identify communities with high prevalence of intestinal parasite are usually too expensive and time-consuming for countries such as Belize. There are valid alternative approaches, such as using morbidity questionnaires, to screen villages with high prevalence of intestinal parasites as was done in Tanzania and other countries in Africa (Booth *et al.*, 1998). There are several diagnostic or suggestive symptoms of intestinal parasite infections, such as watery, mucous and bloody diarrhea, abdominal pain, tenesmus, constipation, nausea, vomiting, and fever) that are used in surveys. Using these symptoms to identify intestinal parasitic infection with morbidity questionnaires will save time, money, and skilled personnel. This screening technique helps health care personnel identify villages with high prevalence of intestinal parasitic infections and to plan prevention and control programs.

There is an additional method for studying associations between environmental exposures and the spatial distribution of disease, i.e. the use of Geographic Information System (GIS) techniques (Scholten and de Lepper, 1991). GIS is a powerful mapping and analysis technology that allows large quantities of information to be viewed and analyzed within a geographic context (Vine *et al.*, 1997). It has been used in various public health studies, such as malaria control program (Andre *et al.*, 1995; Omumbo *et al.*, 1998; Rejmankova *et al.*, 1998), lead poisoning (Guthe *et al.*, 1992), Lyme disease (Kitron and Kazmierczak, 1997), fasciolosis control (Yilma and Malone, 1998), and others. The association between intestinal parasitic infection and geographic information may be used in prevention and control of diseases.

Foreign travelers and the U.S. military who travel or work in Belize may be exposed to various intestinal parasites. A study of the veterans that returned from Vietnam showed 7.9% of them had intestinal parasites and 51% of Vietnamese subjects had at least one intestinal parasite (Berke *et al.*, 1972). U.S. Army construction teams often build bridges in Belize and carry out military operations with British and Belizian troops. Several companies of U.S. Special Forces hold jungle warfare exercises in Belize. They will live, eat and train in the Belize jungle. Knowledge of intestinal parasites and the risk factors for infection may help in preventing parasitic infections in the Special Force population group.

Materials and Methods

Study sites

During April to May and October to November of 1999 a study of intestinal parasites was conducted in the rural area of southern Belize to determine the prevalence of intestinal parasitic infections and risk factors which may be associated with these infections.

Golden Stream, Medina Bank, San Marcos, Bladden and Tambran villages were recommended by the Ministry of Health of Belize for survey.

These villages are located in the Toledo district (Figure 2) which is the most southern district of Belize. Toledo district shares a border with Guatemala. The settlement of the area with diverse groups dates back to the 1600s with the arrival of Garifuna, the first immigrants to the country. Punta Gorda is the largest city in the district. There is an equal blend of Caucasians, Ketchi Mayans, Mopan Mayans, Mestizoes, Garifunas, Creoles, Chinese and East Indians in the area. The villagers in which the study was conducted were mainly Ketchi Mayan and Mopan Mayan. Except for Punta Gorda, most villages do not have electricity and piped water. The village areas are covered with lush green forest.

Golden Stream, the first village to be surveyed, was composed of 47 houses with a total population of approximately 297. It is located 47 kilometers north of Punta Gorda next to Golden Stream River and Joshua Creek. The area is surrounded by orange groves and cornfields. Medina Bank had 21 houses and a population of 114. It is located further north, 58 kilometers from Punta Gorda near the Deep River. It is a logging area of dense forest. San Marcos, located about 3 kilometers off the main highway, had more than 26 houses and a population of 168. It is 22 kilometers from Punta Gorda. It is surrounded by cornfields and orange groves. Bladden and Tambran together had 11 houses and 93 people. Tambran is a group of houses scattered along the southern highway between Golden Stream and Medina Bank, 51 kilometers from Punta Gorda. It is a densely forested area. Bladden, located 80 kilometers from Punta Gorda, has a banana plantation surrounded by a dense forest.

The total population consisted of 672 individuals and 111 houses. The villages are located along the southern highway, except San Marcos which is located on a side road about 3 kilometers off the main highway.

Logistics and supplies

All supplies from USUHS were sent by FedEx to the Malaria Control Program Unit and U.S. Military Liaison Officer office (US.MLO) in Belize City. They consisted of stool cups, 20 ml glass vials containing 10 ml of 10% formalin, applicator sticks, parafilm, disposable tongue depressors, microscope slides, cover slips, batteries, questionnaires, and consent forms. Other supplies and equipment such as a compound microscope, flash light, handheld Global Position System (GPS), incentives such as pencils for children, etc., were hand carried.

A rental car was used for in county transportation. . Travel time from Belize City to Punta Gorda is about 6 hours for approximately 350 kilometers or 12 hours by bus. More than half of the road is gravel.

After arriving in Belize city, an appointment was made with the representative of Ministry of health. The final draft of the proposal for the study was discussed and approved by the Ministry of Health, including the potential and obstacles that might occur in the study area. Likewise points of contact and facilities available in the study area were provided.

Accommodations were arranged at the Ridieu Camp of the Belize Defense Force. A medic from the camp was assigned to be a translator during the study.

The director of the Punta Gorda district hospital and district health educator provided a list of the villages that have health care volunteers, including: Golden Stream, Medina Bank, San Marcos, Bladden and Tambran.

The study was conducted in each village with assistance from the health care volunteers familiar with the areas. The objectives, benefits, processes and significance of the study were explained to the village chiefs. Permission to administer the questionnaire and obtain stool samples from the villagers was approved by the chiefs. The chiefs were also asked to spread the news and request the cooperation of the villagers to participate in the study.

The study started in the afternoon after meeting with the chiefs by distributing the stool cups and disposable tongue depressors that were used as paddles to collect each stool specimen. The roster with six-digit identification number for each villager was created with village number, house number and person number (VVHHPP). Approximately 60 to 70 people from 10 to 15 houses were recruited into the study each day. The method of stool collection was explained at the time cups were distributed. The villagers were instructed on the amount of formed stool (about 20 to 40 grams), or watery stool to provide (5 to 6 tablespoon) (Ash and Orihel, 1991). Collection of feces directly into the container is preferred since contamination of the specimen by water, urine or other extraneous material should be avoided. Water and urine will destroy protozoan trophozoites and contamination with free living organism may complicate diagnoses. The villagers were told to be at home on the next day to answer the questionnaire and to return the stool samples.

On the morning of the next day, the specimens were collected. The rationale and objectives of the study were explained to the occupants of each house. The questionnaire was completed and a consent form (Appendix 1) was signed by each participant. Incentive pencils were distributed based on the number of stool samples that were returned. The questionnaire was administered to a representative of the household. Basic information from each participant was recorded, including: identification number, village, house number, demographic information (age, sex, ethnicity, occupation, educational level), house construction (floor type, number of rooms and people), sanitation practices (toilet facilities, trash, type of water, drinking water treatment, hand washing and wearing shoes), socioeconomic status (ownership of house, electrical appliances, livestock), and whether symptoms of common intestinal parasites (diarrhea, bloody stool) were experienced, (Appendix 2).

Location of each house was recorded by the Global Positioning System (GPS) unit (Magellan® ColorTrack) and coordinates were recorded in Universal Transverse Mercator (UTM) units. The location was checked before entering and before leaving the house. An effort was made to collect stool samples from the houses that were in the roster of that day. If there were stool samples that remained to be collected, the investigators would do so on the next or following days. The stool samples were processed in the afternoon of each day.

Aliquots of submitted stools were placed into 20 ml. screw-capped vials containing 10 ml of 10% formalin using applicator sticks (chop-stick method). The stools were mixed thoroughly in the formalin to ensure fixation. The vials were labeled with an identification number and the collection date.

At the end of each day, the cycle was repeated. Questionnaires administration, stool collection and stool processing was performed until the whole village was covered. Similar methods were used for all villages surveyed.

The questionnaires were sorted by village and securely maintained. The stool specimen vials were sealed with parafilm and tightly packed for air transportation back to Uniformed Services University of the Health Sciences (USUHS).

Stool specimens were examined by the investigator in the parasitology laboratory at USUHS. The formalin-ethyl acetate concentration technique was used to examine the stools (Appendix 3). This technique is designed to recover small numbers of eggs or larvae or protozoan cysts which may have been missed using the direct examination method (Parasitology subcomittee, 1978). Material from application of the concentration technique was systematically examined under a compound microscope (Appendix 4). The results of examinations were reported to each participant. Albendazole tablet (400 mg), provided by the investigator, was distributed to everyone in the villages by the community health care workers.

Data management

The slides were examined and the parasitologic findings recorded in an Excel® file. Data from the questionnaire and the results of microscopic examination of the stool specimens were included. The data was double entered and compared for errors. Personal identifying information such as name was deleted and not used in the analysis. Only the principal investigator had access to this information. The data was converted into SPSS (Chicago, IL) program for analysis and also transferred to the Unix system for Global Information Systems (GIS) analysis.

Demographic data: age was used as a continuous variable; sex, ethnicity, and occupation were used as categorical data. Sex was coded as 0 for "female" and 1 for "male". Ethnicity was reduced to "Mayan Mopan" and "Mayan Ketchi" because only these ethnic groups lived in the villages surveyed. The occupation categories of housewife, handicraft maker and dependent elders were combined as "housework"; agriculture and banana plantation workers, laborers, merchants were combined as "labor". "Young child" and "student" remained the same.

The environmental data of the house included GPS readings; location of the house (village, grassland, forest); and floor material (dirt, wood or cement). Density level was calculated by dividing number of people in each house with the number of rooms in each house. If the number was more than 4 people per room, the household was classified as an overcrowded condition.

The sanitation information included toilet use (Yes, No); garbage disposal (Yes, No); water supplies (stream, well); and water treatment (Yes, No).

Socioeconomic information included ownership of the house and electric appliances (Yes, No); ownership of livestock and pets.

Personal hygiene data included hand washing (Yes, No); wearing shoes (Yes, No).

These questions were used in other studies to find an association of the factors and the parasites (Anderson *et al.*, 1993; Borda *et al.*, 1996; Gamboa *et al.*, 1998; Gross *et al.*, 1989; Hidayah *et al.*, 1997; Kightlinger *et al.*, 1998; Montresor *et al.*, 1998; Oberhelman *et al.*, 1998; Sanchez *et al.*, 1997).

The stool examination results were used as a binary variable (1 for "Positive for parasite" and 0 for "Negative for parasite"). The other variables were coded as continuous or categorical according to the type of each variable.

Each variable was tabulated for frequency and descriptive information. Continuous variables such as age and density of people in the houses were analyzed and summarized to determine mean for central tendency, standard deviation (SD) for dispersion, skew and kurtosis for deviation from normality. The data was evaluated and presented by histogram, stem and leaf, and box plots.

Intestinal parasitic infection data was stratified by age group and sex. Some variables such as occupation, type of water, water treatment, and garbage disposal were classified into lower numbers of categories, as described.

Contingency table technique was used to find the association between intestinal parasitic infections and risk factors by calculating Pearson chi-square, odds ratio and 95% confidence interval. The calculated result from each variable was analyzed to find any significant protective or risk factor for each intestinal helminthic, and protozoan infection (Appendix 5).

Variables that have a confidence interval of odds ratio that does not include 1, or Pearson chi-square *p*-value less than 0.25 (Hosmer and Lemeshow, 1989) and variables that are biologically important such as ethnicity, population density, and floor type were selected for multivariate analysis. Logistic regression was performed to obtain the associations between parasitic infection and risk factors (Appendix 6). The model was constructed with each parasitic infection as the binomial dependent variable, and risk factors as independent variables. The maximum likelihood estimation of each risk factor was calculated and tested (likelihood ratio test, and Wald test) to determine which factor should be included in the model. Stepwise procedures, both forward selection and backward elimination, were performed to select the best model. These models are used to predict a odd of intestinal infection with various risk factors.

The geographic data including house latitude/longitude locations that were recorded in Universal Transverse Mercator (UTM) projection by handheld GPS units were input to the computer with information on intestinal parasitic infections and questionnaire data. The data was converted from an SPSS (.sav) file to an Excel (.xls) file, then saved as a comma-delimited (.csv) file. The file was transferred to a Silicon Graphics Unix system that runs ARC/INFO. The data file containing the location of each house and the file containing the attribute information of the main intestinal parasitic infection and the questionnaire data were joined together by ARC/INFO using a common identification number in both files to create the GIS. A Landsat image was transformed from a PCI format file into GEOTIF file by the PCI FEXPORT program. Then, the result was viewed by using the ArcView program. The houses that were positive for each parasite were displayed. The spatial analysis in ArcView was done to find the association between intestinal parasitic infection and spatial distribution (ESRI, 1996).

Results

The prevalence surveys for intestinal parasitic infections in southern Belize were conducted during April to May and October to November 1999. The surveys were carried out in 3 villages and 2 sub-villages; Golden Steam, Medina Bank, San Marcos, Bladden and Tambran in Toledo district.

The population consisted of 672 people and 553 stool samples were obtained. The participation rate was 82.3%. At least one parasite per specimen was found in 418 stool samples, or 75.6% were positive. Helminthic infections only were found in 371 stool samples (67.1%) and protozoa were detected in 188 stools (34%). Multiple infections were common with 150 (27.1%) with two parasites, 104 (18.8%) with 3-4 parasites, and 16 (2.9%) with 5-7 parasites.

The prevalence of intestinal parasitic infections is shown in Table 1. The most common infections were with the soil-transmitted nematodes, followed by protozoans. The prevalence rates for the parasites were variable among the villages. The most common parasites were hookworms (*Necator americanus* or *Ancylostoma duodenale*) which were found in 41% to 60% (average 55%) of those examined, *Ascaris lumbricoides* 13% to 52% (average 30%), *Trichuris trichiura*, 6% to 32% (average 18.6%),

Table 1.

Number and prevalence (%) of intestinal parasites by single stool examination in 5 villages in the Toledo District, southern Belize.

	Village											
	Golden Stream		Medina Bank		San Marcos		Bladden		Tambran		Total	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Protozoa	91	(37.3)	29	(31.5)	59	(39.6)	2	(9.1)	7	(15.2)	188	(34.0)
Giardia lamblia	22	(9.0)	10	(10.9)	31	(20.8)	2	(9.1)	2	(4.3)	67	(12.1)
Entamoeba histolytica/dispar	19	(7.8)	4	(4.3)	10	(6.7)					33	(6.0)
Entomoeba coli	57	(23.4)	14	(15.2)	38	(25.5)			5	(10.9)	114	(20.6)
Entamoeba hartmani	10	(4.1)	2	(2.2)	4	(2.7)					16	(2.9)
Iodamoeba beutschlii	24	(9.8)	11	(12.0)	15	(10.1)					50	(9.0)
Endolimax nana	2	(.8)									2	(.4)
Isospora belli	2	(.8)									2	(.4)
Chilomastix mesnili	2	(.8)									2	(.4)
Helminth	149	(61.1)	76	(82.6)	109	(73.2)	12	(54.5)	25	(54.3)	371	(67.1)
Ascaris lumbricoides	53	(21.7)	48	(52.2)	55	(36.9)	5	(22.7)	6	(13.0)	167	(30.2)
Hookworm	127	(52.0)	52	(56.5)	90	(60.4)	9	(40.9)	25	(54.3)	303	(54.8)
Trichuris trichiura	35	(14.3)	11	(12.0)	47	(31.5)	7	(31.8)	3	(6.5)	103	(18.6)
Strongyloides stercoralis	3	(1.2)			2	(1.3)	2	(9.1)			7	(1.3)
Total	244	(100)	92	(100)	149	(100)	22	(100)	46	(100)	553	(100)
Number parasites found	172	(70.5)	81	(88.0)	125	(83.9)	13	(59.1)	27	(58.7)	418	(75.6)
Number no parasites found	72	(29.5)	11	(12.0)	24	(16.1)	9	(40.9)	19	(41.3)	135	(24.4)

Table 2.

Number and prevalence (%) of intestinal parasites (by single stool examination) in males in 5 villages in the Toledo District, southern Belize.

	Males						
Age	0-9	10-19	20-29	30-39	40-49	50+	Total
	(n) (%)	(n) (%)	(n) (%)	(n) (%)	(n) (%)	(n) (%)	(n) (%)
Protozoa	47 (40.9)	19 (35.8)	9 (32.1)	6 (30.0)	3 (13.6)	7 (36.8)	91 (35.4)
Giardia lamblia	26 (22.6)	7 (13.2)	2 (7.1)		1 (4.5)	1 (5.3)	37 (14.4)
Entamoeba histolytica/dispar	4 (3.5)	4 (7.5)	1 (3.6)	2 (10.0)		1 (5.3)	14 (5.4)
Entomoeba coli	22 (19.1)	13 (24.5)	5 (17.9)	5 (25.0)	2 (9.1)	3 (15.8)	50 (19.5)
Entamoeba hartmani	4 (3.5)	2 (3.8)	1 (3.6)	1 (5.0)			8 (3.1)
Iodamoeba beutschlii	10 (8.7)	6 (11.3)	2 (7.1)		2 (9.1)		20 (7.8)
Endolimax nana	1 (.9)						1 (.4)
Isospora belli			1 (3.6)				1 (.4)
Chilomastix mesnili	1 (.9)						1 (.4)
Helminth	63 (54.8)	45 (84.9)	22 (78.6)	14 (70.0)	10 (45.5)	11 (57.9)	165 (64.2)
Ascaris lumbricoides	39 (33.9)	19 (35.8)	5 (17.9)	4 (20.0)	4 (18.2)	4 (21.1)	75 (29.2)
Hookworm	41 (35.7)	37 (69.8)	18 (64.3)	13 (65.0)	9 (40.9)	8 (42.1)	126 (49.0)
Trichuris trichiura	24 (20.9)	13 (24.5)	6 (21.4)	3 (15.0)	2 (9.1)	2 (10.5)	50 (19.5)
Strongyloides stercoralis	2 (1.7)	1 (1.9)	2 (7.1)			1 (5.3)	6 (2.3)
Total	115 (100)	53 (100)	28 (100)	20 (100)	22 (100)	19 (100)	257 (100)
Number parasites found	80 (69.6)	46 (86.8)	22 (78.6)	14 (70.0)	12 (54.5)	13 (68.4)	187 (72.8)
Number no parasites found	35 (30.4)	7 (13.2)	6 (21.4)	6 (30.0)	10 (45.5)	6 (31.6)	70 (27.2)

Table 2.(Cont.)

Number and prevalence (%) of intestinal parasites (by single stool examination) in females in 5 villages in the Toledo District, southern Belize.

	Females						
Age	0-9	10-19	20-29	30-39	40-49	50+	Total
	(n) (%)	(n) (%)	(n) (%)	(n) (%)	(n) (%)	(n) (%)	(n) (%)
Protozoa	45 (38.8)	21 (26.3)	13 (35.1)	9 (27.3)	6 (50.0)	3 (16.7)	97 (32.8)
Giardia lamblia	20 (17.2)	4 (5.0)	2 (5.4)	2 (6.1)	1 (8.3)	1 (5.6)	30 (10.1)
Entamoeba histolytica/dispar	9 (7.8)	4 (5.0)	3 (8.1)		2 (16.7)	1 (5.6)	19 (6.4)
Entomoeba coli	26 (22.4)	15 (18.8)	11 (29.7)	5 (15.2)	5 (41.7)	2 (11.1)	64 (21.6)
Entamoeba hartmani	3 (2.6)	3 (3.8)	1 (2.7)		1 (8.3)		8 (2.7)
Iodameba beutschlii	12 (10.3)	10 (12.5)	4 (10.8)	2 (6.1)	2 (16.7)		30 (10.1)
Endolimax nana	1 (.9)						1 (.3)
Isospora belli	1 (.9)						1 (.3)
Chilomastix mesnili		1 (1.3)					1 (.3)
Helminth	63 (54.3)	58 (72.5)	33 (89.2)	26 (48.5)	10 (83.3)	16 (88.9)	206 (69.6)
Ascaris lumbricoides	32 (27.6)	31 (38.8)	14 (37.8)	10 (30.3)	2 (16.7)	3 (16.7)	92 (31.1)
Hookworm	48 (41.4)	49 (61.3)	31 (83.8)	24 (72.7)	10 (83.3)	15 (83.3)	177 (59.8)
Trichuris trichiura	21 (18.1)	17 (21.3)	7 (18.9)	4 (12.1)	1 (8.3)	3 (16.7)	53 (17.9)
Strongyloid stercolaris						1 (5.6)	1 (.3)
Total	116 (100)	80 (100)	37 (100)	33 (100)	12 (100)	18 (100)	296 (100)
Number parasites found	80 (69.0)	62 (77.5)	35 (94.6)	27 (81.8)	11 (91.7)	16 (88.9)	231 (78.0)
Number no parasites found	36 (31.0)	18 (22.5)	2 (5.4)	6 (18.2)	1 (8.3)	2 (11.1)	65 (22.0)

Table 3.

Distribution of intestinal parasitic infections in males and females by age from inhabitants of 5 villages in Toledo District, southern Belize. (Appendix7)

Mean Age											
	Male		Female		Total		Levene's Test for Equality of Variances		Equal Variance	t-test for Equality of Means	
	n	(%)	n	(%)	n	(%)	F	Sig.	assume	t	Sig.
Total population	325	48.4	347	51.6	672	100					
Mean age	19	(SD 17.8)	17.7	(SD 15.5)	18.1	(SD 16.7)	3.930	0.048	No	1.046	0.296
Stool specimens	257	46.5	296	53.5	553	100					
Mean age	18.6	(SD 18.5)	17.7	(SD 15.8)	18.1	(SD 17.1)	5.532	0.019	No	0.590	0.556
Parasite positive	187	44.7	231	55.3	418	100					
Mean age	17.7	(SD 16.4)	19.2	(SD 16.1)	18.6	(SD 16.2)	0.001	0.975	Yes	-0.956	0.340
Helminthic positive	165	(SD 44.5)	206	(SD 55.5)	371	100					
Mean age	18.3	(SD 15.7)	20.3	(SD 16.4)	19.4	(SD 16.1)	0.445	0.505	Yes	-1.191	0.234
Protozoan positive	91	48..4	97	51.6	188	100					
Mean age	15.9	(SD 16.3)	16	(SD 14.4)	15.9	(SD 15.3)	0.244	0.622	Yes	-0.058	0.953

Table 4.

Prevalence of intestinal parasitic infections in males and females in 5 villages in the Toledo District, southern Belize. (Appendix 8)

Two-sample test for Binomial propartions (Normal-theory test)						
	Gender					
	Male	Female				
	Count (%)	Count (%)	*p*^	*q*^	*z*	*p*-value
Protozoa	91 (35.4)	97 (32.8)	0.340	0.660	0.653	0.743
Giardia lamblia	37 (14.4)	30 (10.1)	0.121	0.879	1.532	0.937
Entamoeba histolytica/dispar	14 (5.4)	19 (6.4)	0.060	0.940	-0.481	0.315
Entomoeba coli	50 (19.5)	64 (21.6)	0.206	0.794	-0.628	0.265
Entamoeba hartmani	8 (3.1)	8 (2.7)	0.029	0.971	0.287	0.613
Iodamoeba beutschlii	20 (7.8)	30 (10.1)	0.090	0.910	-0.962	0.168
Endolimax nana	1 (.4)	1 (.3)	0.004	0.996	0.100	0.540
Isospora belli	1 (.4)	1 (.3)	0.004	0.996	0.100	0.540
Chilomastix mesnili	1 (.4)	1 (.3)	0.004	0.996	0.100	0.540
Helminth	165 (64.2)	206 (69.6)	0.671	0.329	-1.346	0.089
Ascaris lumbricoides	75 (29.2)	92 (31.1)	0.302	0.698	-0.485	0.314
Hookworm	126 (49.0)	177 (59.8)	0.548	0.452	-2.538	0.006*
Trichuris trichiura	50 (19.5)	53 (17.9)	0.186	0.814	0.467	0.680
Strongyloides stercoralis	6 (2.3)	1 (.3)	0.013	0.987	2.095	0.982*
Total	257 (100.0)	296 (100.0)				
Number parasite found	187 (72.8)	231 (78.0)	0.756	0.244	-1.441	0.075
Number no parasite	70 (27.2)	65 (22.0)	0.244	0.756	1.441	0.925

* Significant difference (*p*-value > 0.975 or *p*-value < 0.025)

and *Strongyloides stercoralis* 1% to 9% (average 1%). Combined helminthic infections varied from 52% to 82% (average 67%). The protozoan infections were *Entamoeba coli* 11% to 26% (average 21%), *Giardia lamblia* 4% to 21% (average 12%), *Iodamoeba beutschlii* 10% to 12% (average 9%), *Entamoeba histolytica/dispar* 4% to 8% (average 6%), *Entamoeba hartmani 3%*, and *Endolimax nana, Isospora belli, Chilomastix mesnili* were each found in 0.4% of the population sample.

Table 2 lists the findings in these villages by age and sex. The age ranged from 1 month to 98 years. The average age of the total population was 18 years; 19 in males and 17 in females. The average age of individuals with intestinal parasitic infections was 18 years, but the average male age was 17 and female was 19, this represents a reverse of the total population average age. There was no difference in frequency of infections with intestinal parasites for males and females of average age, (Table 3).

The prevalence of intestinal parasites was similar in both males and females, with the exception of hookworm and *S. stercoralis* infections, (Table 4). Females (60%) had a higher prevalence of hookworm infections than males (49%). Males (2.3%) were infected more often with *S. stercoralis* than females (0.3%).

In each gender, there was no difference between age groups for each intestinal parasite except in males *G. lamblia*, hookworms, and other helminths were more common in younger age groups (Table 5). In females, hookworms, helminthic infections and parasites in general were more prevalent in younger age groups (Table 6).

Table 5.

Results of Chi-square tests for differences in prevalence (%) by age group, of parasitic infections in males in 5 villages in the Toledo District, southern Belize. (Appendix 5)

	Male							Chi-square test or Fisher's Exact Test			
Age group	0-9	10-19	20-29	30-39	40-49	50+	Total				
(n)	(115)	(53)	(28)	(20)	(22)	(19)	(257)	value	df	*p*-value	remark
Protozoa	40.9	35.8	32.1	30	13.6	36.8	35.4	0.65	5	0.263	a
Giardia lamblia	22.6	13.2	7.1		4.5	5.3	14.4			0.020*	b
Entamoeba histolytica/dispar	3.5	7.5	3.6	10			5.3			0.217	b
Entomoeba coli	19.1	24.5		17.9	25	9.1	15.8			0.721	b
Entamoeba hartmani	3.5	3.8	3.6	5			3.1			0.972	b
Iodamoeba beutschlii	8.7	11.3	7.1		9.1		7.8			0.280	b
Helminth	54.8	84.9	78.6	70	45.5	57.9	64.2	20.83	5	0.001*	a
Ascaris lumbricoides	33.9	35.8	17.9	20	18.2	21.1	29.2	6.84	5	0.233	a
Hookworm	35.7	69.8	64.3	65.0	40.9	42.1	49.0	22.99	5	<0.001*	a
Trichuris trichiura	20.9	24.5	21.4	15	9.1	10.5	19.5			0.638	b
Strongyloides stercoralis	1.7	1.9	7.1				2.3			0.351	b
Parasite positive	69.6	86.8	78.6	70	54.5	68.4	72.8	10.28	5	0.068	a

* Significant difference (p-value < 0.05)
a = Chi-square test, b = Fisher's Exact test

Table 6.

Results of Chi-square tests for differences in prevalence (%) by age group, of parasitic infections in females in 5 villages in the Toledo District, southern Belize. (Appendix 5)

	Female							Chi-square test or Fisher's Exact test			
Age group	0-9	10-19	20-29	30-39	40-49	50+	Total				
(n)	(116)	(80)	(37)	(33)	(12)	(18)	(296)	value	df	p-value	remark
Protozoa	38.8	26.3	35.1	27.3	50	16.7	32.8	7.74	5	0.171	a
Giardia lamblia	17.2	5	5.4	6.1	8.3	5.6	10.1			0.078	b
Entamoeba histolytica/disp	7.8	5	8.1		16.7	5.6	6.4			0.308	b
Entomoeba coli	22.4	18.8	29.7	15.2	41.7	11.1	21.6	6.7	5	0.244	a
Entamoeba hartmani	2.6	3.8	2.7		8.3		2.7			0.631	b
Iodamoeba beutschlii	10.3	12.5	10.8	6.1	16.7		10.1			0.588	b
Helminth	54.3	72.5	89.2	48.5	83.3	88.9	31.1	25.39	5	<0.001*	a
Ascaris lumbricoides	27.6	38.8	37.8	30.3	16.7	16.7	31.1	6.57	5	0.255	a
Hookworm	41.4	61.3	83.8	72.7	83.3	83.3	59.8	34.5	5	<0.001*	a
Trichuris trichiura	18.1	21.3	18.9	12.1	8.3	16.7	17.9	2.16	5	0.827	a
Strongyloides stercoralis						5.6	0.3			0.101	b
Parasite positive	69	77.5	94.6	81.8	91.7	88.9	78	14.32	5	0.014*	a

* Significant difference (p-value < 0.05)
a = Chi-square test, b = Fisher's Exact test

The demographic data and risk factors of the study population are described in Table 7. Golden Stream had a population of 297 persons living in 47 houses, 36 with toilets (76%). The number of villagers participating in the study was 244 (82%). Medina Bank had a population of 114 persons living in 21 houses, all with toilets (100%). Ninety-two or 81% participated in the study. San Marcos had a population of 168 persons living in 26 houses, but only 4 had toilets (15%). One hundred and forty-nine or 89% participated in the study. Bladden and Tambran together had 93 persons living in 17 houses with 7 toilets (41%). Sixty-eight or 73% participated in the study.

The total population participating in the study was 553, 296 (54%) females and 257 (46%) males. There were two ethnic groups, 187 Mayan Mopan (34%) and 366 Mayan Ketchi (66%). The age ranged from 1 month to 91 years. Half of the study population was 12 or younger. There were four main occupations: 126 preschool children (23%), 203 students (37%), 120 houseworkers (22%), and 104 laborers (18%). Education levels ranged from 0 to 14 years, but 370 (67%) of them were not able to read or had less than 3 years of schooling. Only 196 (35%) of those surveyed wore shoes all the time.

Table 7.

Demographic data of study populations in 5 villages in Toledo District, southern Belize.

	Village				
	Golden Stream	Medina Bank	San Marcos	Bladden & Tambran	Total
	n (%)	n (%)	n (%)	n (%)	n (%)
Population	297 (44.2)	114 (17.0)	168 (25.0)	93 (13.8)	672 (100.0)
Stool specimens	244 (44.1)	92 (16.6)	149 (26.9)	68 (12.4)	553 (100.0)
Participation rate	(82.2)	(80.7)	(88.7)	(73.1)	(82.3)
Sex					
Male	119 (48.8)	40 (43.5)	65 (43.6)	33 (48.5)	257 (46.5)
Female	125 (51.2)	52 (56.5)	84 (56.4)	35 (51.5)	296 (53.5)
Ethnicity					
Mopan	159 (65.2)	7 (7.6)		21 (30.9)	187 (33.8)
Ketchi	85 (34.8)	85 (92.4)	149 (100.0)	47 (69.1)	336 (66.2)
Education level					
0-3	157 (64.0)	61 (66.0)	98 (66.0)	54 (79.0)	370 (67.0)
4+	87 (36.0)	31 (34.0)	51 (34.0)	14 (21.0)	183 (33.0)
House					
Number	47 (42.3)	21 (18.9)	26 (23.4)	17 (15.4)	111 (100.0)
Floor					
Dirt	19 (40.4)	8 (38.1)	25 (96.2)	15 (88.2)	67 (60.4)
Wooden/cement	28 (59.6)	13 (61.9)	1 (3.8)	2 (11.8)	44 (39.6)
Rooms					
1	16 (34.0)	10 (47.6)	15 (57.7)	12 (70.6)	53 (47.7)
2	24 (51.1)	8 (38.1)	10 (38.5)	3 (17.6)	45 (40.5)
3+	7 (14.9)	3 (14.3)	1 (3.8)	2 (11.8)	13 (11.8)
Density					
High	16 (34.0)	6 (28.6)	11 (42.3)	6 (35.3)	39 (35.1)
Low	31 (66.0)	15 (71.4)	15 (57.7)	11 (64.7)	72 (64.9)
Toilet					
Yes	31 (66.0)	21 (100.0)	4 (15.4)	7 (41.2)	63 (56.8)
No	16 (34.0)		22 (84.6)	10 (58.8)	48 (43.2)
Trash					
Yes	47 (100.0)	21 (100.0)	24 (92.3)	8 (47.1)	100 (90.1)
No			2 (7.7)	9 (52.9)	11 (9.9)
Water					
Stream	9 (19.1)	2 (9.5)			11 (9.9)
Pump	38 (80.9)	19 (90.5)	26 (100.0)	17 (100.0)	100 (90.1)
Drinking water					
Treated	45 (95.7)	13 (61.9)	22 (84.6)	13 (76.5)	93 (83.8)
No treatment	2 (4.3)	8 (38.1)	4 (15.4)	4 (23.5)	18 (16.2)
Electric appliances					
Yes	18 (38.3)	8 (38.1)	12 (46.2)	6 (35.3)	44 (39.6)
No	29 (61.7)	13 (61.9)	14 (53.8)	11 (64.7)	67 (60.4)
Pet & livestocks					
Pig	13 (27.7)	6 (28.6)		10 (58.8)	29 (26.1)
Poultry	45 (95.7)	18 (85.7)	26 (100.0)	14 (82.4)	103 (92.8)
Horse	19 (40.4)	2 (9.5)	3 (11.5)		24 (21.6)
Dog	30 (63.8)	16 (76.2)	20 (76.9)	13 (76.5)	79 (71.2)
Cat	20 (42.6)	2 (9.5)	12 (46.2)	9 (52.9)	43 (38.7)

The population density in each house was obtained by dividing number of rooms by number of people in each house. Thirty-nine (35.1%) houses had more than 4 people in one room; considered a high-density population. The number of houses with wooden or cement floors was 44 (40%) and 67 (60%) had dirt floors. Houses were constructed with thatch and wooden slats for the roof and walls, respectively. Two hundred and forty (43%) houses had one room, 239 (43%) had 2 rooms, and 74 (16%) had 3 rooms. Residents of 63 houses (57%) had access to a toilet. There was no community system for garbage disposal and eleven (10%) houses did not burn or bury their trash. Most of the houses were in the vicinity of a water pump. Only 11 households (10%) used stream water. Eighteen households (16%) drank untreated or boiled water. There was no electricity in any of the villages, but 44 (40%) houses had battery operated electrical appliances such as radios, television, etc. Most of the houses had pets or livestock, (e.g., 29 had pigs (26%), 103 had poultry (93%), 24 had horses (22%), 79 had dogs (71%) and 43 had cats (39%)).

Two by two tables (Table 8-17.) stratified the factors that influenced each intestinal infection. Odds ratio and Pearson's Chi-square were calculated for each factor and showed in Tables 8-17. The factors included a person's gender, ethnicity, occupation, education level, type of floor, population density, availability of a toilet, garbage disposal method, source of water, drinking water treatment, wearing shoes, ownership of electrical appliances, ownership of animals such as pigs, poultry, horses, dogs and cats, gastrointestinal symptoms such as diarrhea and melana.

Table 8.

Association between each risk factor and ascariasis in Toledo District, southern Belize.

		Ascaris lumbricoides					
		Positive	Negative	Odds	95% Confidence interval		Pearson Chi-square
		n (%)	n (%)	ratio	Lower	Upper	*p*
Gender	Male	75 (29.2)	182 (70.8)	0.914	0.635	1.316	0.628
	Female	92 (31.1)	204 (68.9)				
Ethnicity	Mopan	38 (20.3)	149 (79.7)	0.469	0.309	0.710	<0.001*
	Ketchi	129 (35.2)	237 (64.8)				
Job	Children	112 (34.0)	217 (66.0)	1.586	1.084	2.320	0.017*
	Adult	55 (24.6)	169 (75.4)				
Education level	0-3	104 (71.9)	266 (28.1)	0.745	0.509	1.089	0.128
	4+	120 (65.6)	63 (34.4)				
Floor type	Dirt	109 (31.1)	241 (68.9)	1.131	0.774	1.652	0.526
	Wooden/cement	58 (28.6)	145 (71.4)				
Population density	High	91 (35.7)	164 (64.3)	1.621	1.125	2.336	0.009*
	Low	76 (25.5)	222 (74.5)				
Toilet	Yes	84 (28.7)	209 (71.3)	0.857	0.596	1.233	0.405
	No	83 (31.9)	177 (68.1)				
Garbage disposal	Yes	151 (30.3)	347 (69.7)	1.061	0.75	1.957	0.85
	No	16 (29.1)	39 (70.9)				
Type of water	Stream	29 (41.4)	41 (58.6)	1.768	1.057	2.959	0.029*
	Pump	138 (28.6)	345 (71.4)				

Table 8. (Cont.)

		Positive	Negative	Odds	95% Confidence interval		Pearson Chi-square
		n (%)	n (%)	ratio	Lower	Upper	*p*
Ascaris lumbricoides							
Drinking water	No treat	32 (41.0)	46 (59.0)	1.752	1.07	2.869	0.025*
	Treat	135 (28.4)	340 (71.6)				
Wearing shoes	Yes	57 (29.1)	139 (70.9)	0.921	0.629	1.348	0.672
	No	110 (30.8)	247 (69.2)				
Electrical appliances	Yes	62 (25.8)	178 (74.2)	0.69	0.476	1.001	0.050
	No	105 (33.5)	208 (66.5)				
Pig	Yes	38 (25.9)	109 (74.1)	0.749	0.49	1.144	0.180
	No	129 (31.8)	277 (68.2)				
Poultry	Yes	161 (30.3)	370 (69.7)	1.16	0.446	3.019	0.760
	No	6 (27.3)	16 (72.7)				
Horse	Yes	26 (19.0)	111 (81.0)	0.457	0.285	0.733	0.001*
	No	141 (33.9)	275 (66.1)				
Dog	Yes	138 (32.9)	281 (67.1)	1.778	1.124	2.813	0.014
	No	29 (21.6)	105 (78.4)				
Cat	Yes	59 (24.8)	179 (75.2)	0.632	0.434	0.919	0.016*
	No	108 (34.3)	207 (65.7)				
Loose stool	Yes	42 (32.8)	86 (67.2)	1.172	0.767	0.791	0.463
	No	125 (29.4)	300 (70.6)				
Melana	Yes	15 (34.9)	28 (65.1)	1.262	0.655	2.43	0.486
	No	152 (29.8)	358 (70.2)				

Each risk factor associated with *A. lumbricoides* infection is shown in Table 8. There were several significant findings associated with the ascarid infections such as; ethnic Mayan Mopan had fewer infections than Mayan Ketchi, with odds ratio of 0.47 and its corespondent 95% confidence interval (0.31,0.71). Laborers, farmers and housewives had more infections than pre-school children and students, with odds ratio of 1.59 and its corespondent 95% confidence interval (1.13,2.32). People who lived in crowded houses had more infections than people in less crowded houses, with odds ratio of 1.62 and its corespondent 95% confidence interval (1.12,2.34). People using water from streams had more infections than people using pump water, with odds ratio of 1.77 and its corespondent 95% confidence interval (1.06,3.0). People drinking untreated water had more infections than people drinking treated or boiled water, with odds ratio of 1.75 and its corespondent 95% confidence interval (1.07,2.87). People who had electrical appliances in the house had fewer infections than people without electrical appliances, with odds ratio of 0.69 and its corespondent 95% confidence interval (0.48,1.0). People who had horses had fewer infections than people who did not have a horse, with odds ratio of 0.46 and its corespondent 95% confidence interval (0.28,0.73). People who had a dog had more infections than people who did not have a dog, with odds ratio of 1.78 and its corespondent 95% confidence interval (1.12,2.81). People who had a cat had fewer infections than people who did not have a cat, with odds ratio of 0.63 and its corespondent 95% confidence interval (0.43,0.92).

Table 9.

Association between each risk factor and hookworm in Toledo District, southern Belize.

		Hookworm					
		Positive	Negative	Odds	95% Confidence interval		Pearson Chi-square
		n (%)	n (%)	ratio	Lower	Upper	*p*
Gender	Male	126 (49.0)	131 (51.0)	0.647	0.461	0.906	0.011*
	Female	177 (59.8)	119 (40.2)				
Ethnicity	Mopan	98 (52.4)	89 (47.6)	0.865	0.607	1.231	0.420
	Ketchi	205 (56.0)	161 (44.0)				
Job	Children	152 (46.2)	177 (53.8)	0.415	0.292	0.591	<0.001*
	Adult	151 (67.4)	73 (32.6)				
Education level	0-3	184 (49.7)	186 (50.3)	0.532	0.369	0.767	<0.001*
	4+	119 (65.0)	64 (35.0)				
Floor type	Dirt	204 (58.3)	146 (41.7)	1.468	1.037	2.078	0.030*
	Wooden/cement	99 (48.8)	104 (51.2)				
Population densi	High	155 (60.8)	100 (39.2)	1.571	1.12	2.204	0.009*
	Low	148 (49.7)	150 (50.3)				
Toilet	Yes	153 (52.2)	140 (47.8)	0.801	0.573	1.122	0.197
	No	150 (57.7)	110 (42.3)				
Garbage disposal	Yes	275 (55.2)	223 (44.8)	1.189	0.681	2.076	0.542
	No	28 (50.9)	27 (49.1)				
Type of water	Stream	39 (55.7)	31 (44.3)	1.044	0.63	1.728	0.868
	Pump	264 (54.7)	219 (45.3)				

Table 9. (Cont.)

		Hookworm					
		Positive	Negative	Odds	95% Confidence interval		Pearson Chi-square
		n (%)	n (%)	ratio	Lower	Upper	*p*
Drinking water	No treat	47 (60.3)	31 (39.7)	1.297	0.796	2.113	0.295
	Treat	256 (53.9)	219 (46.1)				
Wearing shoes	Yes	95 (48.5)	101 (51.5)	0.674	0.475	0.956	0.027*
	No	208 (58.3)	149 (41.7)				
Electrical appliances	Yes	124 (51.7)	116 (48.3)	0.8	0.571	1.122	0.196
	No	179 (57.2)	134 (42.8)				
Pig	Yes	84 (57.1)	63 (42.9)	1.139	0.778	1.666	0.504
	No	219 (53.9)	187 (46.1)				
Poultry	Yes	293 (55.2)	238 (44.8)	1.477	0.627	3.479	0.369
	No	10 (45.5)	12 (54.5)				
Horse	Yes	71 (51.8)	66 (48.2)	0.853	0.579	1.256	0.421
	No	232 (55.8)	184 (44.2)				
Dog	Yes	230 (54.9)	189 (45.1)	1.017	0.688	1.503	0.933
	No	73 (54.5)	61 (45.5)				
Cat	Yes	130 (54.6)	108 (45.4)	0.988	0.705	1.386	0.944
	No	173 (54.9)	142 (45.1)				
Loose stool	Yes	60 (46.9)	68 (53.1)	0.661	0.444	0.983	0.040*
	No	243 (57.2)	182 (42.8)				
Melana	Yes	22 (51.2)	21 (48.8)	0.854	0.458	1.592	0.619
	No	281 (55.1)	229 (44.9)				

Each risk factor associated with hookworm infection is shown in Table 9. Some risk factors were significant. Laborers, farmers and housewives had fewer infections than children and students, with odds ratio of 0.42 and its corespondent 95% confidence interval (0.29,0.59). People who could not read had fewer infections than people could read, with odds ratio of 0.53 and its corespondent 95% confidence interval (0.37,0.77). People living on a dirt floor had more infections than people living on a wooden or cement floor, with odds ratio of 1.47 and its corespondent 95% confidence interval (1.04,2.08). People who lived in crowded houses had more infections than people in less crowded houses, with odds ratio of 1.57 and its corespondent 95% confidence interval (1.12,2.2). People wearing shoes had fewer infections than people who did not wear shoes, with odds ratio of 0.64 and its corespondent 95% confidence interval (0.48,0.96).

Table 10.

Association between each risk factor and *Trichuris trichiura* in Toledo District, southern Belize.

		Trichuris trichiura					
		Positive	Negative	Odds	95% Confidence interval		Pearson Chi-square
		n (%)	n (%)	ratio	Lower	Upper	*p*
Gender	Male	50 (19.5)	207 (80.5)	1.107	0.721	1.7	0.641
	Female	53 (17.9)	243 (82.1)				
Ethnicity	Mopan	26 (13.9)	161 (86.1)	0.606	0.373	0.984	0.041*
	Ketchi	77 (21.0)	289 (79.0)				
Job	Children	68 (20.7)	261 (79.3)	1.407	0.898	2.203	0.135
	Adult	35 (15.6)	189 (84.4)				
Education level	0-3	68 (18.4)	302 (81.6)	0.952	0.605	1.497	0.832
	4+	35 (19.1)	148 (80.9)				
Floor type	Dirt	74 (21.1)	276 (78.9)	1.609	1.006	2.572	0.046*
	Wooden/cement	29 (14.3)	174 (85.7)				
Population density	High	68 (26.7)	187 (73.3)	2.732	1.744	4.28	<0.001*
	Low	35 (11.7)	263 (88.3)				
Toilet	Yes	40 (13.7)	253 (86.3)	0.494	0.319	0.766	0.001*
	No	63 (24.2)	197 (75.8)				
Garbage disposal	Yes	92 (18.5)	406 (81.5)	0.906	0.451	1.822	0.783
	No	11 (20.0)	44 (80.0)				
Type of water	Stream	12 (17.1)	58 (82.9)	0.891	0.46	1.728	0.733
	Pump	91 (18.8)	392 (81.2)				

Table 10. (Cont.)

Trichuris trichiura							
		Positive	Negative	Odds	95% Confidence interval		Pearson Chi-square
		n (%)	n (%)	ratio	Lower	Upper	*p*
Drinking water	No treat	20 (25.6)	58 (74.4)	1.629	0.93	2.853	0.086
	Treat	83 (17.5)	392 (82.5)				
Wearing shoes	Yes	34 (17.3)	162 (82.7)	0.876	0.557	1.379	0.567
	No	69 (19.3)	288 (80.7)				
Electrical appliances	Yes	39 (16.3)	201 (83.7)	0.755	0.486	1.171	0.209
	No	64 (20.4)	249 (79.6)				
Pig	Yes	20 (13.6)	127 (86.4)	0.613	0.361	1.041	0.068
	No	83 (20.4)	323 (79.6)				
Poultry	Yes	97 (18.3)	434 (81.7)	0.596	0.227	1.562	0.288
	No	6 (27.3)	16 (72.7)				
Horse	Yes	18 (13.1)	119 (86.9)	0.589	0.34	1.021	0.057
	No	85 (20.4)	331 (79.6)				
Dog	Yes	82 (19.6)	337 (80.4)	1.309	0.775	2.212	0.313
	No	21 (15.7)	113 (84.3)				
Cat	Yes	47 (19.7)	191 (80.3)	1.138	0.74	1.75	0.556
	No	56 (17.8)	259 (82.2)				
Loose stool	Yes	22 (17.2)	106 (82.8)	0.881	0.525	1.481	0.634
	No	81 (19.1)	344 (80.9)				
Melana	Yes	4 (9.3)	39 (90.7)	0.426	0.149	1.219	0.102
	No	99 (19.4)	411 (80.6)				

Each risk factor associated with *T. trichiura* infection is shown in Table 10. There were some significant risk factors; ethnic Mayan Mopan had fewer infections than Mayan Ketchi, with odds ratio of 0.61 and its corespondent 95% confidence interval (0.37,0.98). On the other hand people who lived in crowded houses had more infections than people in less crowded houses, with odds ratio of 2.73 and its corespondent 95% confidence interval (1.47,4.28).

Table 11.

Association between each risk factor and *Strongyloides stercoralis* in Toledo District, southern Belize.

		Strongyloides stercoralis					
		Positive	Negative	Odds	95% Confidence interval		Pearson Chi-square
		n (%)	n (%)	ratio	Lower	Upper	*p*
Gender	Male	6 (2.3)	251 (97.7)	7.052	0.843	58.966	0.036*
	Female	1 (.3)	295 (99.7)				
Ethnicity	Mopan	4 (2.1)	183 (97.9)	2.645	0.586	11.942	0.189
	Ketchi	3 (.8)	363 (99.2)				
Job	Children	3 (.9)	326 (99.1)	0.506	0.112	2.284	0.367
	Adult	4 (1.8)	220 (98.2)				
Education level	0-3	4 (1.1)	336 (98.9)	0.656	0.145	2.958	0.581
	4+	3 (1.6)	180 (98.4)				
Floor type	Dirt	4 (1.1)	346 (98.9)	0.771	0.171	3.478	0.734
	Wooden/cement	3 (1.5)	200 (98.5)				
Population density	High	2 (.8)	253 (99.2)	0.463	0.089	2.408	0.349
	Low	5 (1.7)	293 (98.3)				
Toilet	Yes	5 (1.7)	288 (98.3)	2.24	0.431	11.643	0.325
	No	2 (.8)	258 (99.2)				
Garbage disposal	Yes	6 (1.2)	492 (98.8)	0.659	0.078	5.572	0.699
	No	1 (1.8)	54 (98.2)				
Type of water	Stream	1 (1.4)	69 (98.6)	1.152	0.137	9.715	0.896
	Pump	6 (1.2)	477 (98.8)				

Table 11. (Cont.)

		Strongyloides stercoralis					
					95% Confidence interval		Pearson Chi-square
		Positive n (%)	Negative n (%)	Odds ratio	Lower	Upper	*p*
Drinking water	No treat	2 (2.6)	76 (97.4)	2.474	0.471	12.979	0.268
	Treat	5 (1.1)	470 (98.9)				
Wearing shoes	Yes	2 (1.0)	194 (99.0)	0.726	0.14	3.776	0.702
	No	5 (1.4)	352 (98.6)				
Electrical appliances	Yes	1 (.4)	239 (99.6)	0.214	0.026	1.79	0.118
	No	6 (1.9)	307 (98.1)				
Pig	Yes	2 (1.4)	145 (98.6)	1.106	0.212	5.765	0.905
	No	5 (1.2)	(98.8)				
Poultry	Yes	4 (.8)	527 (99.2)	0.048	0.01	0.23	<0.001*
	No	3 (13.6)	19 (86.4)				
Horse	Yes	2 (1.5)	135 (98.5)	1.218	0.234	6.349	0.815
	No	5 (1.2)	411 (98.8)				
Dog	Yes	3 (.7)	416 (99.3)	0.234	0.052	1.061	0.041*
	No	4 (3.0)	130 (97.0)				
Cat	Yes	3 (1.3)	235 (98.7)	0.993	0.22	4.477	0.992
	No	4 (1.3)	311 (98.7)				
Loose stool	Yes	1 (.8)	127 (99.2)	0.55	0.066	4.61	0.576
	No	6 (1.4)	419 (98.6)				
Melana	Yes	1 (2.3)	42 (97.7)	2	0.235	17.004	0.517
	No	6 (1.2)	504 (98.8)				

Risk factors associated with *S. stercoralis* infection are shown in Table 11. There were some significant risk factors associated with the infection. Males had more infections than females, with odds ratio of 7.05 and its corespondent 95% confidence interval (0.84,58.97). People who raised chickens or ducks had fewer infections than people who did not, with odds ratio of 0.05 and its corespondent 95% confidence interval (0.01,0.23).

Table 12.

Association between each risk factor and *Giardia lamblia* in Toledo District, southern Belize.

		Giardia lamblia Positive n (%)	Negative n (%)	Odds ratio	95% Confidence interval Lower	Upper	Pearson Chi-square *p*
Gender	Male	37 (14.4)	220 (85.6)	1.491	0.892	2.492	0.126
	Female	30 (10.1)	226 (89.9)				
Ethnicity	Mopan	16 (8.6)	171 (91.4)	0.578	0.32	1.044	0.067
	Ketchi	51 (13.9)	315 (86.1)				
Job	Children	54 (16.4)	275 (83.6)	3.187	1.695	5.993	<0.001*
	Adult	13 (5.8)	211 (94.2)				
Education level	0-3	54 (14.6)	316 (85.4)	2.235	1.186	4.219	0.011*
	4+	13 (7.1)	170 (92.9)				
Floor type	Dirt	46 (13.1)	304 (86.9)	1.311	0.758	2.268	0.331
	Wooden/cement	21 (10.3)	182 (89.7)				
Population density	High	26 (10.2)	229 (89.8)	0.712	0.422	1.2	0.201
	Low	41 (13.8)	257 (86.2)				
Toilet	Yes	32 (10.9)	261 (89.1)	0.788	0.473	1.314	0.361
	No	35 (13.5)	225 (86.5)				
Garbage disposal	Yes	62 (12.4)	436 (87.6)	1.422	0.546	3.703	0.469
	No	5 (9.1)	50 (90.9)				
Type of water	Stream	6 (8.6)	64 (91.4)	0.649	0.269	1.562	0.331
	Pump	61 (12.6)	422 (87.4)				

Table 12 (Cont.)

		Giardia lamblia					
		Positive	Negative	Odds	95% Confidence interval		Pearson Chi-square
		n (%)	n (%)	ratio	Lower	Upper	*p*
Drinking water	No treat	12 (15.4)	66 (84.6)	1.388	0.706	2.73	0.34
	Treat	55 (11.6)	420 (88.4)				
Wearing shoes	Yes	25 (12.8)	171 (87.2)	1.096	0.646	1.861	0.733
	No	42 (11.8)	315 (88.2)				
Electrical appliances	Yes	27 (11.3)	213 (88.7)	0.865	0.514	1.455	0.585
	No	40 (12.8)	273 (87.2)				
Pig	Yes	12 (8.2)	135 (91.8)	0.267	0.295	1.092	0.087
	No	55 (13.5)	351 (86.5)				
Poultry	Yes	64 (12.1)	467 (87.9)	0.868	0.25	3.015	0.823
	No	3 (13.6)	16 (86.4)				
Horse	Yes	14 (10.2)	123 (89.8)	0.78	0.418	1.454	0.433
	No	53 (12.7)	363 (87.3)				
Dog	Yes	53 (12.6)	366 (87.4)	1.241	0.665	2.317	0.497
	No	14 (10.4)	120 (89.6)				
Cat	Yes	24 (10.1)	214 (89.9)	0.709	0.417	1.206	0.203
	No	43 (13.7)	272 (86.3)				
Loose stool	Yes	16 (12.5)	112 (87.5)	1.048	0.575	1.909	0.879
	No	51 (12.0)	486 (88.0)				
Melana	Yes	4 (9.3)	39 (90.7)	0.728	0.252	2.105	0.556
	No	63 (12.4)	447 (87.6)				

Each risk factor associated with *G. lamblia* infection is shown in Table 12. Laborers, farmers and housewives had more infections than children and students, with odds ratio of 3.19 and its corespondent 95% confidence interval (1.7,6.0). People who could not read or went to school less than 3 years had more infections than people who could read, with odds ratio of 2.235 and its corespondent 95% confidence interval (1.2,4.2).

Table 13.

Association between each risk factor and *Entamoeba histolytica* in Toledo District, southern Belize.

		Entamoeba histolytica					
		Positive	Negative	Odds	95% Confidence interval		Pearson Chi-square
		n (%)	n (%)	ratio	Lower	Upper	*p*
Gender	Male	14 (5.4)	243 (94.6)	0.84	0.412	1.711	0.631
	Female	19 (6.4)	277 (93.6)				
Ethnicity	Mopan	15 (8.0)	172 (92.0)	1.686	0.83	3.426	0.145
	Ketchi	18 (4.9)	348 (95.1)				
Job	Children	22 (6.7)	307 (93.3)	1.388	0.659	2.922	0.387
	Adult	11 (4.9)	213 (95.1)				
Education level	0-3	20 (5.4)	350 (94.6)	0.747	0.363	1.538	0.428
	4+	13 (7.1)	170 (92.9)				
Floor type	Dirt	19 (5.4)	331 (94.6)	0.775	0.38	1.581	0.482
	Wooden/cement	14 (6.9)	189 (93.1)				
Population density	High	8 (3.1)	247 (96.9)	0.354	0.157	0.799	0.009*
	Low	25 (8.4)	273 (91.6)				
Toilet	Yes	20 (6.8)	273 (93.2)	1.392	0.678	2.857	0.366
	No	13 (5.0)	247 (95.0)				
Garbage disposal	Yes	31 (6.2)	467 (93.8)	1.759	0.409	7.558	0.442
	No	2 (3.6)	53 (96.4)				
Type of water	Stream	3 (4.3)	67 (95.7)	0.676	0.201	2.277	0.525
	Pump	30 (6.2)	453 (93.8)				

Table 13. (Cont.)

		Entamoeba histolytica					
		Positive	Negative	Odds	95% Confidence interval		Pearson Chi-square
		n (%)	n (%)	ratio	Lower	Upper	*p*
Drinking water	No treat	5 (6.4)	73 (93.6)	1.093	0.409	2.923	0.859
	Treat	28 (5.9)	447 (94.1)				
Wearing shoes	Yes	7 (3.6)	189 (96.4)	0.472	0.201	1.107	0.078
	No	26 (7.3)	331 (92.7)				
Electrical appliances	Yes	18 (7.5)	222 (92.5)	1.611	0.794	3.266	0.183
	No	15 (4.8)	298 (95.2)				
Pig	Yes	6 (4.1)	141 (95.9)	0.597	0.242	1.477	0.260
	No	27 (6.7)	379 (93.3)				
Poultry	Yes	32 (6.0)	499 (94.0)	1.347	0.176	10.333	0.774
	No	1 (4.5)	31 (95.5)				
Horse	Yes	9 (6.6)	128 (93.4)	1.148	0.52	2.535	0.732
	No	24 (5.8)	392 (94.2)				
Dog	Yes	18 (4.3)	401 (95.7)	0.356	0.174	0.728	0.003*
	No	15 (11.2)	119 (88.8)				
Cat	Yes	16 (6.7)	222 (93.3)	1.263	0.625	2.555	0.515
	No	17 (5.4)	298 (94.6)				
Loose stool	Yes	6 (4.7)	122 (95.3)	0.725	0.293	1.797	0.486
	No	27 (6.4)	398 (93.6)				
Melana	Yes	2 (4.0)	41 (96.0)	0.754	0.174	3.262	0.704
	No	31 (6.1)	479 (93.9)				

Risk factors associated with *E. histolytica* infection are shown in Table 13. Some were significant. People who lived in crowded houses had fewer infections than people in less crowded houses, with odds ratio of 0.35 and its corespondent 95% confidence interval (0.16,0.8). Likewise, people who had a dog had fewer infections than people who did not have a dog, with odds ratio of 0.37 and its corespondent 95% confidence interval (0.17,0.73).

Table 14.

Association between each risk factor and *Entamoeba coli* in Toledo District, southern Belize.

		Entamoeba coli					
		Positive	Negative	Odds	95% Confidence interval		Pearson Chi-square
		n (%)	n (%)	ratio	Lower	Upper	*p*
Gender	Male	50 (19.5)	207 (80.5)	0.876	0.578	1.326	0.530
	Female	64 (21.6)	232 (78.4)				
Ethnicity	Mopan	42 (22.5)	145 (77.5)	1.183	0.77	1.817	0.443
	Ketchi	72 (19.7)	294 (80.3)				
Job	Children	69 (21.0)	260 (79.0)	1.056	0.693	1.608	0.801
	Adult	45 (20.1)	179 (79.9)				
Education level	0-3	72 (19.5)	298 (80.5)	0.811	0.538	1.247	0.340
	4+	42 (23.)	141 (77.0)				
Floor type	Dirt	68 (19.4)	282 (80.6)	0.823	0.54	1.255	0.365
	Wooden/cement	46 (22.7)	157 (77.3)				
Population density	High	48 (18.8)	207 (81.2)	0.815	0.538	1.236	0.335
	Low	66 (22.1)	232 (77.9)				
Toilet	Yes	61 (20.8)	232 (79.2)	1.027	0.679	1.552	0.900
	No	53 (20.4)	207 (79.6)				
Garbage disposal	Yes	111 (22.3)	387 (77.7)	4.972	1.523	16.224	0.003*
	No	3 (5.5)	52 (94.5)				
Type of water	Stream	22 (31.4)	48 (68.6)	1.948	1.12	3.388	0.017*
	Pump	92 (19.)	391 (81.0)				

Table 14. (Cont.)

		Entamoeba coli					
		Positive	Negative	Odds	95% Confidence interval		Pearson Chi-square
		n (%)	n (%)	ratio	Lower	Upper	*p*
Drinking water	No treat	15 (19.2)	63 (80.8)	0.904	0.494	1.656	0.744
	Treat	99 (20.8)	376 (79.2)				
Wearing shoes	Yes	25 (12.8)	171 (87.2)	0.44	0.272	0.714	0.001*
	No	89 (24.9)	268 (75.1)				
Electrical appliances	Yes	62 (25.8)	178 (74.2)	1.748	1.155	2.647	0.008*
	No	52 (16.6)	261 (83.4)				
Pig	Yes	34 (23.1)	113 (76.9)	1.226	0.778	1.932	0.379
	No	80 (19.7)	326 (80.3)				
Poultry	Yes	113 (21.3)	418 (78.7)	5.677	0.755	42.66	0.057
	No	1 (4.5)	21 (95.5)				
Horse	Yes	41 (29.9)	96 (70.1)	2.007	1.287	3.13	0.002*
	No	73 (17.5)	343 (82.5)				
Dog	Yes	87 (20.8)	332 (79.2)	1.038	0.64	1.684	0.878
	No	27 (20.1)	107 (79.9)				
Cat	Yes	60 (25.2)	178 (74.8)	1.629	1.077	2.465	0.020*
	No	54 (17.1)	261 (82.9)				
Loose stool	Yes	16 (12.5)	112 (87.5)	0.477	0.269	0.843	0.010*
	No	98 (23.1)	327 (76.9)				
Melana	Yes	4 (9.3)	39 (90.7)	0.373	0.13	1.066	0.056
	No	110 (21.6)	400 (78.4)				

Each risk factor associated with *E. coli* infection is shown in Table 14. People who bury or burn their trash had more infections than people who indiscriminately dispose of their trash, with odds ratio of 4.97 and its corespondent 95% confidence interval (1.52,16.22). People using stream water had more infections than people using pump water, with odds ratio of 1.95 and its corespondent 95% confidence interval (1.12,3.38). People wearing shoes had fewer infections than people who did not wear shoes, with odds ratio of 0.44 and its corespondent 95% confidence interval (0.27,0.71). People who had electrical appliance in the house had more infections than people without electrical appliance, with odds ratio of 1.75 and its corespondent 95% confidence interval (1.16,2.65). People who had horses had more infections than people who did not have a horse, with odds ratio of 2.01 and its corespondent 95% confidence interval (1.29,3.13). People who had cats had more infections than people who did not have a cat, with odds ratio of 1.63 and its corespondent 95% confidence interval (1.01,2.46).

Table 15.

Association between each risk factor and parasitic infections in Toledo District, southern Belize.

		Positive for parasites					
		Positive	Negative	Odds	95% Confidence interval		Pearson Chi-square
		n (%)	n (%)	ratio	Lower	Upper	*p*
Gender	Male	187 (72.8)	70 (27.2)	0.752	0.51	1.109	0.15
	Female	231 (78.)	65 (22.0)				
Ethnicity	Mopan	131 (70.1)	56 (29.9)	0.644	0.432	0.961	0.030*
	Ketchi	287 (78.4)	79 (21.6)				
Job	Children	241 (73.3)	88 (26.7)	0.727	0.486	1.089	0.121
	Adult	177 (79.)	47 (21.0)				
Education level	0-3	274 (74.1)	96 (25.9)	0.773	0.506	1.181	0.233
	4+	144 (78.7)	39 (21.3)				
Floor type	Dirt	264 (75.4)	86 (24.6)	0.977	0.653	1.462	0.909
	Wooden/cement	154 (75.9)	49 (24.1)				
Population density	High	199 (78.)	56 (22.0)	1.282	8.66	1.898	0.214
	Low	219 (73.5)	79 (26.5)				
Toilet	Yes	216 (73.7)	77 (26.3)	0.581	0.545	1.191	0.278
	No	202 (77.7)	58 (22.3)				
Garbage disposal	Yes	382 (76.7)	116 (23.3)	1.738	0.96	3.146	0.065
	No	36 (65.5)	19 (34.5)				
Type of water	Stream	58 (82.9)	12 (17.1)	1.651	0.858	3.177	0.13
	Pump	360 (74.5)	123 (25.5)				

Table 15. (Cont.)

		Positive for parasites					
		Positive	Negative	Odds	95% Confidence interval		Pearson Chi-square
		n (%)	n (%)	ratio	Lower	Upper	*p*
Drinking water	No treat	67 (85.9)	11 (14.1)	2.152	1.101	4.204	0.022*
	Treat	351 (73.9)	124 (26.1)				
Wearing shoes	Yes	136 (69.4)	60 (30.6)	0.603	0.406	0.896	0.012*
	No	282 (79.)	75 (21.0)				
Electrical appliances	Yes	176 (73.3)	64 (26.7)	0.807	0.564	1.191	0.280
	No	242 (77.3)	71 (22.7)				
Pig	Yes	112 (76.2)	35 (23.8)	1.046	0.672	1.626	0.843
	No	306 (75.4)	100 (24.6)				
Poultry	Yes	402 (75.7)	129 (24.3)	1.169	0.448	3.049	0.750
	No	16 (72.7)	6 (27.3)				
Horse	Yes	103 (75.2)	34 (24.8)	0.971	0.621	1.52	0.899
	No	315 (75.7)	101 (24.3)				
Dog	Yes	322 (76.8)	97 (23.2)	1.314	0.847	2.038	0.222
	No	96 (71.6)	38 (28.4)				
Cat	Yes	172 (72.3)	66 (27.7)	0.731	0.495	1.079	0.114
	No	246 (78.1)	69 (21.9)				
Loose stool	Yes	95 (74.2)	33 (25.8)	0.909	0.577	1.432	0.681
	No	323 (76.)	102 (24.0)				
Melana	Yes	33 (76.7)	10 (23.3)	1.071	0.513	2.236	0.854
	No	385 (75.5)	125 (24.5)				

Each risk factor associated with at least one parasite found in a specimen is shown in Table 15. Some risk factors were significant. Mayan Mopan had fewer infections than Mayan Ketchi, with odds ratio of 0.64 and its corespondent 95% confidence interval (0.43,0.96). People drinking untreated water had more infections than those drinking treated or boiled water, with odds ratio of 2.15 and its corespondent 95% confidence interval (1.1,4.24). People wearing shoes had fewer infections than people who did not wear shoes, with odds ratio of 0.6 and its corespondent 95% confidence interval (0.4,0.9).

Table 16.

Association between each risk factor and helmints in Toledo District, southern Belize.

		Positive for helminthes					
		Positive	Negative	Odds	95% Confidence interval		Pearson Chi-square
		n (%)	n (%)	ratio	Lower	Upper	*p*
Gender	Male	165 (64.2)	92 (35.8)	0.784	0.549	1.118	0.178
	Female	206 (69.6)	90 (30.4)				
Ethnicity	Mopan	113 (60.4)	74 (39.6)	0.639	0.442	0.925	0.017*
	Ketchi	258 (70.5)	108 (29.5)				
Job	Children	202 (61.4)	127 (38.6)	0.518	0.355	0.754	0.001*
	Adult	169 (75.4)	55 (24.6)				
Education level	0-3	233 (63.0)	137 (37.0)	0.555	0.373	0.825	0.003*
	4+	138 (75.4)	45 (24.6)				
Floor type	Dirt	238 (68.0)	112 (32.0)	1.118	0.775	1.613	0.549
	Wooden/cement	133 (65.0)	70 (35.0)				
Population density	High	185 (72.5)	70 (27.5)	1.591	1.109	2.284	0.011*
	Low	186 (62.4)	112 (37.6)				
Toilet	Yes	192 (65.5)	101 (34.5)	0.86	0.602	1.228	0.407
	No	179 (68.8)	81 (31.2)				
Garbage disposal	Yes	338 (67.9)	160 (32.1)	1.408	0.795	2.494	0.238
	No	33 (60.)	22 (40.0)				
Type of water	Stream	51 (72.9)	19 (27.1)	1.367	0.781	2.393	0.272
	Pump	320 (66.3)	163 (33.7)				

Table 16. (Cont.)

		Positive for helminthes					
		Positive	Negative	Odds	95% Confidence interval		Pearson Chi-square
		n (%)	n (%)	ratio	Lower	Upper	*p*
Drinking water	no treat	62 (79.5)	16 (20.5)	2.082	1.164	3.722	0.012*
	Treat	309 (65.1)	166 (34.9)				
Wearing shoes	Yes	119 (60.7)	77 (39.3)	0.644	0.447	0.929	0.018*
	No	252 (70.6)	105 (29.4)				
Electrical appliances	Yes	153 (63.8)	87 (36.2)	0.766	0.536	1.095	0.143
	No	218 (69.6)	95 (30.4)				
Pig	Yes	101 (68.7)	46 (31.3)	1.106	0.738	1.658	0.626
	No	270 (66.5)	136 (33.5)				
Poultry	Yes	357 (67.2)	174 (32.8)	1.172	0.483	2.847	0.725
	No	14 (63.6)	8 (36.4)				
Horse	Yes	87 (63.5)	50 (36.5)	0.809	0.54	1.212	0.303
	No	284 (68.4)	132 (31.6)				
Dog	Yes	287 (68.5)	132 (31.5)	1.294	0.862	1.943	0.213
	No	84 (62.7)	50 (37.3)				
Cat	Yes	150 (63.)	88 (37.0)	0.725	0.507	1.036	0.077
	No	221 (70.2)	94 (29.8)				
Loose stool	Yes	81 (63.3)	47 (36.7)	0.802	0.531	1.213	0.296
	No	290 (68.2)	135 (31.8)				
Melana	Yes	30 (69.8)	13 (30.2)	1.144	0.581	2.249	0.697
	No	341 (66.9)	169 (33.1)				

Each risk factor associated with at least one helminth found in a specimen is shown in Table 16. Mayan Mopan had fewer infections than Mayan Ketchi, with odds ratio of 0.64 and its corespondent 95% confidence interval (0.44,0.92). Laborers, farmers and housewives also had fewer infections than children and students, with odds ratio of 0.52 and its corespondent 95% confidence interval (0.34,0.75). People who could not read had fewer infections than people who had had school more than 4 years, with odds ratio of 0.56 and its corespondent 95% confidence interval (0.37,0.83). People who lived in crowded houses had more infections than people in less crowded houses, with odds ratio of 1.59 and its corespondent 95% confidence interval (1.11,2.28). People drinking untreated water had more infections than those drinking treated or boiled water, with odds ratio of 2.08 and its corespondent 95% confidence interval (1.16,3.72). People wearing shoes had fewer infections than people who did not wear shoes, with odds ratio of 0.64 and its corespondent 95% confidence interval (0.45,0.93).

Table 17.

Association between each risk factor and protozoa in Toledo District, southern Belize.

		Positive for protozoa					
		Positive	Negative	Odds	95% Confidence interval		Pearson Chi-square
		n (%)	n (%)	ratio	Lower	Upper	*p*
Gender	Male	91 (35.4)	166 (64.6)	1.125	0.791	1.600	0.514
	Female	97 (32.8)	199 (67.2)				
Ethnicity	Mopan	67 (35.8)	120 (64.2)	1.131	0.781	1.636	0.516
	Ketchi	121 (33.1)	245 (66.9)				
Job	Children	121 (36.8)	208 (63.2)	1.363	0.948	1.960	0.094
	Adult	67 (29.9)	157 (70.1)				
Education level	0-3	132 (35.7)	238 (64.3)	1.258	0.860	1.838	0.236
	4+	56 (30.6)	127 (69.4)				
Floor type	Dirt	114 (32.6)	236 (67.4)	0.842	0.586	1.210	0.353
	Wooden/cement	74 (36.5)	129 (63.5)				
Population density	High	76 (29.8)	179 (70.2)	0.705	0.494	1.007	0.054
	Low	112 (37.6)	186 (62.4)				
Toilet	Yes	98 (33.4)	195 (66.6)	0.949	0.667	1.350	0.772
	No	90 (34.6)	170 (65.4)				
Garbage disposal	Yes	180 (36.1)	318 (63.9)	3.325	1.537	7.194	0.001*
	No	8 (14.5)	47 (85.5)				
Type of water	Stream	33 (47.1)	37 (52.9)	1.887	1.137	3.133	0.013*
	Pump	155 (32.1)	328 (67.9)				

Table 17. (Cont.)

Positive for protozoa							
		Positive n (%)	Negative n (%)	Odds ratio	95% Confidence interval Lower	Upper	Pearson Chi-square *p*
Drinking water	No treat	28 (35.9)	50 (64.1)	1.103	0.669	1.818	0.702
	Treat	160 (33.7)	315 (66.3)				
Wearing shoes	Yes	58 (29.6)	138 (70.4)	0.734	0.504	1.068	0.105
	No	130 (36.4)	227 (63.6)				
Electrical appliances	Yes	87 (36.3)	153 (63.7)	1.194	0.838	1.701	0.327
	No	101 (32.3)	212 (67.7)				
Pig	Yes	53 (36.1)	94 (63.9)	1.132	0.763	1.68	0.539
	No	135 (33.3)	271 (66.7)				
Poultry	Yes	185 (34.8)	346 (65.2)	3.386	0.989	11.593	0.040*
	No	3 (13.6)	19 (86.4)				
Horse	Yes	56 (40.9)	81 (59.1)	1.487	0.999	2.215	0.050
	No	132 (31.7)	284 (68.3)				
Dog	Yes	143 (34.1)	276 (65.9)	1.025	0.679	1.546	0.907
	No	45 (33.6)	89 (66.4)				
Cat	Yes	84 (35.3)	154 (64.7)	1.107	0.776	1.578	0.575
	No	104 (33.)	211 (67.0)				
Loose stool	Yes	41 (32.)	87 (68.0)	0.891	0.585	1.359	0.592
	No	147 (34.6)	278 (65.4)				
Melana	Yes	12 (27.9)	31 (72.1)	0.735	0.368	1.466	0.38
	No	176 (34.5)	334 (65.5)				

Each risk factor associated with at least one protozoan parasite found in the specimen is listed in Table 17. People who destroyed their trash had more infections than people who indiscriminately disposed of their trash, with odds ratio of 3.32 and its corespondent 95% confidence interval (1.54,7.19). People using stream water had more infections than those using water from a pump, with odds ratio of 1.89 and its corespondent 95% confidence interval (1.14,3.13). People who had poultry had more infections than people who did not have poultry, with odds ratio of 3.39 and its corespondent 95% confidence interval (0.99,11.59).

Table 18.

Results of logistic regression analyses of *Ascaris lumbricoides* prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	-1.329	0.846	0.116			
Age	-0.003	0.011	0.765	0.997	0.975	1.017
Sex (1=male, 0=female)	-0.031	0.240	0.898	0.969	0.606	1.553
Race (1= Ketchi, 0=Mopan)	0.672	0.275	0.014*	1.958	1.144	3.447
Occupation (0=labour)			0.299			
Pre-school	0.564	0.529	0.286	1.750	0.623	4.961
Student	0.760	0.420	0.070	2.131	0.939	4.869
Housework	0.419	0.397	0.290	1.521	0.699	3.310
Education level	0.055	0.037	0.137	1.056	0.983	1.136
Floor (1=dirt, 0=w/c)	-0.054	0.247	0.826	0.947	0.584	1.536
Density group (1=high, 0=low)	0.380	0.214	0.075	1.462	0.961	2.223
Toilet (1=yes, 0=no)	0.214	0.247	0.307	1.238	0.763	2.009
Trash (1=yes, 0=no)	0.260	0.372	0.403	1.298	0.626	2.687
Water (1=stream, 0=pump)	1.067	0.330	0.001*	2.908	1.524	5.547
Water treatment (1=yes, 0=no)	-0.446	0.297	0.133	0.640	0.358	1.145
Electrical appliance (1=yes, 0=no)	-0.455	0.223	0.041*	0.635	0.410	0.982
Pig (1=yes, 0=no)	-0.176	0.262	0.503	0.839	0.502	1.403
Poultry (1=yes, 0=no)	-0.302	0.615	0.623	0.739	0.221	2.468
Horse (1=yes, 0=no)	-0.022	0.279	0.003*	0.440	0.255	0.759
Dog (1=yes, 0=no)	0.357	0.297	0.229	1.429	0.799	2.555
Cat (1=yes, 0=no)	-0.059	0.238	0.804	0.943	0.592	1.502
Wearing shoes (1=yes, 0=no)	-0.437	0.231	0.058	0.646	0.411	1.015

Table 19.

Results of logistic regression analyses of *Ascaris lumbricoides* prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.
The variables were selected by the forward stepwise method.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	-1.822	0.310	0.000			
Race (1= Ketchi, 0=Mopan)	0.766	0.228	0.001	2.152	1.377	3.362
Occupation (0=labour)			0.012			
Pre-school	0.350	0.319	0.273	1.419	0.759	2.652
Student	0.863	0.288	0.003	2.370	1.348	4.167
Housework	0.343	0.323	0.287	1.410	0.749	2.653
Water (1=stream, 0=pump)	1.006	0.292	0.006	2.734	1.542	4.847
Horse (1=yes, 0=no)	-0.821	0.259	0.002	0.440	0.265	0.731

Table 20.

Results of logistic regression analyses of *Ascaris lumbricoides* prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection. The variables were selected by the backward stepwise method.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	-1.197	0.406	0.003			
Race (1= Ketchi, 0=Mopan)	0.747	0.234	0.001	2.110	1.335	3.335
Occupation (0=labour)			0.008			
Pre-school	0.557	0.339	0.101	1.745	0.898	3.392
Student	0.953	0.294	0.001	2.595	1.458	4.618
Housework	0.417	0.327	0.203	1.518	0.799	2.883
Water (1=stream, 0=pump)	1.107	0.297	0.000	3.024	1.689	5.414
Water treatment (1=yes, 0=no)	-0.493	0.271	0.068	0.611	0.359	1.038
Electrical appliance (1=yes, 0=no)	-0.364	0.202	0.071	0.695	0.468	1.032
Horse (1=yes, 0=no)	-0.803	0.263	0.002	0.448	0.268	0.750
Wearing shoes (1=yes, 0=no)	-0.461	0.223	0.039	0.631	0.408	0.976

Logistic regression analyses were used to identify risk factors of parasite infections after adjusting for other risk factors.

Table 18-20 show the risk factors significantly associated with *A. lumbricoides*. The factors were selected by full model, forward stepwise and backward stepwise methods, respectively.

Table 18 shows the result of logistic regression analyses that were adjusted for all other risk factors. The factors significantly associated with cases of *A. lumbricoides* as risk factors are Mayan Ketchi ancestry and use of stream water; protective factors are ownership of electrical appliances and/or horses.

Table 19 is a result of selecting variables with the forward stepwise method, i.e., choosing the risk factors that were associated significantly with *A. lumbricoides* infection. These risk factors are used in the model to predict the chance of infection. Risk factors include Mayan Ketchi, pre-school age children, students, houseworkers and using stream water. A protective factor is ownership of horses.

Table 20 is a result of selecting variables with the backward stepwise method i.e., choosing the factors that were significantly associated with the parasite. These factors are used in the model to predict the chance of the infection. The factors are similar to Tables 18 and 19. The risk factors are Mayan Ketchi, pre-school children, students, houseworkers and using stream water. The protective factors are treated drinking water, wearing shoes, and ownership of electrical appliances and horses.

Table 21.

Results of logistic regression analyses of hookworm prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	0.067	0.781	0.932			
Age	-0.003	0.010	0.753	0.997	0.978	1.016
Sex (1=male, 0=female)	-0.240	0.225	0.286	0.787	0.507	1.222
Race (1= Ketchi, 0=Mopan)	-0.023	0.246	0.928	0.978	0.603	1.586
Occupation (0=labour)			0.001*			
Pre-school	-1.139	0.460	0.018	0.320	0.125	0.820
Student	-0.387	0.376	0.303	0.679	0.325	1.418
Housework	0.695	0.364	0.056	2.005	0.982	4.093
Year of education	0.061	0.036	0.088	1.063	0.991	1.140
Floor (1=dirt, 0=w/c)	0.324	0.224	0.148	1.383	0.891	2.147
Density group (1=high, 0=low)	0.644	0.201	0.001*	1.904	1.283	2.826
Toilet (1=yes, 0=no)	-0.014	0.228	0.951	0.986	0.631	1.540
Trash (1=yes, 0=no)	0.503	0.348	0.149	1.654	0.836	3.273
Water (1=stream, 0=pump)	0.201	0.319	0.527	1.223	0.655	2.284
Water treatment (1=yes, 0=no)	-0.371	0.298	0.212	0.690	0.385	1.237
Electrical appliance (1=yes, 0=no)	-0.311	0.208	0.124	0.727	0.484	1.092
Pig (1=yes, 0=no)	0.294	0.238	0.217	1.342	0.041	2.141
Poultry (1=yes, 0=no)	0.048	0.562	0.932	1.049	0.349	3.160
Horse (1=yes, 0=no)	-0.209	0.241	0.384	0.811	0.506	1.300
Dog (1=yes, 0=no)	-0.184	0.268	0.493	0.832	0.492	1.407
Cat (1=yes, 0=no)	0.056	0.218	0.790	1.060	0.691	1.625
Wearing shoes (1=yes, 0=no)	-0.153	0.215	0.478	0.858	0.563	1.301

Table 22.
Results of logistic regression analyses of hookworm prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.
The variables were selected by the forward stepwise method.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	0.061	0.210	0.770			
Occupation (0=labour)			0.001			
Pre-school	-1.157	0.281	0.000	0.314	0.181	0.545
Student	-0.197	0.247	0.425	0.821	0.505	1.330
Housework	0.863	0.294	0.003	2.370	1.330	4.220
Density group (1=high, 0=low)	0.654	0.185	0.004	1.924	1.337	2.768

Table 23.
Results of logistic regression analyses of hookworm prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.
The variables were selected by the backward stepwise method.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	0.009	0.249	0.970			
Occupation (0=labour)			<0.001			
Pre-school	-0.989	0.300	0.001	0.372	0.207	0.669
Student	-0.229	0.250	0.360	0.795	0.487	1.298
Housework	0.894	0.296	0.003	2.444	1.368	4.367
Year of education	0.060	0.034	0.078	1.061	0.993	1.134
Density group (1=high, 0=low)	0.654	0.187	0.001	1.923	1.332	2.776
Electrical appliance (1=yes, 0=no)	-0.320	0.188	0.089	0.726	0.502	1.050

Table 21 shows the result of logistic regression analyses which adjust for all other variables. The risk factors that are significantly associated with hookworm infection are houseworkers and living in overcrowded houses.

Tables 22 and 23 show the results of the logistic regression method with forward stepwise and backward stepwise method selection, respectively. In forward stepwise method, the significant risk factor are houseworkers, and living in overcrowded houses.

Backward stepwise selection identified additional risk factors from Table 22. People with more education had a higher risk of hookworm infection, and people who owned electrical appliances were at less risk of infection.

Table 24.

Results of logistic regression analyses of *Trichuris trichiura* prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	-0.116	0.924	0.900			
Age	-0.020	0.014	0.163	0.980	0.954	1.008
Sex (1=male, 0=female)	0.116	0.277	0.676	1.123	0.652	1.933
Race (1= Ketchi, 0=Mopan)	0.077	0.339	0.820	1.080	0.556	2.097
Occupation (0=labour)			0.643			
Pre-school	-0.549	0.614	0.371	0.578	0.174	1.923
Student	-0.072	0.486	0.082	0.931	0.359	2.412
Housework	-0.007	0.464	0.981	0.994	0.401	2.465
Year of education	-0.025	0.044	0.574	0.975	0.895	1.064
Floor (1=dirt, 0=w/c)	0.167	0.298	0.575	1.182	0.659	2.120
Density group (1=high, 0=low)	0.877	0.255	0.001*	2.404	1.458	3.964
Toilet (1=yes, 0=no)	-0.543	0.290	0.061	0.581	0.329	1.026
Trash (1=yes, 0=no)	0.586	0.434	0.177	1.797	0.767	4.210
Water (1=stream, 0=pump)	0.122	0.419	0.772	1.129	0.497	2.567
Water treatment (1=yes, 0=no)	-0.707	0.346	0.041*	0.493	0.250	0.972
Electrical appliance (1=yes, 0=no)	-0.194	0.255	0.447	0.824	0.500	1.358
Pig (1=yes, 0=no)	-0.621	0.328	0.059	0.538	0.282	1.023
Poultry (1=yes, 0=no)	-1.338	0.670	0.040*	0.252	0.068	0.936
Horse (1=yes, 0=no)	-0.224	0.328	0.494	0.799	0.421	1.519
Dog (1=yes, 0=no)	0.345	0.346	0.318	1.412	0.717	2.781
Cat (1=yes, 0=no)	0.503	0.276	0.069	1.654	0.963	2.842
Wearing shoes (1=yes, 0=no)	-0.252	0.268	0.347	0.777	0.459	1.314

Table 25.
Results of logistic regression analyses of *Trichuris trichiura* prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.
The variables were selected by the forward stepwise method.

				Odds	95% CI	
Independent Variable	*b*	(SE)	*p*	ratio	Upper	Lower
Constant	-1.597	0.224	0.000			
Density group (1=high, 0=low)	0.960	0.237	0.000	2.613	1.642	4.158
Toilet (1=yes, 0=no)	-0.517	0.232	0.026	0.596	0.379	0.940
Pig (1=yes, 0=no)	-0.634	0.278	0.023	0.531	0.308	0.914

Table 26.
Results of logistic regression analyses of *Trichuris trichiura* prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.
The variables were selected by the backward stepwise method.

				Odds	95% CI	
Independent Variable	*b*	(SE)	*p*	ratio	Upper	Lower
Constant	-1.094	0.353	0.002			
Density group (1=high, 0=low)	0.933	0.238	0.000	2.541	1.594	4.049
Toilet (1=yes, 0=no)	-0.585	0.237	0.014	0.557	0.350	0.886
Water treatment (1=yes, 0=no)	-0.553	0.304	0.069	0.575	0.317	1.045
Pig (1=yes, 0=no)	-0.587	0.279	0.035	0.556	0.322	0.959

Table 24 shows the risk factors that were significantly associated with *Trichuris trichiura* infection after adjusting for all other factors. The risk factor is an overcrowded house. The protective factors are treated drinking water and ownership of poultry.

Table 25 is a result of using the forward stepwise method of choosing the risk factors that were significantly associated with *T. trichiura* infection. The risk factor is an overcrowded house. The protective factors are using toilet and ownership of pigs.

Table 26 is a result of the backward stepwise method of choosing the risk factors that were significantly associated with *T. trichiura* infection. The result is similar to the forward stepwise selection with addition of treated drinking water as a protective factor.

Table 27.

Results of logistic regression analyses of *Giardia lamblia* prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	-1.829	1.288	0.156			
Age	-0.034	0.022	0.127	0.967	0.926	1.010
Sex (1=male, 0=female)	0.624	0.313	0.046*	1.667	1.011	3.448
Race (1= Ketchi, 0=Mopan)	0.390	0.395	0.323	1.477	0.681	3.205
Occupation (0=labour)			0.631			
Pre-school	0.775	0.885	0.381	2.171	0.364	12.292
Student	0.860	0.762	0.259	2.362	0.531	10.513
Housework	0.781	0.670	0.244	2.184	0.587	8.121
Year of education	-0.130	0.065	0.045	0.878	0.773	0.998
Floor (1=dirt, 0=w/c)	0.420	0.338	0.215	1.521	0.784	2.952
Density group (1=high, 0=low)	-0.764	0.303	0.012*	0.466	0.257	0.844
Toilet (1=yes, 0=no)	-0.191	0.331	0.565	0.827	0.432	1.581
Trash (1=yes, 0=no)	0.412	0.572	0.471	1.511	0.493	4.630
Water (1=stream, 0=pump)	-0.520	0.516	0.314	0.595	0.216	1.635
Water treatment (1=yes, 0=no)	-0.169	0.406	0.677	0.845	0.382	1.870
Electrical appliance (1=yes, 0=no)	-0.029	0.308	0.926	0.972	0.532	1.777
Pig (1=yes, 0=no)	-0.529	0.386	0.170	0.589	0.276	1.255
Poultry (1=yes, 0=no)	-0.733	0.806	0.364	0.481	0.099	2.334
Horse (1=yes, 0=no)	0.056	0.371	0.880	1.058	0.512	2.187
Dog (1=yes, 0=no)	0.483	0.402	0.229	1.622	0.738	3.561
Cat (1=yes, 0=no)	-0.252	0.322	0.433	0.777	0.414	1.459
Wearing shoes (1=yes, 0=no)	-0.394	0.317	0.214	0.675	0.363	1.255

Table 28.

Results of logistic regression analyses of *Giardia lamblia* prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.
The variables were selected by the forward stepwise method.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	-1.353	0.190	0.000			
Age	-0.044	0.012	0.000	0.957	0.934	0.980

Table 29.

Results of logistic regression analyses of *Giardia lamblia* prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.
The variables were selected by the backward stepwise method.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	-1.466	0.359	0.000			
Age	-0.041	0.011	0.000	0.960	0.939	0.981
Sex (1=male, 0=female)	0.504	0.273	0.065	1.655	0.969	2.825
Race (1= Ketchi, 0=Mopan)	0.690	0.321	0.032	1.993	1.063	3.736
Year of education	-0.112	0.052	0.031	0.894	0.808	0.990
Density group (1=high, 0=low)	-0.633	0.284	0.026	0.531	0.304	0.927
Pig (1=yes, 0=no)	-0.610	0.348	0.079	0.543	0.275	1.073

Table 27 shows the factors significantly associated with *Giardia lamblia* infection after adjusting for other factors. The risk factor is being a male. The protective factor is living in overcrowded house.

Table 28 is a result of forward stepwise method of choosing the factors that are significantly associated with *G. lamblia*. The factors are used in the model to predict the chance of infection. The protective factor is age. Older persons had a lower risk of giardiasis [0.96 (0.93,0.98)] than younger residents.

Table 29 is a result of backward stepwise method of choosing the factors that significantly associate with *G. lamblia*. The risk factors are the male sex and Mayan Ketchi ancestry. The protective factors are older age, higher year of education, overcrowded houses and ownership of pigs.

Table 30.

Results of logistic regression analyses of *Entomoeba histolytica* prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	-2.699	1.730	0.119			
Age	0.002	0.020	0.914	1.002	0.963	1.043
Sex (1=male, 0=female)	-0.111	0.443	0.082	0.895	0.376	2.131
Race (1= Ketchi, 0=Mopan)	-0.125	0.501	0.803	0.883	0.331	2.357
Occupation (0=labour)			0.753			
Pre-school	0.804	1.092	0.462	2.234	0.263	19.001
Student	0.927	0.886	0.296	2.526	0.445	14.332
Housework	0.377	0.776	0.627	1.457	0.319	6.663
Year of education	-0.068	0.075	0.367	0.935	0.807	1.082
Floor (1=dirt, 0=w/c)	-0.311	0.459	0.499	0.733	0.298	1.803
Density group (1=high, 0=low)	-0.831	0.458	0.070	0.436	0.178	1.069
Toilet (1=yes, 0=no)	-0.067	0.494	0.893	0.936	0.355	2.463
Trash (1=yes, 0=no)	-0.292	0.086	0.742	0.747	0.131	4.249
Water (1=stream, 0=pump)	0.202	0.719	0.770	1.224	0.299	5.006
Water treatment (1=yes, 0=no)	-0.238	0.599	0.692	0.788	0.244	2.553
Electrical appliance (1=yes, 0=no)	0.284	0.432	0.511	1.328	0.570	3.096
Pig (1=yes, 0=no)	-0.423	0.559	0.450	0.655	0.219	1.961
Poultry (1=yes, 0=no)	1.323	1.253	0.291	3.754	0.322	43.763
Horse (1=yes, 0=no)	-0.143	0.474	0.762	0.867	0.343	2.192
Dog (1=yes, 0=no)	-0.942	0.488	0.054	0.390	0.150	1.015
Cat (1=yes, 0=no)	0.303	0.436	0.487	1.354	0.576	3.183
Wearing shoes (1=yes, 0=no)	-0.890	0.498	0.074	0.411	0.155	1.091

Table 31.

Results of logistic regression analyses of *Entomoeba histolytica* prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.
The variables were selected by the forward stepwise method.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	-1.873	0.285	0.000			
Density group (1=high, 0=low)	-0.878	0.424	0.038	0.416	0.181	0.954
Dog (1=yes, 0=no)	-0.865	0.372	0.020	0.421	0.203	0.874

Table 32.

Results of logistic regression analyses of *Entomoeba histolytica* prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.
The variables were selected by the backward stepwise method.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	-1.873	0.285	0.000			
Density group (1=high, 0=low)	-0.878	0.424	0.038	0.416	0.181	0.954
Dog (1=yes, 0=no)	-0.865	0.372	0.020	0.421	0.203	0.874

Table 30, there are no factors significantly associated with *Entamoeba histolytica* infection after controlling for other factors.

Tables 31 and 32 are results of forward stepwise and backward stepwise method of choosing the risk factors that are significantly associated with *E. histolytica* infection. The factors are used in the model to predict the chance of infection. The protective factors are living in overcrowded house and ownership of dogs.

Table 33.

Results of logistic regression analyses of *Entomoeba coli* prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	-3.628	1.354	0.007			
Age	0.018	0.013	0.153	0.982	0.958	1.007
Sex (1=male, 0=female)	0.047	0.273	0.864	1.048	0.614	1.788
Race (1= Ketchi, 0=Mopan)	0.314	0.300	0.295	1.369	0.761	2.464
Occupation (0=labour)			0.350			
Pre-school	-0.164	0.600	0.785	0.849	0.262	2.753
Student	0.224	0.462	0.627	1.252	0.506	3.099
Housework	0.607	0.437	0.165	1.835	0.779	4.322
Year of education	-0.036	0.042	0.394	0.965	0.889	1.047
Floor (1=dirt, 0=w/c)	-0.033	0.272	0.902	0.967	0.568	1.647
Density group (1=high, 0=low)	-0.046	0.246	0.853	0.956	0.590	1.547
Toilet (1=yes, 0=no)	-0.148	0.273	0.587	0.862	0.505	1.472
Trash (1=yes, 0=no)	1.316	0.657	0.045*	3.729	1.030	13.502
Water (1=stream, 0=pump)	1.003	0.357	0.005*	2.727	1.355	5.487
Water treatment (1=yes, 0=no)	-0.282	0.364	0.438	0.754	0.370	1.538
Electrical appliance (1=yes, 0=no)	0.435	0.250	0.082	1.544	0.947	2.510
Pig (1=yes, 0=no)	0.109	0.294	0.711	1.115	0.627	1.984
Poultry (1=yes, 0=no)	1.277	1.118	0.253	3.587	0.401	32.065
Horse (1=yes, 0=no)	0.317	0.267	0.234	1.374	0.814	2.316
Dog (1=yes, 0=no)	-0.401	0.318	0.207	0.670	0.359	1.249
Cat (1=yes, 0=no)	0.544	0.261	0.037*	1.723	1.033	2.876
Wearing shoes (1=yes, 0=no)	-0.902	0.288	0.002*	0.406	0.231	0.713

Table 34.
Results of logistic regression analyses of *Entomoeba coli* prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.
The variables were selected by the forward stepwise method.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	-2.946	0.623	0.000			
Trash (1=yes, 0=no)	1.565	0.612	0.011	4.782	1.442	15.854
Water (1=stream, 0=pump)	0.763	0.297	0.010	2.145	1.199	3.837
Cat (1=yes, 0=no)	0.550	0.220	0.013	1.734	1.126	2.670
Wearing shoes (1=yes, 0=no)	-0.802	0.253	0.002	0.449	0.273	0.736

Table 35.
Results of logistic regression analyses of *Entomoeba coli* prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.
The variables were selected by the backward stepwise method.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	-2.848	0.636	0.000			
Age	-0.012	0.007	0.107	0.990	0.975	1.003
Trash (1=yes, 0=no)	1.530	0.616	0.013	4.619	1.380	15.462
Water (1=stream, 0=pump)	0.811	0.301	0.007	2.250	1.248	4.057
Electrical appliance (1=yes,0=no)	0.384	0.225	0.089	1.468	0.945	2.281
Cat (1=yes, 0=no)	0.483	0.226	0.032	1.621	1.042	2.523
Wearing shoes (1=yes, 0=no)	-0.871	0.265	0.001	0.418	0.249	0.703

Table 33 shows factors that are significantly associated with *Entamoeba coli* infection after controlling for all other factors. The risk factors are using toilets, disposal of trash and ownership of cats. The protective factor associated with infection is wearing shoes.

Table 34 is a result of forward stepwise method of choosing risk factors. The results are the same as listed in Table 33.

Table 35 is a result of backward stepwise method of choosing risk. The result is also similar to Tables 33 and 34, but with an additional risk factor, ownership of electrical appliances.

Table 36.

Results of logistic regression analyses of parasites prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	1.591	0.892	0.074			
Age	-0.005	0.011	0.629	0.995	0.974	1-0160
Sex (1=male, 0=female)	-0.090	0.254	0.723	0.914	0.556	1.503
Race (1= Ketchi, 0=Mopan)	0.408	0.274	0.137	1.503	0.878	2.572
Occupation (0=labour)			0.006*			
Pre-school	-0.561	0.540	0.298	0.571	0.198	1.643
Student	0.370	0.431	0.390	1.448	0.622	3.368
Housework	0.794	0.411	0.058	2.212	0.974	5.023
Year of education	-0.005	0.042	0.910	0.995	0.918	1.080
Floor (1=dirt, 0=w/c)	-0.061	0.255	0.811	0.941	0.571	1.551
Density group (1=high, 0=low)	0.300	0.229	0.190	1.350	0.862	2.115
Toilet (1=yes, 0=no)	-0.158	0.263	0.548	0.854	0.511	1.429
Trash (1=yes, 0=no)	0.778	0.367	0.034*	2.177	1.060	4.471
Water (1=stream, 0=pump)	0.601	0.383	0.116	1.825	0.862	3.864
Water treatment (1=yes, 0=no)	-0.784	0.384	0.041*	0.457	0.215	0.970
Electrical appliance (1=yes, 0=no)	-0.272	0.234	0.246	0.762	0.481	1.206
Pig (1=yes, 0=no)	0.184	0.271	0.497	1.202	0.707	2.042
Poultry (1=yes, 0=no)	-0.519	0.611	0.395	0.595	0.180	1.969
Horse (1=yes, 0=no)	-0.067	0.272	0.749	0.917	0.538	1.563
Dog (1=yes, 0=no)	0.068	0.296	0.819	1.070	0.597	1.912
Cat (1=yes, 0=no)	-0.097	0.245	0.687	0.906	0.561	1.464
Wearing shoes (1=yes, 0=no)	-0.495	0.241	0.040*	0.609	0.380	0.977

Table 37.

Results of logistic regression analyses of parasites prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.
The variables were selected by the forward stepwise method.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	1.652	0.387	0.000			
Occupation (0=labour)			0.000			
Pre-school	-0.517	0.287	0.072	0.596	0.340	1.046
Student	0.479	0.283	0.091	1.614	0.926	2.812
Housework	0.774	0.338	0.022	2.168	1.119	4.203
Water treatment (1=yes, 0=no)	-0.784	0.348	0.024	0.457	0.231	0.902

Table 38.

Results of logistic regression analyses of parasites prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.
The variables were selected by the backward stepwise method.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	1.369	0.436	0.002			
Race (1= Ketchi, 0=Mopan)	0.464	0.218	0.033	1.591	1.038	2.440
Occupation (0=labour)			0.001			
Pre-school	-0.298	0.312	0.339	0.742	0.403	1.367
Student	0.552	0.289	0.056	1.737	0.986	3.060
Housework	0.854	0.343	0.013	2.350	1.200	4.603
Water (1=stream, 0=pump)	0.820	0.348	0.018	2.271	1.148	4.492
Water treatment (1=yes, 0=no)	-0.820	0.358	0.022	0.441	0.219	0.888
Wearing shoes (1=yes, 0=no)	-0.461	0.230	0.045	0.631	0.402	0.990

Table 36 shows the factors that are significantly associated with positive parasite infections, after controlling for all other factors. The risk factors are houseworkers and disposal of garbage. The protective factors are using treated drinking water and wearing shoes.

Table 37 is a result of forward stepwise method of choosing the risk factors that are significantly associated with presence of parasites. The risk factor is being a houseworker. The protective factor is using treated drinking water.

Table 38 is a result of backward stepwise method of choosing the factors that are significantly associated with presence of parasites. The result is the same as Table 37, with additional risk factors of Mayan Ketchi ancestry and using water from a stream.

Table 39.

Results of logistic regression analyses of helminth prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	0.829	0.829	0.317			
Age	-0.004	0.010	0.704	0.996	0.976	1.016
Sex (1=male, 0=female)	-0.056	0.233	0.810	0.946	0.599	1.493
Race (1= Ketchi, 0=Mopan)	0.378	0.256	0.140	1.459	0.883	2.409
Occupation (0=labour)			0.007*			
Pre-school	-0.797	0.507	0.116	0.451	0.167	1.218
Student	-0.105	0.407	0.796	0.900	0.406	1.998
Housework	0.783	0.392	0.046	2.190	1.016	4.718
Year of education	0.062	0.039	0.113	1.064	0.906	1.150
Floor (1=dirt, 0=w/c)	0.047	0.236	0.842	1.048	0.660	1.664
Density group (1=high, 0=low)	0.606	0.213	0.004*	1.834	1.209	2.782
Toilet (1=yes, 0=no)	0.035	0.242	0.884	1.036	0.645	1.664
Trash (1=yes, 0=no)	0.696	0.355	0.050	2.006	1.000	4.026
Water (1=stream, 0=pump)	0.496	0.339	0.144	1.643	0.845	3.194
Water treatment (1=yes, 0=no)	-0.688	0.340	0.043*	0.503	0.258	0.978
Electrical appliance (1=yes, 0=no)	-0.378	0.219	0.085	0.686	0.446	1.053
Pig (1=yes, 0=no)	0.286	0.250	0.253	1.331	0.816	2.172
Poultry (1=yes, 0=no)	-0.440	0.572	0.444	0.645	0.210	1.981
Horse (1=yes, 0=no)	-0.251	0.250	0.316	0.778	0.477	1.270
Dog (1=yes, 0=no)	0.033	0.279	0.906	1.034	0.599	1.784
Cat (1=yes, 0=no)	-0.124	0.226	0.584	0.083	0.567	1.377
Wearing shoes (1=yes, 0=no)	-0.332	0.225	0.139	0.717	0.462	1.114

Table 40.

Results of logistic regression analyses of helminth prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.
The variables were selected by the forward stepwise method.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	1.218	0.357	0.001			
Occupation (0=labour)			0.000			
Pre-school	-0.957	0.284	0.001	0.384	0.220	0.670
Student	-0.024	0.265	0.928	0.976	0.581	1.641
Housework	0.739	0.320	0.021	2.094	1.118	3.922
Density group (1=high, 0=low)	0.610	0.195	0.002	1.840	1.256	2.697
Water treatment (1=yes, 0=no)	-0.756	0.306	0.014	0.470	0.258	0.855

Table 41.

Results of logistic regression analyses of helminth prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.
The variables were selected by the backward stepwise method.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	0.411	0.522	0.431			
Race (1= Ketchi, 0=Mopan)	0.343	0.208	0.099	1.410	0.937	2.119
Occupation (0=labour)			0.000			
Pre-school	-0.768	0.308	0.013	0.464	0.254	0.840
Student	-0.072	0.270	0.791	0.931	0.548	1.561
Housework	0.709	0.325	0.015	2.200	1.164	4.157
Year of education	0.065	0.037	0.083	1.067	0.992	1.147
Density group (1=high, 0=low)	0.643	0.205	0.002	1.902	1.273	2.842
Trash (1=yes, 0=no)	0.544	0.323	0.092	1.723	0.914	3.245
Water (1=stream, 0=pump)	0.514	0.309	0.096	1.672	0.913	3.060
Water treatment (1=yes, 0=no)	-0.770	0.317	0.015	0.463	0.249	0.862
Electrical appliance (1=yes, 0=no)	-0.382	0.199	0.055	0.683	0.462	1.008

Table 39 shows the factors significantly associated with helminthic infections after adjusting for all other factors. The risk factors are being a houseworker and living in an overcrowded house. The disposal of garbage is a borderline risk factor with *p*-value at 0.05. The protective factor is using treated drinking water.

Table 40 is a result of forward stepwise method of choosing the factors that are significantly associated with the parasites. The result is the same as Table 39 except disposal of garbage is not identified as a significant risk factor.

Table 41 is a result of backward stepwise method of choosing the risk factors significantly associated with helminthic infections. The risk factors are Mayan Ketchi, being houseworkers, more years of education, living in overcrowded houses, disposal of garbage and using stream water. The protective factors are drinking treated water and ownership of electrical appliances.

Table 42.

Results of logistic regression analyses of protozoa prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	-2.025	0.946	0.032			
Age	-0.017	0.011	0.110	0.983	0.963	1.004
Sex (1=male, 0=female)	0.303	0.230	0.187	1.354	0.863	2.124
Race (1= Ketchi, 0=Mopan)	0.078	0.250	0.753	1.082	0.663	1.764
Occupation (0=labour)			0.476			
Pre-school	0.228	0.502	0.649	1.257	0.470	3.365
Student	0.300	0.400	0.454	1.349	0.616	2.956
Housework	0.576	0.373	0.122	1.779	0.857	3.696
Year of education	-0.077	0.037	0.039*	0.926	0.061	0.996
Floor (1=dirt, 0=w/c)	-0.031	0.227	0.893	0.970	0.621	1.514
Density group (1=high, 0=low)	-0.374	0.204	0.067	0.688	0.462	1.027
Toilet (1=yes, 0=no)	-0.167	0.229	0.464	0.846	0.540	1.324
Trash (1=yes, 0=no)	0.962	0.445	0.030*	2.618	1.096	6.256
Water (1=stream, 0=pump)	0.697	0.308	0.024*	2.008	1.097	3.673
Water treatment (1=yes, 0=no)	-0.339	0.299	0.257	0.713	0.396	1.281
Electrical appliance (1=yes, 0=no)	0.150	0.210	0.475	1.162	0.769	1.755
Pig (1=yes, 0=no)	0.066	0.243	0.785	1.069	0.664	1.721
Poultry (1=yes, 0=no)	1.108	0.717	0.122	3.028	0.743	12.344
Horse (1=yes, 0=no)	0.130	0.236	0.581	1.139	0.718	1.807
Dog (1=yes, 0=no)	-0.160	0.266	0.547	0.052	0.506	1.435
Cat (1=yes, 0=no)	0.208	0.222	0.347	1.232	0.798	1.901
Wearing shoes (1=yes, 0=no)	-0.584	0.227	0.010*	0.558	0.357	0.871

Table 43.

Results of logistic regression analyses of protozoa prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection.
The variables were selected by the forward stepwise method.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	-1.333	0.406	0.001			
Age	-0.016	0.006	0.011	0.985	0.973	0.996
Trash (1=yes, 0=no)	1.105	0.399	0.006	3.019	1.381	6.602
Water treatment (1=yes, 0=no)	0.580	0.264	0.028	1.785	1.064	2.995
Wearing shoes (1=yes, 0=no)	-0.463	0.204	0.024	0.630	0.422	0.940

Table 44.

Results of logistic regression analyses of protozoa prevalence in 5 villages of Toledo District, southern Belize with odds ratios for variables associated with the infection. The variables were selected by the backward stepwise method.

Independent Variable	*b*	(SE)	*p*	Odds ratio	95% CI Upper	95% CI Lower
Constant	-1.929	0.735	0.009			
Age	-0.017	0.006	0.006	0.984	0.972	0.995
Year of education	-0.071	0.032	0.025	0.931	0.875	0.991
Density group (1=high, 0=low)	-0.372	0.192	0.052	0.689	0.473	1.004
Trash (1=yes, 0=no)	0.902	0.411	0.028	2.464	1.100	5.518
Water (1=stream, 0=pump)	0.598	0.267	0.025	1.819	1.077	3.072
Poultry (1=yes, 0=no)	1.242	0.663	0.061	3.462	0.944	12.698
Wearing shoes (1=yes, 0=no)	-0.608	0.216	0.005	0.545	0.357	0.832

Table 42 shows the factors significantly associated with protozoan infections after adjusting for all other factors. The risk factors are disposal of garbage and using stream water. The protective factors are higher education and wearing shoes.

Table 43 is a result of forward stepwise method of choosing the factors that are significantly associated with the protozoan parasites. The risk factors are used in the model to predict the chance for protozoan infection. The results are the same as shown in table 42.

Table 44 is a result of backward stepwise method of choosing the risk factors that are significantly associated with protozoan infections. The results are similar to Tables 42 and 43 with additional factors, ownership of poultry as a risk factor and overcrowded houses as a protective factor.

Geographic Information System

Spatial analyses were used in this study to explore the geographic distribution of the parasite infections. Figure 2 presents the location of the 5 villages in Toledo district of Belize, including Bladden (purple), Medina Bank (yellow), Tambran (blue), Golden Stream (green) and San Marcos (brown) on a Landsat Thematic Mapper ™ image. The image is a false color composite of bands 4(color infrared), 3(red), and 2(green) displayed as red, green, and blue on the computer. The red areas show dense, healthy green vegetation of the jungle, the pale blue areas mark the barren areas such as roads and unused fields. The ocean is visible on the lower right side of the image in blue (shallow water), and black (clear deep water). The villages are located along the southern highway.

Figure 3 shows the location of the houses in Golden Stream village plotted on a Landsat image. The village is divided into 2 parts, north and south, by a private farm. The northern part has more houses and is more crowded than the southern part. On the other side of the village is an orange grove, which is pale blue in the map. The contour map in Figure 4 shows that the houses in the southern part of the village have more people per house than in the north.

Figure 5 shows the houses with members who tested positive for a parasite in yellow and houses that tested negative in green. The number of positive cases per house was used to create a contour map, which shows the distribution of the disease. Dark red indicates many cases, lighter red represents fewer cases, and white indicates no cases. The positive houses were aggregated in the north and south of the village.

Figure 6 shows a spatial association of ethnic groups and contour map of parasite positive people in Golden Stream village. The yellow dots represent Mayan Ketchi houses that are mostly located in the higher density of parasite or darker red areas compared to the Mayan Mopan houses that are located in the lower infection areas, or lighter red areas.

Figure 7 shows a spatial association between the location of the houses that had people living more than 4 per room, yellow dots, and higher number of cases that were positive for a parasite, darker red areas.

Figure 8 shows a spatial association of houses constructed with dirt floor or wood/cement floor and contour map of number of people who tested positive for a parasite in those houses. The houses located in the higher prevalence areas of parasites were mostly constructed with dirt floor.

Figure 9 shows a spatial association between houses without a toilet facility and higher parasite infection area, which is located in the northern sector of the village.

Figure 10 shows a location of the houses that used stream water, yellow dots, and pump water, green dots. The houses that used stream water mostly on the further north and south of the village, where streams are located. Most of the houses that used stream water are in the higher parasite density areas, darker red areas.

The spatial associations of each parasite and other risk factors can be presented in the same fashion as used to show distributions of households that were positive for a parasite. The results showed no spatial or significant associations. I had program for spatial analysis of these data so the fit of data was done visually. The location of the positive houses of each parasite infection is shown in appendix 9.

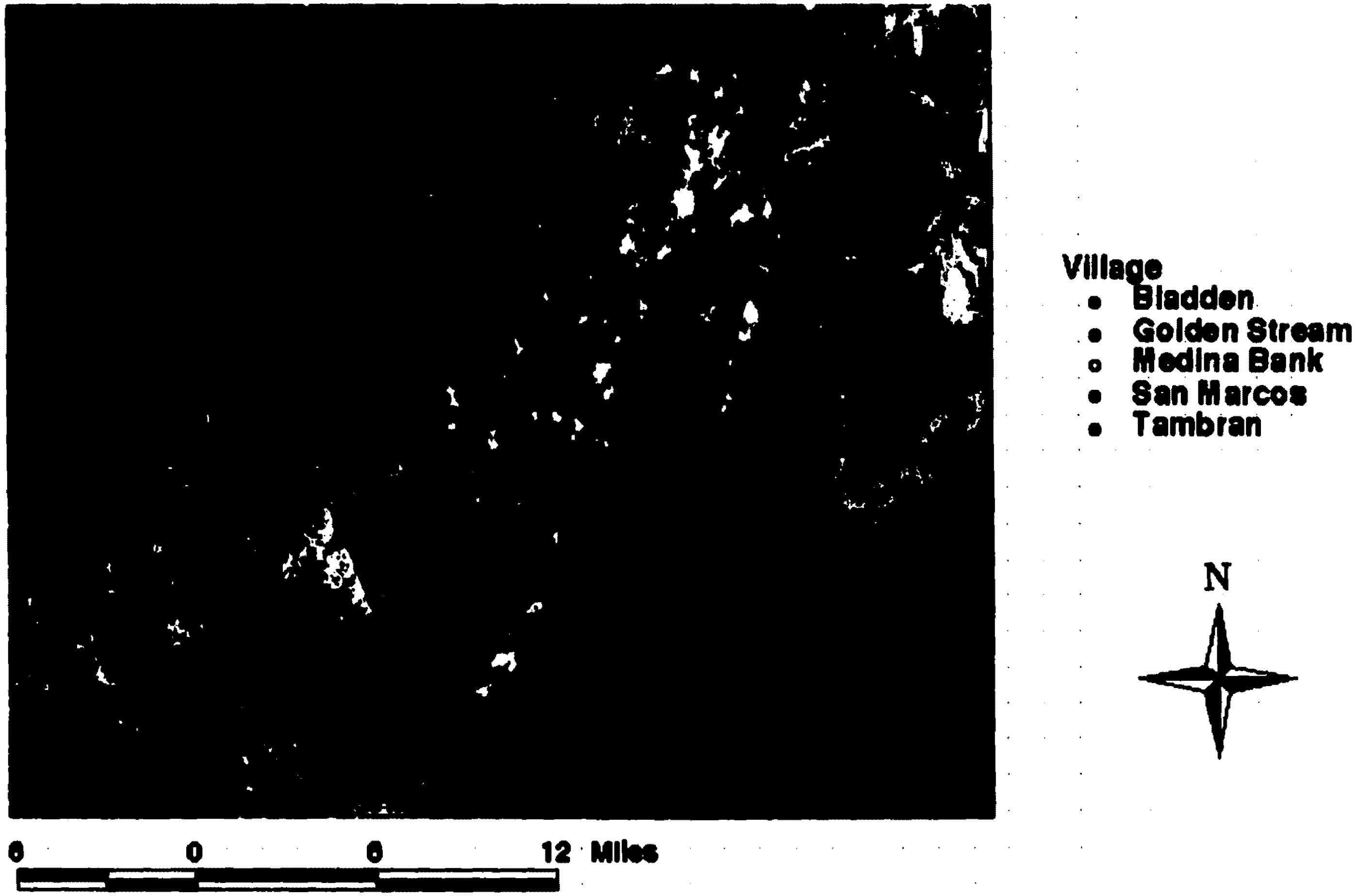

Figure 2.

Location of 5 study villages in Toledo District in southern Belize. Villages are plotted on a Landsat Thematic Mapper image.

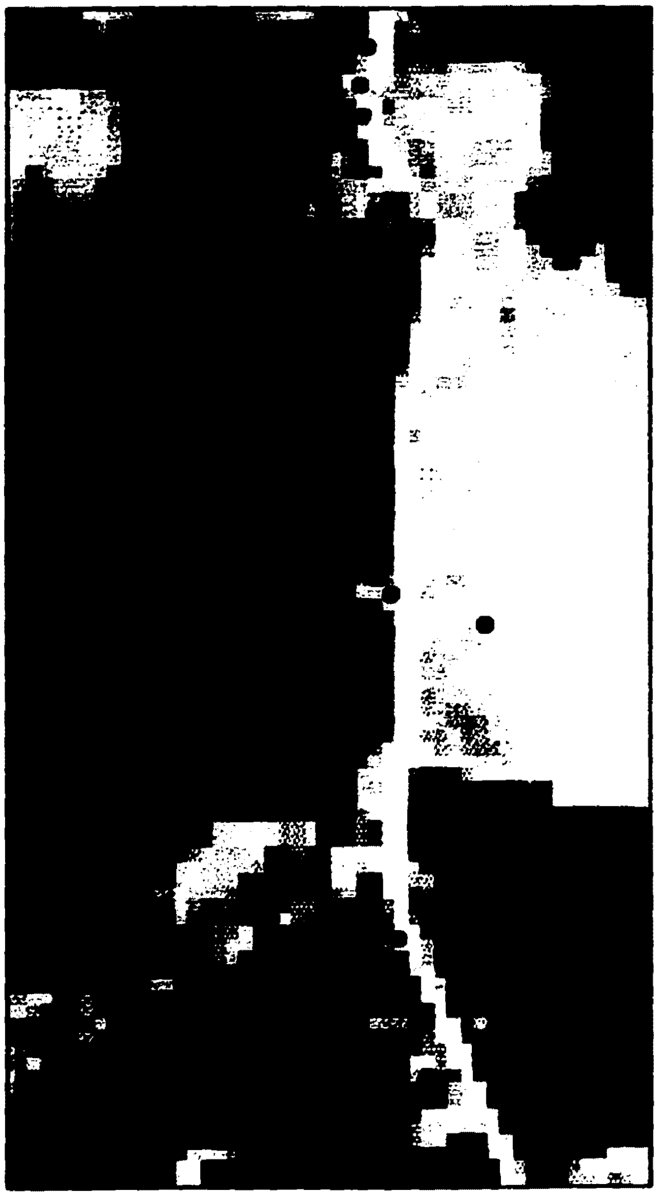

Figure 3.

Location of houses in Golden Stream village in southern Belize. The locations are plotted on a Landsat Thematic Mapper image.

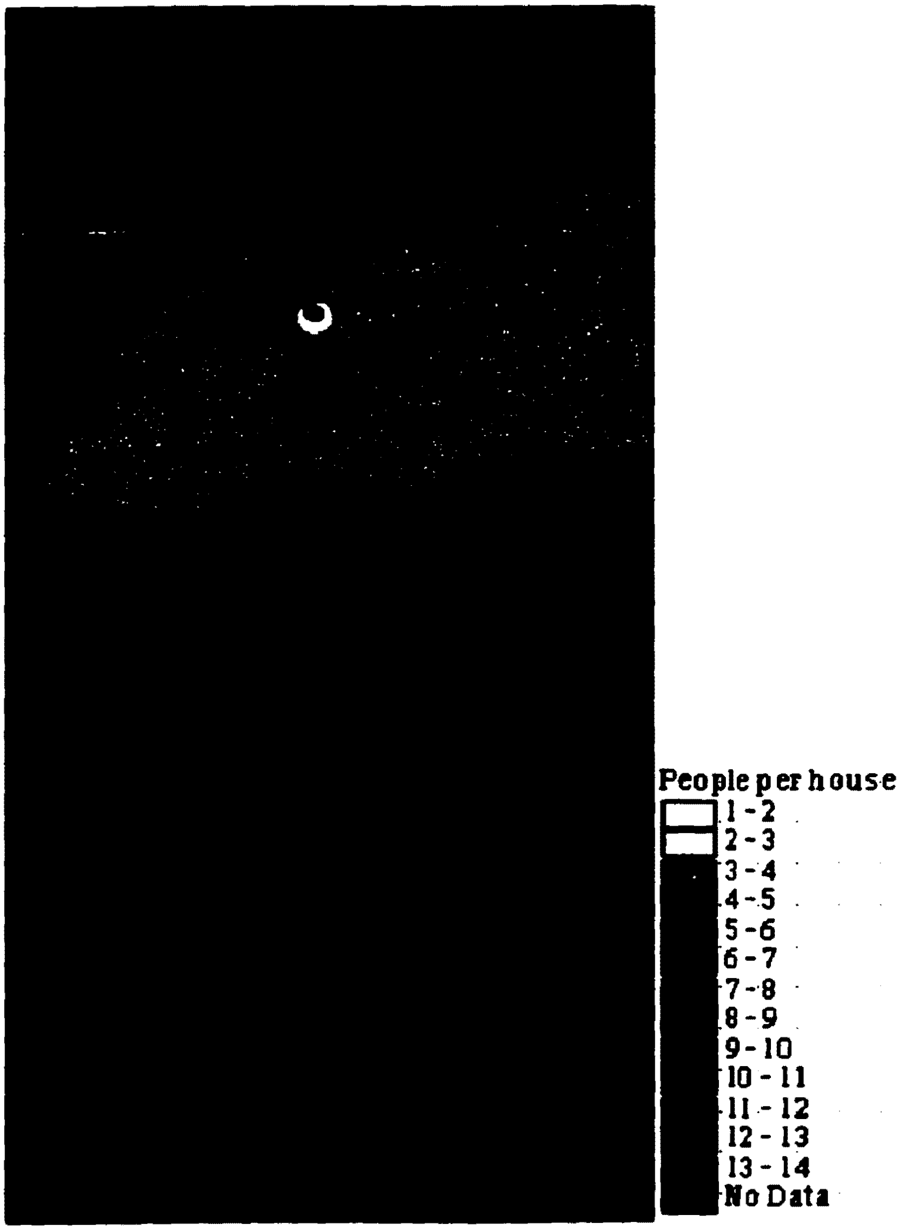

Figure 4.

Contour map of numbers of people per house in Golden Stream village in southern Belize.

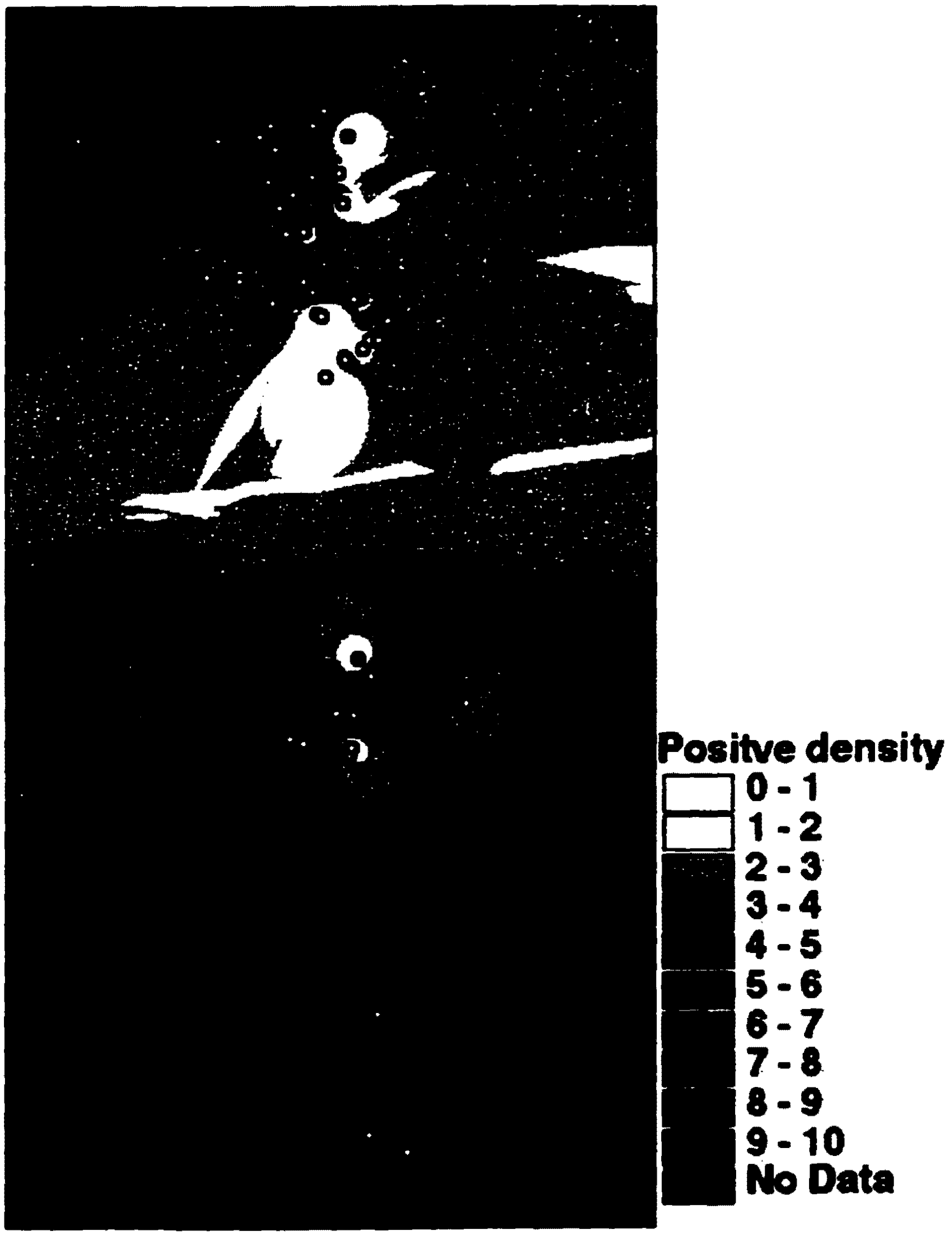

Figure 5.

Contour map showing the number of cases of parasitic infections per house in Golden Stream village, southern Belize.
Yellow dots are positive households for a parasite; green dots are negative households.

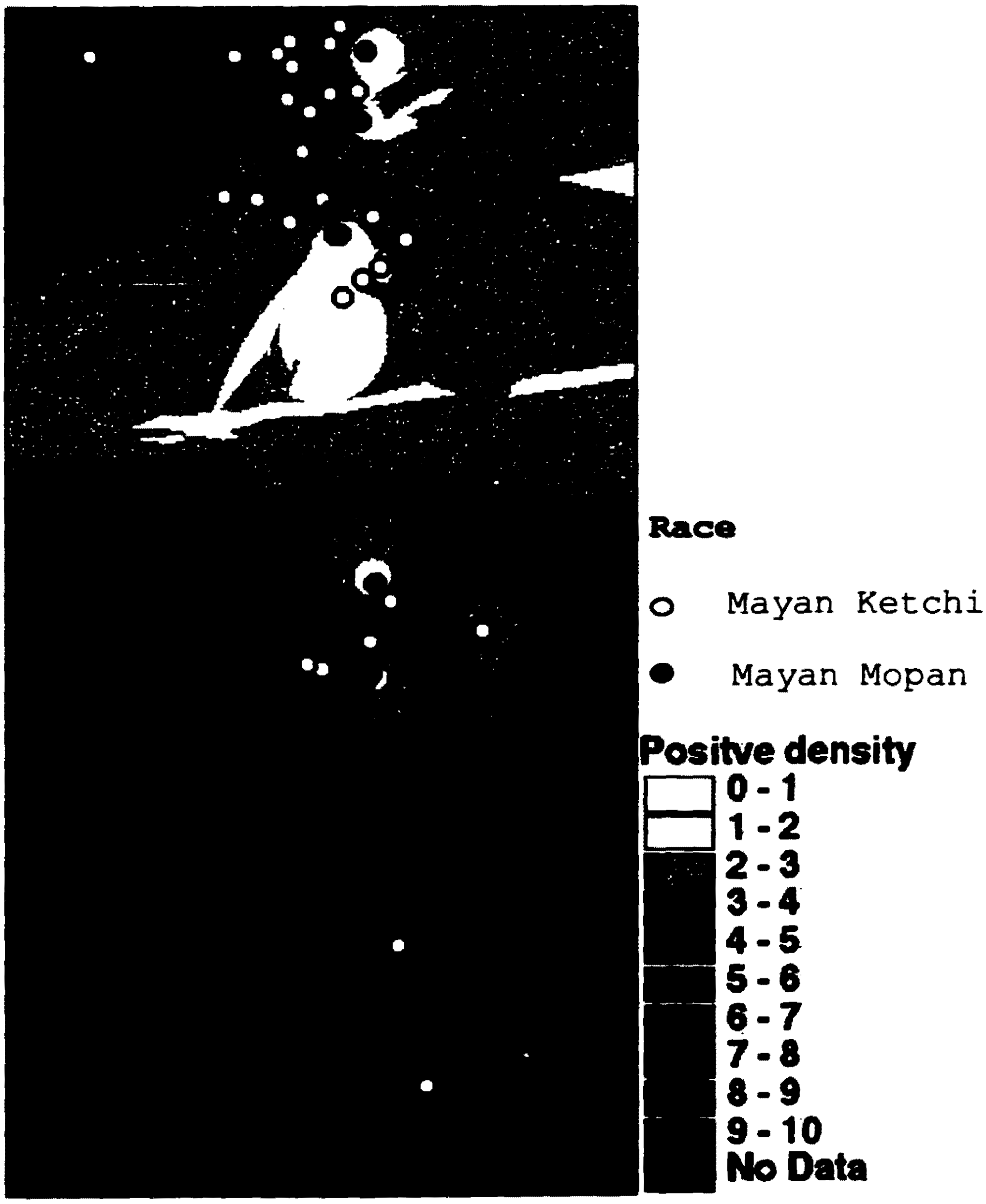

Figure 6.

Contour map showing the number of cases of parasite positives per house and ethnic group of people in the houses in Golden Stream village, southern Belize.
Yellow dots are Mayan Ketchi;
green dots are Mayan Mopan.

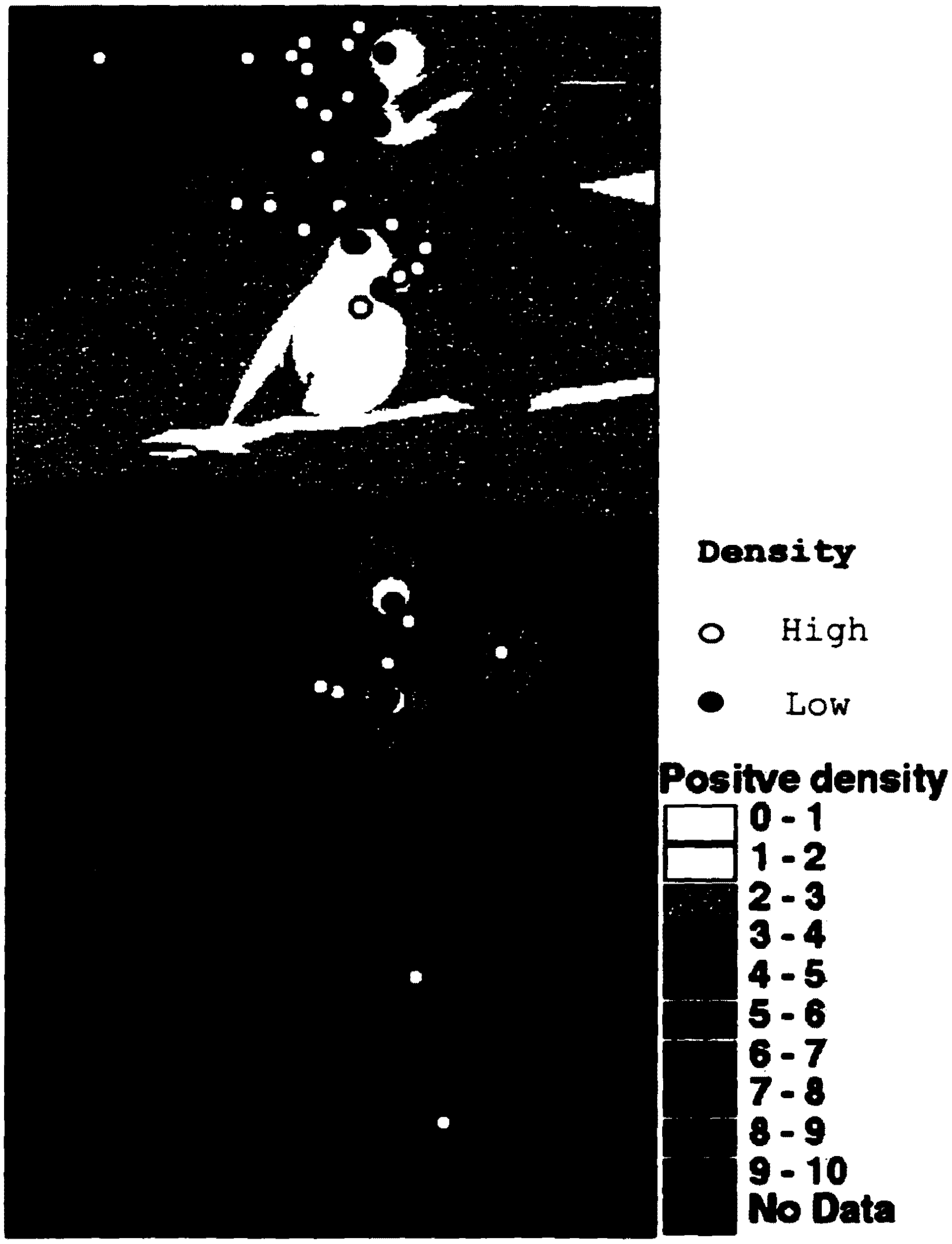

Figure 7.

Contour map showing the number of cases of parasite positive per house and population density per houses in Golden Stream village, southern Belize. Yellow dots are high density population; green dots are low density population.

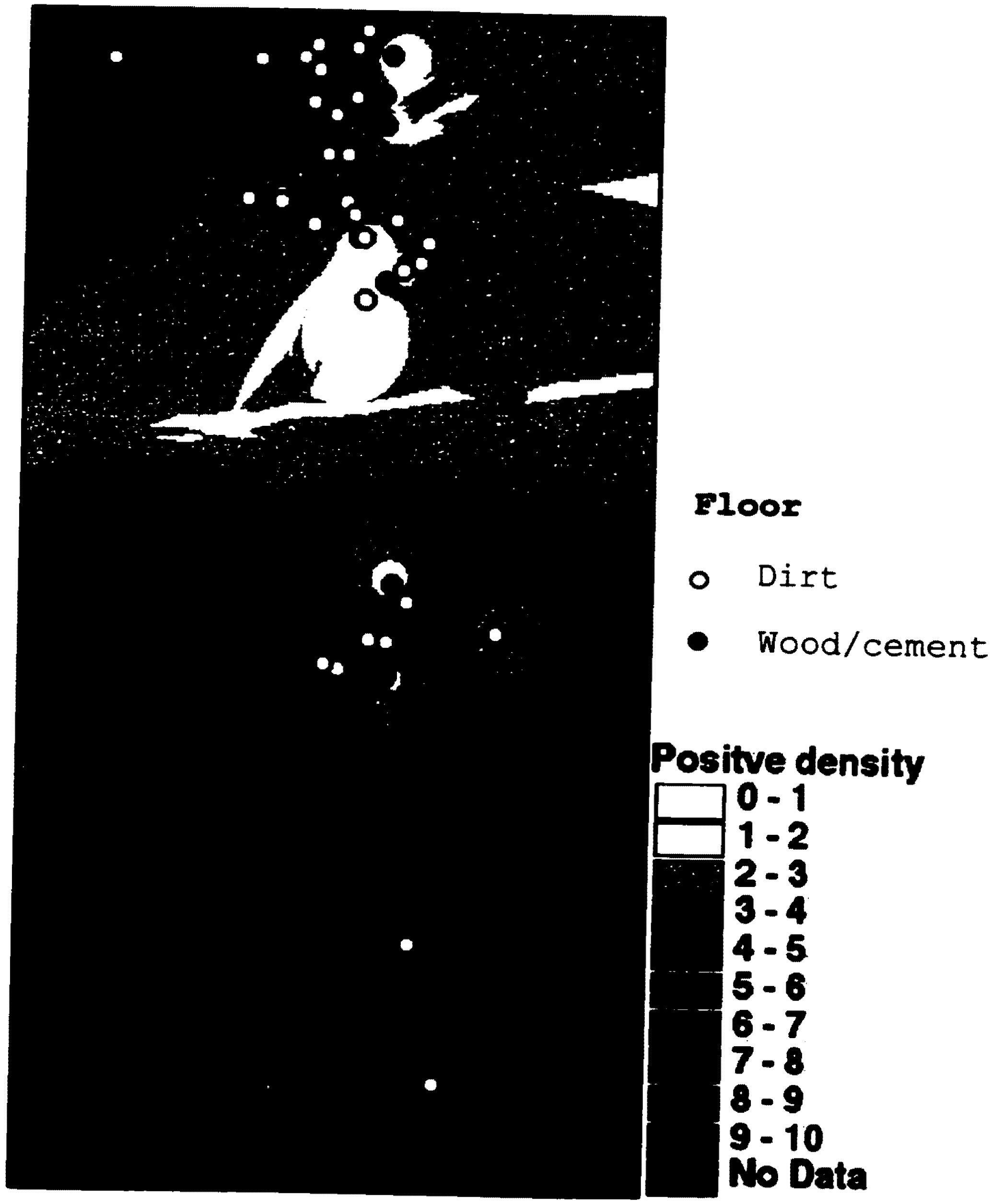

Figure 8.

Contour map showing the number of cases of parasite positives per house and floor types of houses in Golden Stream village, southern Belize. Yellow dot is a dirt floor; green dot is a wood/cement floor.

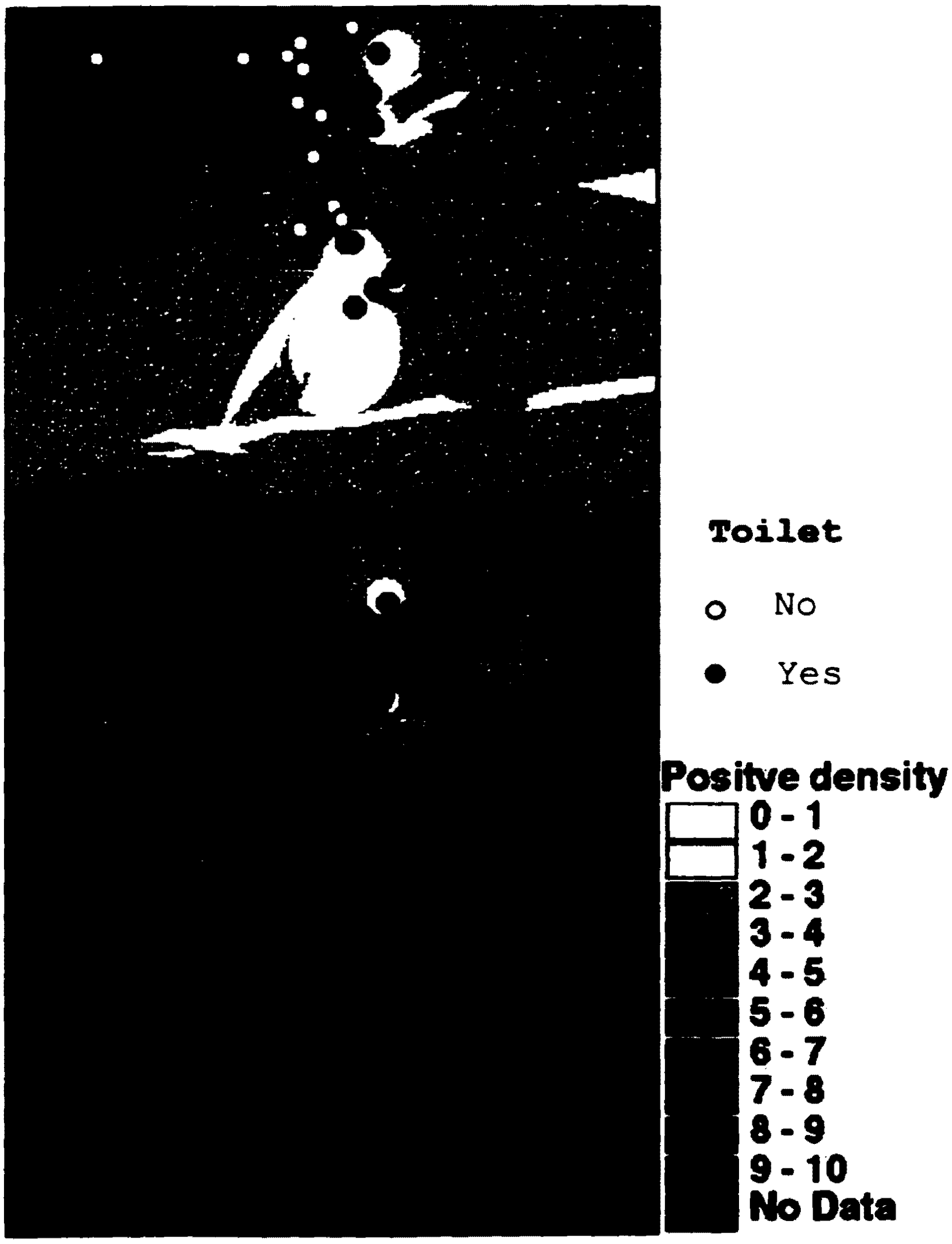

Figure 9.

Contour map showing the number of cases of parasite positives per house and toilet facilities of the houses in Golden Stream village, southern Belize. Yellow dot is a house with toilet; green dot is a house without toilet.

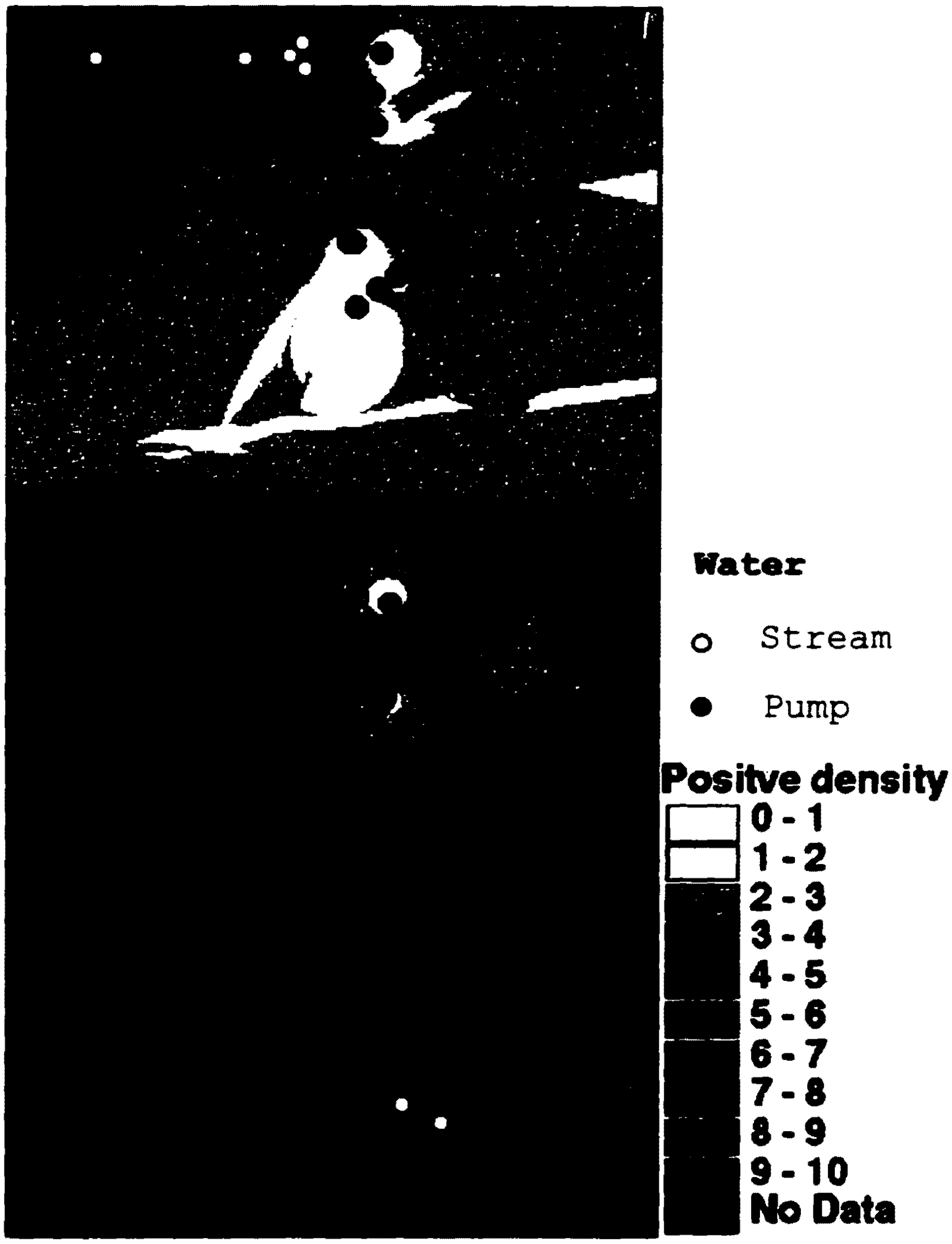

Figure 10.

Contour map showing the number of cases of parasite positives per house and water sources of the houses in Golden Stream village, southern Belize. Yellow dot is a house using stream water; green dot is a house using pump water.

Discussion

The information presented in this study provides insight on intestinal parasitoses in southern Belize. This is the second prevalence study of intestinal parasitic infection in Belize. The first was done by Petana (1968).

Among five villages in this survey, Medina Bank had the highest prevalence rate (88%) of intestinal parasitoses, (Table 1). This village has been established for 5 years. Yet, until recently there were no toilets. Today 100% of the houses have toilets (Table 7), but are not in common use. The residents continue to defecate around their villages and contaminate the environment. Water and food products are especially vulnerable to this form of environmental contamination. The use of toilets has been found to be a protective factor for reducing the prevalence of parasites in other studies (Borda *et al.*, 1996; Gamboa *et al.*, 1998; Gross *et al.*, 1989; Hidayah *et al.*, 1997; Montresor *et al.*, 1998; Sanchez *et al.*, 1997).

The most common parasitic infection in Southern Belize was found to be hookworm (55%) followed by *A. lumbricoides* (30%), *E.coli* (21%), *T. trichiura* (19%), *G. lamblia* (12%), *I. beutschlii* (9%), *E. histolytica* (6%), *E. hartmani* (3%) and *S. stercoralis* (1%). Three other parasite species, *E. nana, I. belli* and *C. mesnili* were found in less than 1% of samples. The soil-transmitted helminths were the leading cause of infections (67%). Although *A. lumbricoides* is the most common helminth parasite worldwide (Bundy *et al.*, 1992; Crompton and Savioli, 1993; Pawlowski, 1983; Pawlowski, 1984), in Belize, hookworms were the most common helminthic parasites.

The overall prevalence of intestinal parasites (76%) in southern Belize in this study, were essentially the same as the 74% infection rate reported by Petana in 1968. Petana surveyed on the western border of Cayo district and found that young children had the highest prevalence of parasites. In the present study, the trend of frequency of infection was lowest in young children and highest in young adults. Frequencies of infection were lower in older age groups (Table 2 and Figure 11).

Females were more commonly positive for intestinal parasites than males (Figure 11). This finding id contrast to most published studies which report a greater prevalence of intestinal parasites in males than females (Bundy, 1988). There was, however, a significant difference between genders, in the case of hookworm and *S. stercoralis* infections, (Table 4). In this study, the prevalence of hookworm in females was higher than in males. Of the males, 38% were laborers who usually wear shoes or boots, and work far from villages. Ninety-four percent of the adult females worked at home and 72% of them did not wear shoes. The females, therefore, were exposed to hookworm infection more often than males.

The 7 cases of *S. stercoralis* are too few in number to examine associations of infection and risk factors.

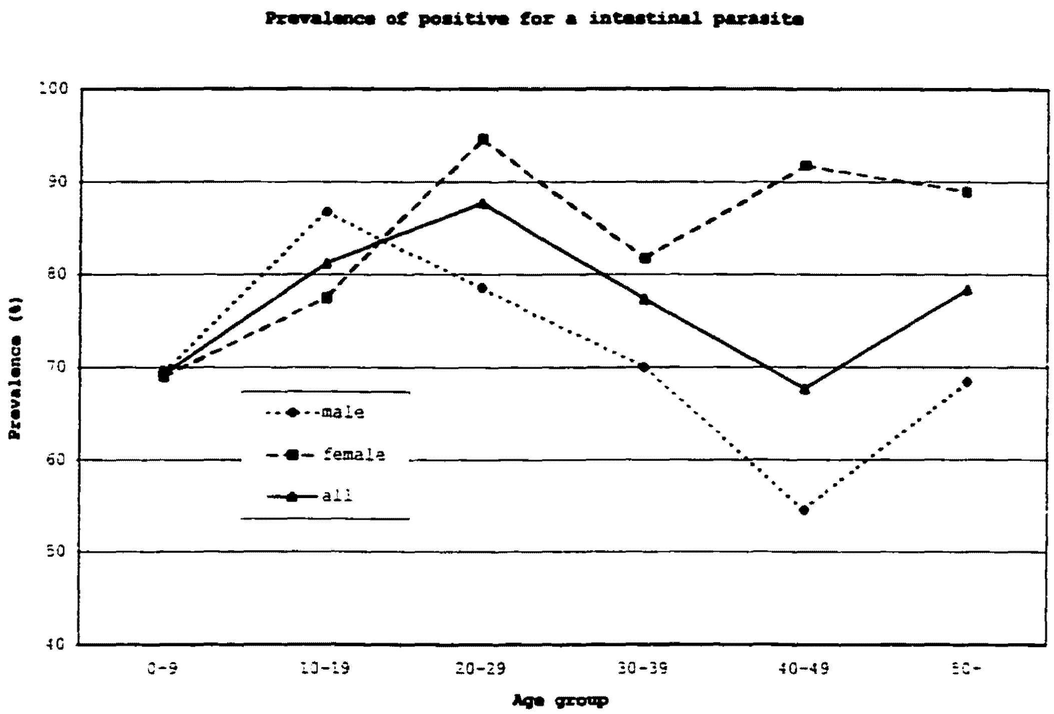

Figure 11.

The association between age, gender and prevalence of intestinal parasitic infections in 5 villages of Toledo district, southern Belize.

Adults had higher prevalence of intestinal parasite infections than children 0-9 years, (Table 5 and 6; Figure 12). The peak infection rate by age was in the 20 to 29 year age group. Protozoan infections were most frequent in children of 0 to 9 years of age. The age prevalences differ from the results of another study where schoolchildren were found to have the highest prevalence of infections (Albonico *et al.*, 1999).

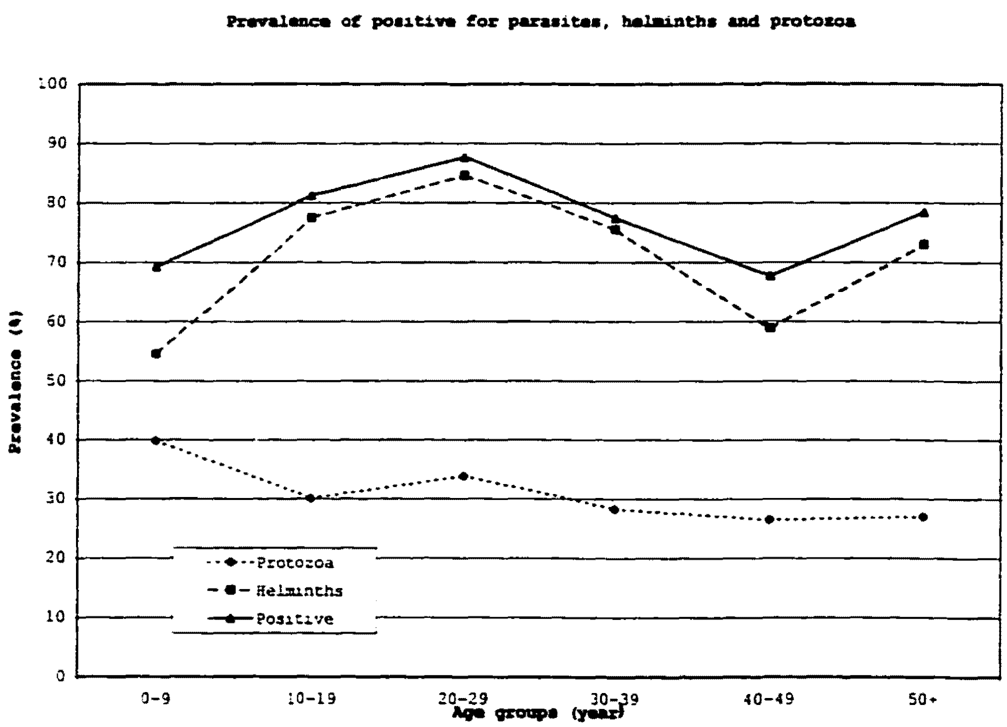

Figure 12.

The association between age and prevalence of intestinal parasitic infections in 5 villages of Toledo District, southern Belize.

Males had a higher prevalence of protozoan infections, and helminthic infections were more common in younger age groups than in older age groups. There were significant differences of the prevalence of hookworm and *G. lamblia*, (table 5, Figure 13).

Overall, the prevalence of helminthic infections was much higher than the prevalence of protozoan infections, in both males and females, (Figure 13). The prevalence of helminthic infections, especially hookworm, was lower in the younger female age group and increased until 20-29 years of age. The prevalence of hookworm was also higher in females than males, (Table 6 and Figure 13). This is similar to the findings of Elkins et al that females of southern Indian children had higher prevalences of intestinal parasites due to socio-cultural factors (Elkins et al., 1986). Basically, it seems that socio-cultural factors confine females to contaminated areas (the domestic and peri-domestic areas). This domestic lifestyle provides more opportunity for exposure to the parasites.

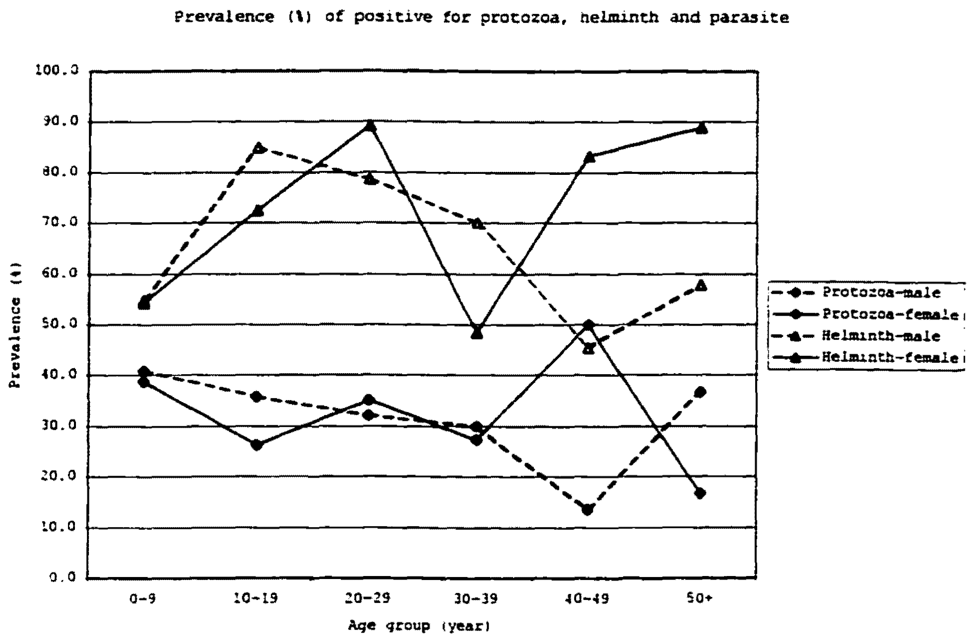

Figure 13.

The association between age, gender and prevalence of intestinal parasite infections (helminth and protozoa) in 5 villages of Toledo District, southern Belize.

For the 5 villages included in this survey, the participation rate ranged from 73.1 to 88.7%, for an average of 82.3%. The most cooperative village was San Marcos where the community health care volunteer encouraged the villagers to participate by stressing the advantages of diagnosis and tretment.

The demographic information showed the gender ratio (male/female distribution) to be 0.87, which does not coincide with the national ratio, 1.03 (CIA, 1999; U.S. Census). The study population consisted of Mayan Mopan (34%) and Mayan Ketchi (66%). There were no other ethnic groups in those villages. The dependent population (less than 14 years and over 65 years old) was 62%, was higher than the dependent population of the entire country, 45% (CIA, 1999). Forty percent of the study population worked as houseworkers, farmers, laborers or merchants.

Literacy is estimated by years of schooling. The number of participants who attended school at least one year was 58.4%. This is lower than the national literacy rate in Belize which is 60-76% (U.S. Department of State, 2000). But if categorized by ability to read or attend school for at least 3 years, only 33% of the population is able to read.

Sanitation in the villages was considered substandard. Fifty-seven percent of village residents had access to a toilet and 10% used stream water for drinking. Eighty four percent of the households treated water before drinking. There was no garbage collection. Each house disposed of their own refuse by burning, or digging and burning in a hole, which was generally not deep enough to prevent dispersion and contamination of the surrounding area. Most of the houses that disposed of their garbage, did so in a substandard manner.

Floor construction materials have been associated with parasite infections in households. Dirt floors seem to favor parasitic infection more than cement or wooden floors (Anderson *et al.*, 1993; Gamboa, et al., 1998; Oberhelman *et* *al.*, 1998; Sanchez, et al., 1997). In the present study, 60% of houses had dirt floors.

Villagers own their houses. Their socioeconomic status is based on ownership of electrical appliances and livestock. Socioeconomic status is considered a relative risk factor for infection of intestinal parasites in many studies (Anderson, et al., 1993; Gross, et al., 1989; Hidayah, et al., 1997; Oberhelman, et al., 1998). The association of socioeconomic status as a risk factor for each parasite species will be discussed later.

The contingency tables were used to find association between each risk factor and parasitic infections by Chi-square testing. A disadvantage is that this method does not adjusted for other factors. The logistic regressions were also performed to select the significant factors adjusted for other factors simultaneously (Hosmer and Lemeshow, 1989; Kleinbaum, 1994). Logistic regression analyses included the full model, plus forward stepwise and backward stepwise methods. Based on the contingency tables and full model results, the best method to explain significant factors in the model was to predict the parasitic infections using the backward stepwise method according to a basic knowledge of the biology and life-cycle of intestinal parasites.

Table 45.

Summary of risk factors for being positive for parasite infection. Data from contingency tables and logistic regression analyses. (only significant factors are listed)

Positive for parasite				
	Odds	95% CI		
Risk factor	ratio	Lower	Upper	*p*
Contingency table				
Race (Ketchi/Mopan)	1.55	1.04	2.31	0.03
Water (untreated/treated)	2.15	1.10	4.02	0.02
Wearing shoes (yes/no)	0.60	0.41	0.90	0.01
Logistic regression				
Full model				
Occupation (Labor=0,				0.01
Pre-school,	0.57	0.20	1.64	0.30
Student,	1.45	0.62	3.37	0.39
Housework)	2.21	0.97	5.02	0.06
Trash disposal (no=0)	2.18	1.06	4.47	0.03
Treated water (no=0)	0.46	0.22	0.97	0.04
Wearing shoes (no=0)	0.61	0.38	0.98	0.04
Forward stepwise method				
Occupation (Labor=0,				<.01
Pre-school,	0.57	0.34	1.05	0.07
Student,	1.61	0.93	2.81	0.09
Housework)	2.17	1.12	4.20	0.02
Treated water (no=0)	0.46	0.23	0.90	0.02
Backward stepwise method				
Race Ketchi (Mopan=0)	1.59	1.04	2.44	0.03
Occupation (Labor=0,				<.01
Pre-school,	0.74	0.40	1.37	0.34
Student,	1.74	0.99	3.06	0.06
Housework)	2.35	1.20	4.60	0.01
Stream water (Pump=0)	2.27	1.15	4.49	0.02
Treated water (no=0)	0.44	0.22	0.89	0.02
Wearing shoes (no=0)	0.63	0.40	0.99	0.05

The contingency tables of data on stool samples that were positive for at least one parasite and significant risk factors are in Tables 15 and 45. Individuals of Mayan Mopan ancestry had a lower risk for parasites and individuals of Mayan Ketchi ancestry had a higher risk for parasites. Both ethnic groups are descendants of the Mayan people, but Mayan Ketchi have a more natural life style (dirt floor houses and not wearing shoes). They are more isolated from other ethnic groups and from technology outside their own region. These practices increase their chance of contacting the parasites. Thus, the more natural life style of Mayan Ketchi exposes them to intestinal parasites. Although this association does not indicate causation, the high level of statistical significance suggests the association of life style and high parasite burden is real.

Individuals who reported drinking untreated water were 2.15 times more likely to have parasitoses than those drinking treated water. Chemical treatment or boiled drinking water destroys parasites and reduces the chance of infection. The findings of this study confirmed that chemical treatment or boiling water prevents the occurrence of intestinal parasites as previously reported (Borda, et al., 1996; Gamboa, et al., 1998; Gross, et al., 1989; Hidayah, et al., 1997).

Each parasite has a certain route of infection. Most intestinal parasites are transmitted through ingestion of fecal contaminated food or water. Hookworm and *S. stercoralis* are the exception. They are acquired when their 3rd stage larvae penetrate the skin of the host (Mata, 1982). These parasites are soil-transmitted helminths, the larvae live in the soil waiting to invade a host. Shoes prevent larvae from penetrating feet and are simple, but important, protective factors. In this study, wearing shoes was a protective measure with odds ratio, 0.6 times, to acquire the parasites.

Other risk factors were identified by using the backward stepwise logistic regression method. Occupation was associated with parasitic infections. Houseworkers were 2.21 times more likely to have an intestinal parasite infection than laborers after controlling for other potential confound factors. Most houseworkers were females who worked in highly contaminated areas. Their exposure to parasites seemed higher than other occupational groups.

Trash disposal is usually considered to be a protective factor (Borda, et al., 1996; Gamboa, et al., 1998; Hidayah, et al., 1997; Kightlinger, et al., 1998; Sanchez, et al., 1997), but in this study, the results suggest that trash disposal was 2.18 times more risky than not employing sanitary methods to dispose of garbage. However, their practices of garbage burning and burial were not proper. Most trash was wet and did not burn properly. In addition, holes dug for garbage disposal were not deep enough to prevent dispersal. The shallow holes allowed garbage to be scattered through out the villages and to contaminate areas around houses in villages.

The odds of people having a parasite who used stream water for drinking is 2.27 times higher than people who used pump water. Surface water has a higher chance of being contaminated with fecal material than closed, hand-pump, underground water which most people (90%) in the villages used. Usage of surface water was also considered a risk factor for intestinal parasites in other studies (Anderson, et al., 1993; Borda, et al., 1996; Gamboa, et al., 1998; Gross, et al., 1989; Hidayah, et al., 1997; Holland *et al.*, 1988).

Table 46.

Summary of risk factors for being positive for helminth infection. Data from contingency tables and logistic regression analyses. (only significant factors are listed)

Positive for helminthic infection				
	Odds	95% CI		
Risk factor	ratio	Lower	Upper	*p*
Contingency table				
Ketchi/Mopan	1.56	1.08	2.26	0.02
Kid/adult job	0.52	0.36	0.75	0.00
Education level 0-3/4+	0.56	0.37	0.82	<.01
High/low density	1.59	1.11	2.28	0.01
Untreated/treated water	2.08	1.16	3.72	0.01
Wearing shoes (yes/no)	0.64	0.45	0.93	0.02
Logistic regression				
Full Model				
Occupation (Labor=0,				0.01
Pre-school,	0.45	0.17	1.22	0.12
Student,	0.90	0.41	2.00	0.80
Housework)	2.19	1.02	4.72	0.05
Population density (low=0)	1.83	1.21	2.78	0.00
Treated water (no=0)	0.50	0.26	0.98	0.04
Forward stepwise method				
Occupation (Labor=0,				<.01
Pre-school,	0.38	0.22	0.67	<.01
Student,	0.98	0.58	1.64	0.93
Housework)	2.09	1.12	3.92	0.02
Population density (low=0)	1.84	1.26	2.70	0.00
Treated water (no=0)	0.47	0.26	0.86	0.01
Backward stepwise method				
Race Ketchi (Mopan=0)	1.41	0.94	2.12	0.10
Occupation (Labor=0,				<.01
Pre-school,	0.46	0.25	0.84	0.01
Student,	0.93	0.55	1.56	0.79
Housework)	2.20	1.16	4.16	0.02
Year of education	1.07	0.99	1.15	0.08
Population density (low=0)	1.90	1.27	2.84	<.01
Trash disposal (no=0)	1.72	0.91	3.25	0.09
Stream water (Pump=0)	1.67	0.91	3.06	0.10
Treated water (no=0)	0.46	0.25	0.86	0.02
Electrical appliance (no=0)	0.68	0.46	1.01	0.06

Helminths were the most commonly found intestinal parasitic infections in this study. Some risk factors associated with helminth infections were similar to the positive for at least one parasite.

Level of education seemed related to intestinal parasite infection, and this is consistent with other studies (Gamboa et al., 1998; Kightlinger *et al.*, 1998). The result of contingency tables, (Table 16), shows that lack of education is a protective factor for helminthic infection. This might not be a true association because a contingency table does not adjust for other factors, and most of the uneducated were pre-school children and infants who were less exposed to helminthic infection. Contrary to this, housewives often cannot read and they were exposed to parasites more than others (Bundy, 1988).

Residents who lived in houses with more than 4 persons per room were 1.59 times more likely to have helminthic infection than persons in less crowded houses. This overcrowding effect has also been noted in other studies (Anderson, et al., 1993; Gamboa, et al., 1998; Gross, et al., 1989; Hidayah, et al., 1997; Kightlinger, et al., 1998).

Logistic regression analysis shows the same risk factors as listed above, plus other risk factors. For example, having an electrical appliances appears to be a protective factor for helminth infection with an odds ratio of 0.68. This result suggests that as people who have electrical appliances are likely to be more affluent than those who do not have electrical appliances, the higher socioeconomic status is associated with less exposure to helminthic infection (Gamboa, et al., 1998; Gross, et al., 1989; Hidayah, et al., 1997; Holland, et al., 1988; Kightlinger, et al., 1998; Mata, 1982; Pongpaew *et al.*, 1993).

Even in regression analysis, higher educational levels, after adjustment for the other factors, appeared to be a risk factor for helminth infection. This contrasted with other studies, which showed education as a protective factor. However, this is a weak, not statistically significant association, (p-value > 0.08).

Table 47.

Summary of risk factors for being positive for *Ascaris lumbricoides* infection.
Data from contingency tables and logistic regression analyses.(only significant factors are listed)

Ascaris lumbricoides				
	Odds	95% CI		
Risk factor	ratio	Lower	Upper	p
2X2				
Race (Ketchi/Mopan)	2.13	1.41	3.24	<0.01
Density (high/low)	1.62	1.13	2.34	0.01
Water (stream/pump)	1.77	1.06	2.96	0.03
Water (untreated/treated)	1.75	1.07	2.87	0.03
Horse (yes/no)	0.63	0.43	0.92	0.02
Logistic regression				
Full Model				
Race Ketchi (Mopan=0)	1.96	1.14	3.45	0.01
Stream water (Pump=0)	2.91	1.52	5.55	<0.01
Electrical appliance (no=0)	0.64	0.41	0.98	0.04
Horse (no=0)	0.44	0.26	0.76	<0.01
Forward stepwise method				
Race Ketchi (Mopan=0)	2.15	1.38	3.36	<0.01
Occupation (Labor=0,				0.01
Pre-school,	1.42	0.76	2.65	0.27
Student,	2.37	1.35	4.17	<0.01
Housework)	1.41	0.75	2.65	0.29
Stream water (Pump=0)	2.73	1.54	4.85	0.01
Horse (no=0)	0.44	0.27	0.73	<0.01
Backward stepwise method				
Race Ketchi (Mopan=0)	2.11	1.34	3.34	<0.01
Occupation (Labor=0,				0.01
Pre-school,	1.75	0.90	3.39	0.10
Student,	2.60	1.46	4.62	<0.01
Housework)	1.52	0.80	2.88	0.20
Stream water (Pump=0)	3.02	1.69	5.41	<0.01
Treated water (no=0)	0.61	0.36	1.04	0.07
Electrical appliance (no=0)	0.70	0.47	1.03	0.07
Horse (no=0)	0.45	0.27	0.75	<0.01
Wearing shoes (no=0)	0.63	0.41	0.98	0.04

Table 47, *Ascaris lumbricoides* is the most common of helminthic infections worldwide (Crompton, 1999). It is a soil-transmitted helminth, which is usually acquired from contaminated food (Markell *et al.*, 1999). The risk factors for *A. lumbricoides* infection were being Mayan Ketchi, living in overcrowded houses, using stream water and drinking untreated water. The protective factor was ownership of horses. People who have horses usually have a higher socioeconomic status.

Using logistic regression, the result was similar to contingency tables with an additional risk factor, being a student. *Ascaris lumbricoides* was more prevalent in younger school age groups. Additional protective factors were ownership of electrical appliances and wearing shoes. These practices were found only in the higher socioeconomic status.

Table 48.

Summary of risk factors for being positive for hookworm infection. Data from contingency tables and logistic regression analyses. (only significant factors are listed)

Positive for hookworm				
	Odds	95% CI		
Risk factor	ratio	Lower	Upper	*p*
Contingency table				
Gender (male/female)	0.65	0.46	0.91	0.01
Job (kid/adult)	0.42	0.29	0.59	<.01
Education level (0-3/4+)	0.53	0.37	0.77	<.01
Floor (dirt/wooden-cement)	1.47	1.04	2.08	0.03
Density (high/low)	1.57	1.12	2.04	0.01
Wearing shoes (yes/no)	0.67	0.48	0.96	0.03
Forward stepwise method				
Full model				
Occupation (Labor=0,				<.01
Pre-school,	0.30	0.13	0.82	0.02
Student,	0.68	0.33	1.42	0.30
Housework)	2.01	0.82	4.09	0.06
Population density (low=0)	1.90	1.28	2.83	0.00
Forward stepwise method				
Occupation (Labor=0,				<.01
Pre-school,	0.31	1.81	0.55	<.01
Student,	0.82	0.51	1.33	0.43
Housework)	2.37	1.33	4.22	<.01
Population density (low=0)	1.92	1.34	2.77	<.01
Backward stepwise method				
Occupation (Labor=0,				<.01
Pre-school,	0.37	0.21	0.67	<.01
Student,	0.80	0.49	1.30	0.36
Housework)	2.44	1.37	4.37	<.01
Year of education	1.06	0.99	1.13	0.08
Population density (low=0)	1.92	1.33	2.78	<.01
Electrical appliance (no=0)	0.73	0.50	1.05	0.09

In this study, the most common intestinal parasitic infection was hookworm. The risk factors significantly associated with hookworm infection were dirt floors and overcrowded houses. The protective factors were being males, wearing shoes, ownership of electrical appliances, being children and having less education. A possible explanation for children and minimal education being identified as protective factors is that older people were more exposed to hookworm than the younger people. The selected factors that were significantly associated with hookworm infection with logistic regression analysis were similar to those that were identified through contingency table analyses.

Table 49.

Summary of risk factors for being positive for *Trichuris trichiura* infection. Data from contingency tables and logistic regression analyses. (only significant factors are listed)

Positive for *Trichuris trichiura*				
	Odds	95% CI		
Risk factor	ratio	Lower	Upper	*p*
Contingency table				
Race (Ketchi/Mopan)	1.65	1.02	2.68	0.04
Floor (dirt/wooden-cement)	1.61	1.01	2.57	0.05
Density (high/low)	2.73	1.74	4.28	<.01
Toilet (Yes/no)	0.49	0.32	0.77	<.01
Logistic regression				
Full model				
Population density (low=0)	2.40	1.46	3.96	<.01
Treated water (no=0)	0.49	0.25	0.97	0.04
Poultry (no=0)	0.25	0.07	0.94	0.04
Forward stepwise method				
Population density (low=0)	2.61	1.64	4.16	<.01
Toilet (no=0)	0.60	0.38	0.94	0.03
Pig (no=0)	0.53	0.31	0.91	0.02
Backward stepwise method				
Population density (low=0)	2.54	1.59	4.05	<.01
Toilet (no=0)	0.56	0.32	0.89	0.01
Treated water (no=0)	0.58	0.31	1.05	0.07
Pig (no=0)	0.56	0.32	0.96	0.04

Trichuris trichiura is the third most common parasitic infection in the world (Crompton, 1999). Factors significantly associated with the risk of infection were being Kitchi Mayan, having dirt floors and living in overcrowded houses. The protective factors were using toilets, drinking treated water and ownership of pig and poultry. The people who have pigs normally have a higher socioeconomic status. Ownership of poultry as a protective factor against *T. trichiura* is difficult to explain.

Table 50.

Summary of risk factors for being positive for protozoan infection infection. Data from contingency tables and logistic regression analyses.
(only significant factors are listed)

Positive for protozoan				
	Odds	95% CI		
Risk factor	ratio	Lower	Upper	p
Contingency table				
Garbage disposal (Yes/No)	3.33	1.54	7.19	0.00
Water (stream/pump)	1.89	1.14	3.13	0.01
Poultry (yes/no)	3.39	0.99	11.59	0.04
Logistic regression				
Full model				
Year of education	0.93	0.06	1.00	0.04
Trash disposal (no=0)	2.62	1.10	6.26	0.03
Stream water (Pump=0)	2.01	1.10	3.67	0.02
Wearing shoes (no=0)	0.56	0.36	0.87	0.01
Forward stepwise method				
Age	0.99	0.97	1.00	0.01
Trash disposal (no=0)	3.02	1.38	6.60	0.01
Treated water (no=0)	1.79	1.06	3.00	0.03
Wearing shoes (no=0)	0.63	0.42	0.94	0.02
Backward stepwise method				
Age	0.98	0.97	1.00	0.01
Year of education	0.93	0.88	0.99	0.03
Population density (low=0)	0.99	0.47	1.00	0.05
Trash disposal (no=0)	2.46	1.10	5.52	0.03
Stream water (Pump=0)	1.82	1.08	3.07	0.03
Poultry (yes/no)	3.46	0.94	12.70	0.06
Wearing shoes (no=0)	0.55	0.36	0.83	0.01

Fewer factors were found to influence the risk of protozoan infection. Most of the risk factors were similar to those for helminthic infections. The older and higher educated people were a protective factor. Some factors are not directly associated with increased risk. This might be the ecological fallacy of a cross-sectional study (Hennekens, 1987). For example, poultry are the risk factor of protozoan infections, but there is no obvious link between poultry and protozoan infection. However, chickens are raised in almost every house and have access to every room, possibly increasing contamination of food and water.

I am not able explain the association of lower infection rates in more density populated households. One would normally expect the opposite relationship to occur. This result should be further investigated by getting more data.

Table 51.

Summary of risk factors for being positive for *Giardia lamblia* infection. Data from contingency tables and logistic regression analyses.
(only significant factors are listed)

Positive for *Giardia lamblia*				
	Odds	95% CI		
Risk factor	ratio	Lower	Upper	p
Contingency table				
Job (kid/adult)	3.19	1.70	5.99	<.01
Logistic regression				
Full model				
Sex (female=0)	1.67	1.01	3.45	0.05
Population density (low=0)	0.47	0.26	0.84	0.05
Forward stepwise method				
Age	0.96	0.93	0.98	<.01
Backward stepwise method				
Age	0.96	0.94	0.98	<.01
Sex (female=0)	1.66	0.97	2.83	0.07
Race (Mopan=0)	1.99	1.06	3.74	0.03
Year of education	0.89	0.81	0.99	0.03
Population density (low=0)	0.53	0.30	0.93	0.03
Pig (no=0)	0.54	0.28	1.07	0.08

The risk factors for *G. lamblia* infection were being male and having Mayan Ketchi ancestry. The protective factors were older age and having a higher level of education. Overcrowded houses and ownership of pigs were protective factors. Ownership of pigs was a weak association ($P = 0.08$).

Risk factors associated with each parasite can be used to target populations for a prevention and control program for each parasitic infection. The protective factors should be promoted and villagers encouraged to practice protective behaviors.

For example, to prevent *A. lumbricoides*, infections the target population of the program should be the Mayan Ketchi groups (OR 2.1), students (OR 2.59), people using stream water (OR 3.0), people drinking untreated water (OR 1.6), people not wearing shoes (OR 1.6) and people with low socioeconomic status; no electrical appliances (OR 1.4) and no horse (OR 2.2). If the target population is treated and health education is promoted, then prevalence and morbidity from *A. lumbricoides* should decrease.

The risk factors identified for hookworm, *T. trichiura* and protozoan parasites from these analyses can be used in designing prevention and control programs in a similar way as those suggested for *A. lumbricoides*. The populations at risk can be identified. This will help health educators identify target populations and plan relevant health education programs.

As shown in Figure 2 to 10, Geographic Information System (GIS) data can be used to locate the area with high prevalence of parasitoses. Using the number of cases in the houses and interpolating the density of parasite infections in various areas of a village, one can estimate and locate the areas or houses that should receive more attention in prevention and control programs. For example, to control *A. lumbricoides* in Golden Stream village, emphasis should be placed on houses in the northern area of the village. By using contour maps, the high density of cases in the north becomes apparent. The GIS also locates houses positive for parasites, and thus can save time in finding positive cases for treatment.

The location of toilets, water pumps, garbage pits, village health centers and houses of volunteer community health workers should be recorded and plotted on the map. These data may show associations between the parasites and sanitation. The point source analysis from the location of toilets or distance from health centers should have an influence on the prevalence of intestinal parasite infections.

This descriptive study was a cross-sectional survey. There was no random selection of samples, but inclusion of as many subjects as possible. This biomedical survey might not represent the whole population of Belize, but these 553 samples from 5 villages are representative of the Mayan populations of Toledo District southern Belize.

The selection of factors associated with the parasites sometimes has unexplainable results such as overcrowded houses as a protective factor for *E. histolytica* infection, (Table 31, 32). This might be an ecological fallacy which creates a spurious association between parasite infections and risk factors, or recall bias from the questionnaire, which leads to an unexplainable association.

The etiology of intestinal parasitic infections could not be tested because a cross-sectional survey does not detect causation (Hennekens and Burning, 1987). The descriptive information can be used in describing the pattern of the infections that lead to preventive and control program. Other studies should be conducted to detect causation and to understand more about the nature of parasitic infections in people of southern Belize.

Summary

A biomedical survey was carried out in 5 villages of southern Belize (Golden Stream, Medina Bank, San Marcos, Bladden and Tambran) to determine the prevalence and distribution of intestinal parasites, and the risk and protective factors associated with parasite infections.

During April to May and October to November 1999, stool specimens were collected and preserved in 10% formalin and later examined with the formalin-ethyl acetate concentration technique. A questionnaire contained demographic information and details about factors that could be associated with the parasitic infections. Geographic Information System (GIS) data were used to find spatial associations between parasite infections and village environments.

Six hundred and seventy-three people completed the questionnaire and 553 stool specimens were examined. The participation rate was 82%. The prevalence of intestinal parasite infection was 76%. Sixty-seven percent were helminth infections and 34% were protozoan infections. The most common infection was hookworm (55%), followed by *Ascaris lumbricoides* (30%), and *Trichuris trichiura* (19%). The prevalence of protozoan infections were *Giardia lamblia* (12%), *Entamoeba histolytica* (6%) and non-pathogen *Entamoeba coli* (21%). There was no difference in prevalence of parasitic infection by gender. The average age of

individuals with positive stools was 18 years, (male 17 years, female 19 years). The prevalence of intestinal parasite infections was higher in younger age groups than older age groups. The prevalence of the parasite infections were not different by gender, except females had higher prevalence of hookworm than males and males had higher prevalence of *S. stercoralis* infection.

Five hundred and fifty-three participants lived in 111 houses. Forty-six percent of the participants were males. The Mayan Mopan ethnic group represented 34% of people surveyed, the others were Mayan Ketchi.

Sixty percent of houses had dirt floors and 43% had no toilets. Thirty-five percent of houses were characterized with overcrowded living conditions and 10% used stream water and 16% consumed untreated water.

Forty percent of the houses had electrical appliances. Most of the families (92%) raised chickens. Horses (22%) and pigs (26%) were raised by the wealthier families.

The risk factors for intestinal parasites were Mayan Ketchi, housework, overcrowded houses, dirt floor construction, using stream water and drinking untreated water. The protective factors were wearing shoes, using a toilet facility, ownership of electrical appliances, and ownership of horses and pigs, indicators of higher socioeconomic status.

The risk factors for *A. lumbricoides* were Mayan Ketchi, students, and using stream water. The protective factors were drinking treated water, wearing shoes, and ownership of electrical appliances and horses.

The risk factors for hookworm were dirt floors, overcrowded houses, higher education and being a housewife (houseworkers). The protective factors were males, pre-school children and ownership of electrical appliances.

The risk factors for *T. trichiura* were Mayan Ketchi, dirt floor and overcrowded houses. The protective factors were using toilet, drinking treated water and ownership of pigs.

The risk factors for protozoan infections were disposing of trash and using stream water. The protective factors were higher education and wearing shoes.

Some results based on statistical analyses might not be logically explainable. A biomedical survey is a cross-sectional study that can not indicate causation between the factors and parasite infections. Additional investigations using other study methods are needed to answer question of causation.

Programs that focus on significant risk factors, associated with distributions of infection could help health care workers identify the target populations for implementing control efforts. Targeting populations at higher risk will reduce the number of people who need to be educated and treated.

Use of GIS technology did help locate positive cases for subsequent prevention and control programs. Accurate and information linked maps could save time and reduce the workload of health care workers and health educators in the field.

Environmental information such as rainfall, temperature, humidity, soil-types and location of well-pump, streams and toilets should be integrated into the GIS and analyzed to find associations among parasitic infections, environment and spatial information.

This study indicates that intestinal parasitic infections are an important public health problem in southern Belize, especially in the Mayan Ketchi ethnic group. Prevention and control program should be established after initial mass treatment programs have been implemented. The results of this study provide baseline information that can be used to begin prevention and control efforts. Further investigations are needed to obtain additional information in order to better understand the causal associations between intestinal parasitic infections, environment, spatial data and human factors.

References

Albonico, M., Crompton, D. W., and Savioli, L. (1999). Control strategies for human intestinal nematode infections. *Adv Parasitol* **42**, 277-341.

Ananthakrishnan, S., Nalini, P., and Pani, S. P. (1997). Intestinal geohelminthiasis in the developing world [published erratum appears in Natl Med J India 1997 May-Jun;10(3):153]. *Natl Med J India* **10**, 67-71.

Anderson, T. J. C., Zizza, C. A., Leche, G. M., Scott, M. E., and Solomons, N. W. (1993). The distribution of intestinal helminth infections in rural village in Guatemala. *Mem. Inst. OSwaldo Cruz* **88**, 53-65.

Andre, R. G., Roberts, D. R., and Rejmankova, E. (1995). The recent application of remote sensing and geographic information system technologies to the study of malaria vector populations. *Acta Medica Philippina* **31**, 27-35.

Ash, L. R., and Orihel, T. C. (1991). "Parasites: a guide to laboratory procedures and identification." American Society of Clinical Pathologists, Chicago.

Ashcroft, M. T. (1965). A history and general survey of the helminth and protozoal infections of the West Indies. *Ann Trop Med Parasitol* **59**, 478-93.

Ashford, R. W., and Crewe, W. (1998). "The parasites of *Homo sapiens*." Cromwell Press, Liverpool.

Berke, R., Wagshol, L. E., and Sullivan, G. (1972). Incidence of intestinal parasites in Vietnam veterans. *Am J Gastroenterol* **57**, 63-7.

Black World. (1996). Belize on the black world profile today page. , Vol. 1998. http://www.tbwt.com/profiles/belize.htm.

Booth, M., Mayombana, C., Machiya, H., Odermatt, P., Utzinger, J., and Kilima, P. (1998). The use of morbidity questionnaires to identify communities with high prevalence of schistosome or geohelminth infections in Tanzania. *Transctions of the Royal Society of Tropical Medicine and Hygiene* **92**, 484-490.

Borda, C. E., Rea, M. J., Rosa, J. R., and Maidana, C. (1996). Intestinal parasitism in San Cayetano, Corrientes, Argentina. *Bull Pan Am Health Organ* **30**, 227-33.

Bundy, D. A., Hall, A., Medley, G. F., and Savioli, L. (1992). Evaluating measures to control intestinal parasitic infections. *World Health Stat Q* **45**, 168-79.

Bundy, D. A. P. (1988). Sexual effects on parasite infection. *Parasitology Today* **4**, 186-193.

Chamberlin, J. (1995). Seroprevalence of Hepatitis B Virus among school-aged children in the Stann Creek district of Belize, Central America. . Uniformed Services University of the Health Sciences, Bethesda.

Chan, M. S., Medley, G. F., Jamison, D., and Bundy, D. A. (1994). The evaluation of potential global morbidity attributable to intestinal nematode infections. *Parasitology* **109**, 373-87.

Chitchang, S. (1982). "Medical Helminthology." Medart, Bangkok.

CIA. (1999). The world factbook 1999 - Belize. , Vol. 2000. http://www.odci.gov/cia/publications/nsolo/factbook/bh.htm.

Crompton, D. W. (1999). How much human helminthiasis is there in the world? [comment]. *J Parasitol* **85**, 397-403.

Crompton, D. W., and Savioli, L. (1993). Intestinal parasitic infections and urbanization. *Bull World Health Organ* **71**, 1-7.

Cross, J. H. (1998). An advice *in* Medical Zoology Seminar.

Ebisawa, I. (1998). Epidemiology and Eradication of *Schistosomiasis japonica* in Japan. *J Travel Med* **5**, 33-35.

Elkins, D. B., Haswell-Elkins, M., and Anderson, R. M. (1986). The epidemiology and control of intestinal helminths in the Pulicat Lake region of Southern India. I. Study design and pre- and post-treatment observations on *Ascaris lumbricoides* infection. *Trans R Soc Trop Med Hyg* **80**, 774-92.

ESRI. (1996). "ArcView GIS The geographic information system for everyone." Environmental Systems Research Institute, Inc., Redland, California, USA.

Gamboa, M. I., Basualdo, J. A., Kozubsky, L., Costas, E., Cueto Rua, E., and Lahitte, H. B. (1998). Prevalence of intestinal parasitosis within three population groups in La Plata, Argentina. *Eur J Epidemiol* **14**, 55-61.

Garcia, L. S., and Bruckner, D. A. (1997). "Diagnostic Medical Parasitology." American Society for Microbiology, Washington D.C.

Gross, R., Schell, B., Molina, M. C., Leao, M. A., and Strack, U. (1989). The impact of improvement of water supply and sanitation facilities on diarrhea and intestinal parasites: a Brazilian experience with children in two low-income urban communities. *Rev Saude Publica* **23**, 214-20.

Guthe, W. G., Tucker, R. K., Murphy, E. A., England, R., Stevenson, E., and Luckhardt, J. C. (1992). Reassessment of lead exposure in New Jersey using GIS technology. *Environ Res* **59**, 318-25.

Hennekens, C. H., and Burning, J. E. (1987). "Epidemiology in Medicine." Little, Brown and company, Boston.

Hidayah, N. I., Teoh, S. T., and Hillman, E. (1997). Socio-environmental predictors of soil-transmitted helminthiasis in a rural community in Malaysia. *Southeast Asian J Trop Med Public Health* **28**, 811-5.

Hilman, R. S. (1998). *In* "Harrison's Principles of Internal Medicine" (A. S. Fauci, J. D. Wilson, E. Braunwald, K. J. Isselbacher, R. G. Peterdorf, J. B. Martin, and R. K. Root, eds.), Vol. 1. McGraw-Hill, New York.

Holland, C. V., Taren, D. L., Crompton, D. W., Nesheim, M. C., Sanjur, D., Barbeau, I., Tucker, K., Tiffany, J., and Rivera, G. (1988). Intestinal helminthiases in relation to the socioeconomic environment of Panamanian children. *Soc Sci Med* **26**, 209-13.

Hosmer, D. W., and Lemeshow, S. (1989). "Applied logistic regression." A Wiley-Interscience publication, New York.

Kightlinger, L. K., Seed, J. R., and Kightlinger, M. B. (1998). *Ascaris lumbricoides* intensity in relation to environmental, socioeconomic, and behavioral determinants of exposure to infection in children from southeast Madagascar. *J Parasitol* **84**, 480-4.

Kitron, U., and Kazmierczak, J. J. (1997). Spatial analysis of the distribution of Lyme disease in Wisconsin. *Am J Epidemiol* **145**, 558-66.

Kleinbaum, D. G. (1994). "Logistic regression: a self-learning text." Springer-Verlag.

Library of Congress. (1992). Belize - a country study on Library of congress / Federal research division. , Vol. 1998. http://lcweb2.loc.gov/frd/cs/bztoc.html.

Macedo, C. G. d. (1990). "Health conditions in the Americas." Pan American Health Organization, Washinton D.C.

Mahler, R., and Wotkyn, S. (1995). "Belize Adventure in nature." Group West, Emeryville, California.

Martin. (1998). Parasites of Cental America. , Vol. 1998. http://martin parasitology.mcgill.ca/JIMSPAGE /CENTRAL .HTM.

Mata, L. (1982). Sociocultural factors in the control and prevention of parasitic diseases. *Rev Infect Dis* **4**, 871-9.

Montresor, A., Crompton, D. W. T., Hall, A., Bundy, D. A. P., and Savioli, L. (1998). "Guidelines for the evaluation of soil-transmitted helminthiasis and schistosomiasis at community level." World Health Organization, Geneva.

Muller, R. (1981). "Introduction to helminthology." SmithKline Beecham, Hundington.

Oberhelman, R. A., Guerrero, E. S., Fernandez, M. L., Silio, M., Mercado, D., Comiskey, N., Ihenacho, G., and Mera, R. (1998). Correlations between intestinal parasitosis, physical growth, and psychomotor development among infants and children from rural Nicaragua. *Am J Trop Med Hyg* **58**, 470-5.

Omumbo, J., Ouma, J., Rapuoda, B., Craig, M. H., le Sueur, D., and Snow, R. W. (1998). Mapping malaria transmission intensity using geographical information systems (GIS): an example from Kenya [published erratum appears in Ann Trop Med Parasitol 1998 Apr;92(3):351]. *Ann Trop Med Parasitol* **92**, 7-21.

Parasitology subcommittee member, (1978). Recommended procedures for the examination of clinical specimens submitted for the diagnosis of parasitic infections. *Am J Med Technol* **44**, 1101-6.

Pawlowski, Z. S. (1983). Intestinal parasitic infections as a public health problem. *Parassitologia* **25**, 141-50.

Pawlowski, Z. S. (1984). Implications of parasite-nutrition interactions from a world perspective. *Fed Proc* **43**, 256-60.

Petana, W. B. (1968). A survey for intestinal parasites in two communities in British Honduras, Central America. *Ann Trop Med Parasitol* **62**, 518-521.

Plorde, J. J., and Ramsey, P. G. (1991). *In* "Harrison's Principles of Internal Medicine" (J. D. Wilson, E. Braunwald, K. J. Isselbacher, R. G. Peterdorf, J. B. Martin, A. S. Fauci, and R. K. Root, eds.), Vol. 1, pp. 817-831. McGraw-Hill, New York.

Pongpaew, P., Tungtrongchitr, R., Radomyos, P., Vudhivai, N., Phonrat, B., Himman-ngan, T., Supawan, V., Tawprasert, S., Migasena, P., and Schelp, F. P. (1993). Parasitic infection and socio-demographic characteristics of urban construction site workers. *Southeast Asian J Trop Med Public Health* **24**, 573-6.

Rejmankova, E., Pope, K. O., Roberts, D. R., Lege, M. G., Andre, R., Greico, J., and Alonzo, Y. (1998). Characterization and detection *of Anopheles vestitipennis* and *Anopheles punctimacula* (Diptera: Culicidae) larval habitats in Belize with field survey and SPOT satellite imagery. *J Vector Ecol* **23**, 74-88.

Salas, S. D., Heifetz, R., and Barrett-Connor, E. (1990). Intestinal parasites in Central American immigrants in the United States. *Arch Intern Med* **150**, 1514-6.

Sanchez, A. L., Gomez, O., Allebeck, P., Cosenza, H., and Ljungstrom, I. (1997). Epidemiological study *of Taenia solium* infections in a rural village in Honduras. *Annals of Tropical Medicine and Parasitology* **91**, 163-171.

Scholten, H. J., and de Lepper, M. J. (1991). The benefits of the application of geographical information systems in public and environmental health. *World Health Stat Q* **44**, 160-70.

Smith, J. (1998). World incidence of parasitic infections. , Vol. 1998. http://martin.parasitology.mcgill.ca/incienc.htm.

Stoll, N. R. (1947). This wormy world. *Journal of Parasitology* **33**, 1-18.

Tanaka, H., and Tsuji, M. (1997). From discovery to eradication of schistosomiasis in Japan: 1847-1996. *Int J Parasitol* **27**, 1465-80.

U.S. Census Bureau, and International database. (2000). IDB Summary demographic data for Belize. , Vol. 2000. http://www.census.gov/cgi-bin/ipc/idbsum?cty=BH.

U.S.Department of State Beureau of Western hemisphere Affairs. (2000). Background notes: Belize. , Vol. 2000. http://www.state.gov/www/background_notes/belize_0400_bgn.html.

UNICEF. (1997). Health of Toledo district. , Vol. 2000. The national committee for families and children, http://www.family.mcw.edu/belize/HealthT.htm.

Vine, M. F., Degnan, D., and Hanchette, C. (1997). Geographic information systems: their use in environmental epidemiologic research. *Environ Health Perspect* **105**, 598-605.

Virk, K. J., Prasad, R. N., and Prasad, H. (1994). Prevalence of intestinal parasites in rural areas of district Shahjahanpur, Uttar Pradesh. *J Commun Dis* **26**, 103-8.

Watkins, W. E., Cruz, J. R., and Pollitt, E. (1996). The effects of deworming on indicators of school performance in Guatemala. *Transaction of the Royal Society of Tropical Medicine and Hygiene* **90**, 156-161.

WHO. (1981). "Intestinal protozoan and helminthic infection." World Health Organization.

WHO. (1987). "Prevention and control of intestinal parasitic infections." World Health Organization, Geneva.

WHO. (1996). "1995 World Health Statistics Annual." World Health Organization, Malta.

World Bank. (1993). "World Development Report 1993: Investing in Health." Oxford University Press, New York.

Yilma, J. M., and Malone, J. B. (1998). A geographic information system forecast model for strategic control of fasciolosis in Ethiopia. *Vet Parasitol* **78**, 103-27.

Appendix 1

Consent form for children.

UNIFORMED SERVICES UNIVERSITY OF THE HEALTH SCIENCES
4301 JONES BRIDGE ROAD
BETHESDA, MARYLAND 20814-4799

Purpose of this study
You are parents or guardian of the child that are being asked to be in a research project entitled, **"The distribution of intestinal parasites in the rural area of southern Belize"**. This study is being done by scientists at the Uniformed Services University of the Health Sciences. You are free to choose whether you allow you child to take part in the study.

Before you decide whether to allow your child to be a part of this study, it is important that you understand what the study will do so that you can make an informed decision. This form gives information about the research study. Once you understand the study, you will be asked to sign this form if you want your child to take part.

Your child is being asked to be in this study because he/she is living in selected villages of Toledo district including Golden Stream, Indian Creek, San Marcos, and Laguna. The researchers will try to find how many of people in these villages have worms.

Information about parasites (worms)
A parasite (worm) is an animal that lives in or on another animal (the host) from which it gets food and shelter. Intestinal worms are most common in countries with warm climates. They are among the major problems that weaken the entire population.

These worms live in the gut. You can get them in various ways. Eggs are passed in an infected person's stool and re-enter on your hands, from your clothing, from the soil, or from dirty food or water. They enter either as eggs with larvae in them or as larvae. Adults develop in man, mate and lay eggs.

Study procedures
If you decide to let your child be in this study we will ask your child to do the following things. The study will last approximately 1 day, or until a stool is collected.

Participant initials________
Witness initials________

1) You will be given a stool cup to collect a thumb-size stool from your child.
2) You will be visited by researchers at your home who will ask you questions related to worms and your child's health.
3) Your child's stool will be preserved and microscopically examined to find worms.

Possible benefits

1) This study may be of benefit to your child by identifying the parasites he/she is infected with.
2) If your child has worms, you can get medicine to treat the worm infections from local Belizian Ministry of Health personnel.
3) The information that comes from this study may help our understanding of worm infections in Belize and improve your child's health.

Possible risks

There is no risk in this study. There may be a little inconvenience while you are collecting the stool. The questions in this study are not sensitive and you should feel no embarrassment in responding.

Your privacy

All information collected for this study including your child's answers to question or results of his/her stool examination may be used only for research purposes and will be kept strictly confidential. The information we collect about your child will be kept in locked files, without his/her name attached but with a special code that allows us to identify him/her if necessary. The questionnaire and stool will contain only his/her code and will not have his/her name or any other identifying information. The researchers in charge of this study, Pote Aimpun and the village health personnel, are the only persons who will have access to his/her name and code. Officials of the Belizian Ministry of Health and the Uniformed Services University of the Health Sciences in the U.S.A. will also have access so that they can be sure that your privacy has been protected. Your child will not be identified by name in any report or publication resulting from this study.

Participant initials________
Witness initials________

Your choice
You are free to choose whether to allow your child to be in the study. Even if you decide to let your child to be in this study now, you may choose to stop participating at any time.

Please feel free to ask me any questions if there is anything you do not understand. If you have any questions about this study later on, you may contact Dr. Polanco, telephone number 23-5785 in the Belize City hospital.

____
Date Signed

__________________________ __________________________
Signature of Parent or Guardian **Printed Name**

__________________________ __________________________
Signature of Witness **Printed Name**

Can you read or write? Yes No

If the response is "No" place thumb print in available space.

____
Thumb Print

Do you understand/speak English?
If the response is "No", the interpreter should fill in the following paragraph:
I, __________________________, certify that the contents of the written consent have been translated from English to (Mayan, Creole) for the study volunteer.

____
Printed Name

Participant initials_______
Witness initials_______

Child's assent:
I agree to participate in this study and to give a stool sample that will be checked for worms.

______________________ ______________________

Child's signature **Printed name**

______________________ ______________________

Signature of Witness **Printed Name**

Can you read or write? **Yes** **No**

If the response is "No" place thumb print in available space.

____

Thumb Print

Do you understand/speak English?
If the response is "No", the interpreter should fill in the following paragraph:
I, ______________________, certify that the contents of the written consent have been translated from English to (Mayan, Creole) for the study volunteer.

____

Printed Name

Participant initials_______
Witness initials_______

Consent form for adults.

UNIFORMED SERVICES UNIVERSITY OF THE HEALTH SCIENCES
4301 JONES BRIDGE ROAD
BETHESDA, MARYLAND 20814-4799

Purpose of this study
You are being asked to be in a research project entitled, "**The distribution of intestinal parasites in the rural area of southern Belize**". This study is being done by scientists at the Uniformed Services University of the Health Sciences. You are free to choose whether you allow you child to take part in the study.

Before you decide whether to be a part of this study, it is important that you understand what the study will do so that you can make an informed decision. This form gives information about the research study. Once you understand the study, you will be asked to sign this form if you want to take part.

You are being asked to be in this study because you are living in selected villages of Toledo district including Golden Stream, Indian Creek, San Marcos, and Laguna. The researchers will try to find how many of people in these villages have worms.

Information about parasites (worms)
A parasite (worm) is an animal that lives in or on another animal (the host) from which it gets food and shelter. Intestinal worms are most common in countries with warm climates. They are among the major problems that weaken the entire population.

These worms live in the gut. You can get them in various ways. Eggs are passed in an infected person's stool and re-enter on your hands, from your clothing, from the soil, or from dirty food or water. They enter either as eggs with larvae in them or as larvae. Adults develop in man, mate and lay eggs.

Study procedures
If you decide to be in this study we will ask you to do the following things. The study will last approximately 1 day, or until a stool is collected.

1) You will be given a stool cup to collect a thumb-size stool.
2) You will be visited by researchers at your home who will ask you questions related to worms and your health.
3) Your stool will be preserved and microscopically examined to find worms.

Participant initials_______
Witness initials_______

Possible benefits

1) This study may be of benefit to you by identifying the parasites he/she is infected with.
2) If you have worms, you can get medicine to treat the worm infections from local Belizian Ministry of Health personnel.
3) The information that comes from this study may help our understanding of worm infections in Belize and improve your health.

Possible risks

There is no risk in this study. There may be a little inconvenience while you are collecting the stool. The questions in this study are not sensitive and you should feel no embarrassment in responding.

Your privacy

All information collected for this study including your answers to questions or results of your stool examination may be used only for research purposes and will be kept strictly confidential. The information we collect about you will be kept in locked files, without your name attached but with a special code that allows us to identify you if necessary. The questionnaire and stool will contain only your code and will not have your name or any other identifying information. The researchers in charge of this study, Pote Aimpun and the village health personnel, are the only persons who will have access to his/her name and code. Officials of the Belizian Ministry of Health and the Uniformed Services University of the Health Sciences in the U.S.A. will also have access so that they can be sure that your privacy has been protected. You will not be identified by name in any report or publication resulting from this study.

Your choice

You are free to choose whether to be in the study. Even if you decide to be in this study now, you may choose to stop participating at any time.

Please feel free to ask me any questions if there is anything you do not understand. If you have any questions about this study later on, you may contact Dr. Polanco, telephone number 23-5785 in the Belize City hospital.

Participant initials_______
Witness initials_______

____
Date Signed

______________________________ ______________________________
Signature of Subject **Printed Name**

______________________________ ______________________________
Signature of Witness **Printed Name**

Can you read or write? Yes No

If the response is "No" place thumb print in available space.

____
Thumb Print

Do you understand/speak English?
If the response is "No", the interpreter should fill in the following paragraph:
I, ____________________________, certify that the contents of the written consent have been translated from English to (Mayan, Creole) for the study volunteer.

____
Printed Name

Participant initials________
Witness initials________

Appendix 2

Questionnaire for a study of intestinal parasites in Belize

1) Village Number __ __
2) House Number __ __
3) ID Number __ __ __ __
4) Date of record __ __ / __ __ / __ __

---

5) House location Latitude __ __ . __ __

   Longitude __ __ . __ __

   Observe the surrounding area of the house:

   What do you consider the area of the house?

   ( ) 1.Jungle ( ) 2.Grass land

   ( ) 3.Village ( ) 4.Others ______

6) How many years that you have been living here? __ __ years

---

7) How old are you? __ __ years
8) Gender ( ) 1.Male ( ) 2.Female
9) What is your race?

   ( ) 1.Mestizo ( ) 2.Creole ( ) 3.Maya

   ( ) 4.Garifuna ( ) 5.Others ______ ( ) 9.N/A

10) What are you doing for living?

   ( ) 1.Young child ( ) 2.Student ( ) 3.Housewife

   ( ) 4.Agriculture ( ) 5.Banana plantation

   ( ) 6.Handicraft ( ) 7.Labor ( ) 8.Merchant

   ( ) 9.Others ______

11) How many years have you been in school? __ __ years

---

12) Observe the house floor: What does it made of?

   ( ) 1.Dirt ( ) 2.Wooden ( ) 3.Cement

   ( ) 4.Mats ( ) 5.Others ______

13) How many people do you have in your house? __ __
14) How many rooms do you have in your house? __ __

---

15) Do you have toilet? ( ) 1.Yes ( ) 2.No

If answer "Yes"; Where is it?

( ) 1.In-house ( ) 2.Out-house

16) How do you get rid of you trash?

( ) 1.Bury ( ) 2.Burn

( ) 3.Municipal ( ) 4.Others _____

17) What kind of water do you have?

( ) 1.Well ( ) 2.Stream

( ) 3.Pipe ( ) 4.Others _____

18) What do you do to the water before you drinking?

( ) 1.Boiled ( ) 2.Treated

( ) 3.Nothing ( ) 4.Others _____

---

19) Do you own your house? ( ) 1.Yes ( ) 2.No

20) Do you have any electrical equipment?

( ) 1.Yes ( ) 2.No

---

21) What kinds of livestock do you have? And numbers?

( ) 1.None ( ) 2.Pigs __ __ ( ) 3.Poultry __

( ) 4.Sheep __ __ ( ) 5.Goat __ __ ( ) 6.Horse __ __

( ) 7.Cow __ __ ( ) 8.Others _____

22) What kind of pets do you have?

( ) 1.None ( ) 2.Dogs

( ) 3.Cats ( ) 4.Others _____

---

23) Do you wash you hands before eating?

( ) 1.Never ( ) 2.Hardly

( ) 3.Sometime ( ) 4.Always

24) How often do you wear your shoes?

( ) 1.Never ( ) 2.Hardly

( ) 3.Sometime ( ) 4.Always

During this past 2 months, did you have any symptoms that caused you could not go to work?

25) Have you ever had diarrhea?

( ) 1.Yes ( ) 2.No

For the last worst diarrhea:

Did you have blood in stool? ( ) Yes ( ) No

Appendix 3

Formalin-ether(ethyl acetate) method [Ash, 1991]

Material and reagents

1. Applicator sticks
2. Bottles, dispensing or plastic squeeze, 250 ml or 500 ml. These bottles are convenient for adding water (0.85% saline solution) to the centrifuge tubes.
3. Centrifuge, with head and cups to hold 15-ml conical tubes. Sealed buckets must be used.
4. Centrifuge tubes, 15 ml, conical
5. Cotton swabs
6. Coverslips
7. Tip-cut paper funnel cups
8. Metal screen
9. Microscope slides
10. Pipettes, Pasteur, with rubber bulbs
11. Rack or support for tubes
12. Formalin, 10%. For everyday use, pour some of the solution into a "squeeze" bottle. Label the bottle.
13. Ethyl acetate.
14. Lugol's iodine, 1% solution in a dispensing bottle with a pipette

15.Saline solution, isotonic.

Procedure

1. Fit a metal screen over a tip-cut paper funnel that is placed on the top of centrifuge tube.
2. Pass the fecal suspension through the screen into the centrifuge tube until 2 ml mark is reached.
3. Remove the screen and discard the filter with the lumpy residue.
4. Add water (0.85% saline solution) 10 ml mark is reached and mix well.
5. Centrifuge the solution at 400 to 500 X g for 1 to 2 minutes. If the supernatant is still cloudy, it should be discarded and the sediment resuspended and centrifuged again using the water (saline solution). If the supernatant following the first wash is relatively clear, proceed to next step.
6. Resuspend the sediment in several milliliters of water (10% formalin) by sharply flicking the bottom of the tube; add more water (10% formalin) to bring the total volume of the suspension to 10 ml.
7. Add 3 ml of ethyl acetate, stopper the tube, and shake vigorously for 30 seconds.

8. Centrifuge at 400 to 500 X g for 2 to 3 minutes. When the tube is removed from the centrifuge, it will be seen to consist of four layers: (a) a top layer of ethyl acetate, (b) a plug of debris that adheres to the wall of the tube, (c) a layer of water (10% formalin), (d) sediment.
9. Insert an applicator stick into the tube to ring and loosen the plug of debris; decant the tube and discard the top three layers. Clean the sides of the tube with cotton swab. After proper decanting, the small amount of fluid left on the sides of the tube will flow back onto the sediment.
10. Mix the fluid with the sediment (sometimes it is necessary to add a drop of saline) using disposable pipette.
11. Prepare unstained and iodine wet mount for examination

Appendix 4

Wet film examination [WHO, 1991]

Materials

1. Compound microscope
2. Slides
3. Coverslips
4. Disposable transfer pipette
5. Isotonic saline solution
6. Lugol's solution (1% iodine)
7. Liquid mixture from formalin-ethyl acetate concentration technique

Procedure

1. Label a microscope slide with an identification number from the stool cup at the end of the slide.
2. With a disposable transfer pipette, place a drop of liquid mixture in the center of the left half of the slide and place a drop of iodine solution in the center of right half of the slide.
3. Mixed liquid mixture with the drop of iodine.
4. Cover the drop of liquid mixture and the drop of iodine with a coverslip. Hold the coverslip at an angle, touch the edge of the drop, and lower gently

on to the slide. This will reduce the chance of including air bubles in the mount.

5. The slide was placed on the compound microscope stage and focussed on the mount with the x10 or low-power objective. The microscope light was adjusted to see objective in the field distinctly. Too much or too little light is not good (light source was Mini Maglite®, Model Number M2A01H, California). Then the entire coverslip area with x10 objective was examined; the objective was focussed on the top left-hand corner, and the slide was moved systematically backwards and forwards or up and down. When organism or suspicious material was seen, the high dry objective was used, and the light was increased by opening the substage diaphragm to observe detailed morphology. This is a systematic examination. If mounts are examined in this way, any parasites present will usually be found. If a mount is not examined systematically, parasites may be missed. The procedure of examining each microscopic field carefully, focusing up and down, before moving to the next field was followed.

6. Record the findings.

Appendix 5

Computational form for the Yates-corrected Chi-Square test for 2x2 contingency tables (Rosner, 1995)

General contingency table

		Parasite Positive	Parasite Negative	
Factor	Positive	*a*	*b*	*a*+*b*
	Negative	*c*	*d*	*c*+*d*
		a+*c*	*b*+*d*	*n*=*a*+*b*+*d*+*c*+*d*

$$X^2 = n\left(|ad - bc| - \frac{n}{2}\right)^2 / [(a + b)(c + d)(a + c)(b + d)]$$

To test the hypothesis $H_0: p_1 = p_2$ versus $H_1: p_1 \neq p_2$ using a contingency table format.

1. Compute the test statistic X^2 which under H_0 approximately follow a X_1^2 distribution.
2. For a level α test, reject H_0 if $X^2 > X^2_{1,1-\alpha}$ and accept H_0 if $X^2 \leq X^2_{1,1-\alpha}$.
3. The exact p-value is given by the area to the right of X^2 under a X_1^2 distribution.
4. Use this test only if none of the four expected values is less than 5.

Point and interval estimation for odds ratio

Odds ratio = ad/bc

1. A point estimation of the true odds ratio (OR) is given by $OR = ad / bc$.

2. An approximate two-sided 100% X (1-α) CI for OR is given by $\left(e^{c_1}, e^{c_2}\right)$ where

$$c_1 = \ln(OR) - z_{1-\alpha/2}\sqrt{\frac{1}{a} + \frac{1}{b} + \frac{1}{c} + \frac{1}{d}}$$

$$c_2 = \ln(OR) + z_{1-\alpha/2}\sqrt{\frac{1}{a} + \frac{1}{b} + \frac{1}{c} + \frac{1}{d}}$$

Appendix 6

Multiple logistic regression (Rosner, 1995)

If $x_1, .., x_k$ are a collection of independent factors and y is a binomial-outcome factor with probability of success = *p*, then the multiple logistic regression model is given by

$$\text{logit}(p) = \ln\left(\frac{p}{1-p}\right) = \alpha + \beta_1 x_1 + \ldots + \beta_k x_k$$

or equivalently, if we solve for *p*, then the model can be expressed in the form

$$p = \frac{e^{\alpha + \beta_1 x_1 + \ldots + \beta_k x_k}}{1 + e^{\alpha + \beta_1 x_1 + \ldots + \beta_k x_k}}$$

Appendix 7

F test for the equality of two variances (Rosner, 1995)

To test of the hypothesis $H_0:\sigma_1=\sigma_2$ versus $H_1:\sigma_1\neq\sigma_2$ with significance level α.

Compute the test statistic $F = s_1^2 / s_2^2$ if

$$F > F_{n_1-1,n_2-1,1-\alpha/2} \text{ or } F < F_{n_1-1,n_2-1,1-\alpha/2}$$

then H_0 is rejected. If

$$F_{n_1-1,n_2-1,1-\alpha/2} \leq F \leq F_{n_1-1,n_2-1,1-\alpha/2}$$

then H_0 is accepted.

Two-sample t test for independent samples with equal variances (Rosner, 1995)

To test the hypothesis $H_0:\mu_1=\mu_2$ versus $H_1:\mu_1\neq\mu_2$ with significance level α for two normally distributed populations, where σ^2 is assume to be the same for each population.

Compute the test statistic:

$$= \frac{\bar{x}_1 - \bar{x}_2}{s\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

where $s = \sqrt{\left[(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2\right] / (n_1 + n_2 - 2)}$

if $> t_{n_1+n_2-2,1-\alpha/2}$ or $< -t_{n_1+n_2-2,1-\alpha/2}$

then H_0 is rejected. If

$$- t_{n_1+n_2-2,1-\alpha/2} \le t \le t_{n_1+n_2-2,1-\alpha/2}$$

then H_0 is accepted.

Two-sample *t* test for independent samples with unequal variances (Rosner, 1995)

Compute the test statistic

$$= \frac{\bar{x}_1 - \bar{x}_2}{s\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Compute the approximate degree of freedom d', where

$$d' = \frac{\left(s_1^2 / n_1 + s_2^2 / n_2\right)^2}{\left(s_1^2 / n_1\right)^2 / (n_1 - 1) + \left(s_2^2 / n_2\right)^2 / (n_2 - 1)}$$

Round d' down to the nearest integer d''. If

$$> t_{d'',1-\alpha/2} \quad \text{or} \quad < -t_{d'',1-\alpha/2}$$

then reject H_0. If

$$- t_{d'',1-\alpha/2} \le t \le t_{d'',1-\alpha/2}$$

then accept H_0.

Appendix 8

Two-sample test for binomial proportions (Normal-theory test) (Rosner, 1995)

To test the hypothesis $H_0: p_1 = p_2$ versus $H_1: p_1 \neq p_2$ where the proportions are obtained from two independent samples

Compute the test statistic:

$$z = \frac{\hat{p}_1 - \hat{p}_2}{\sqrt{\hat{p}\hat{q}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

where $$\hat{p} = \frac{n_1\hat{p}_1 + n_2\hat{p}_2}{n_1 + n_2} = \frac{x_1 + x_2}{n_1 + n_2},\ \hat{q} = 1 - \hat{p}$$

and x_1, x_2 are the number of events in the first and second samples, respectively.

For two-sided level-α test, if

$$z > z_{1-\alpha/2} \text{ or } z < z_{1-\alpha/2}$$

then reject H_0. If

$$z_{\alpha/2} \leq z \leq z_{1-\alpha/2}$$

then accept H_0.

The exact p-value for this test is given by

$$p = 2[1-\Phi(z)] \quad \text{if } z \geq 0$$

$$= 2\Phi(z) \quad \text{if } z < 0$$

Use this test only when the normal approximation to the binomial distribution is valid for each of the two samples, when $n_1\hat{p}\hat{q} \geq 5$ and $n_2\hat{p}\hat{q} \geq 5$.

Appendix 9

The distribution of cases of *A. lumbricoides* in Golden Stream village is shown in Figure 14. The northern part of the village contains more houses that are positive, thus more positive cases.

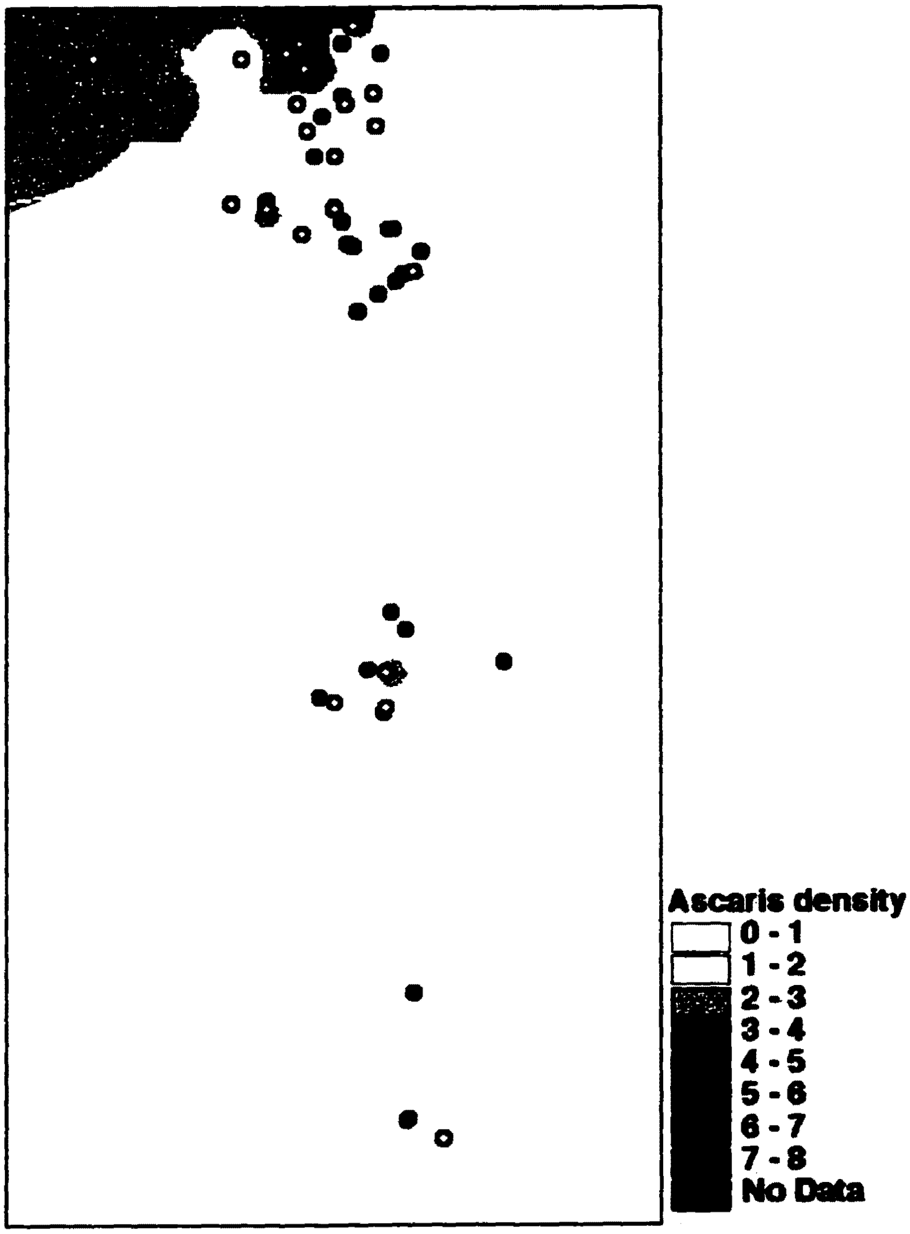

Figure 14.

Contour map showing the number of cases of *Ascaris lumbricoides* per house in Golden Stream village, southern Belize.
Yellow dots are positive households for the parasite; green dots are negative households.

Figure 15 shows the distribution of hookworm cases by household in Golden Stream village. Only 4 of 47 houses had no infections. One of the negative houses belonged to a licensed food handler who had to pass an examination and be negative for parasites. Hookworm is the most common parasitic infection found in the current survey of Golden Stream village. The infection was scattered through out the village.

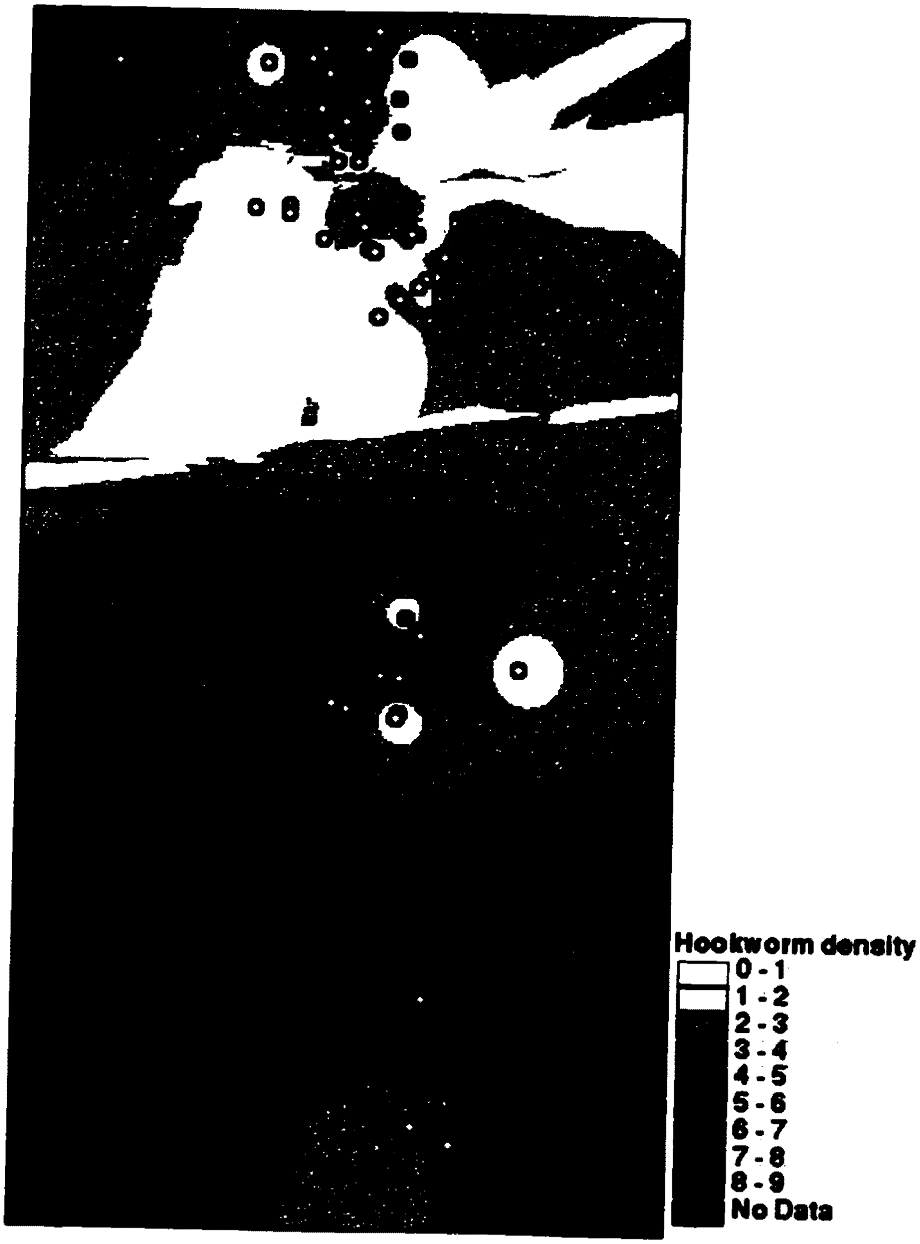

Figure 15.

Contour map showing the number of cases of Hookworm per house in Golden Stream village, southern Belize.
Yellow dots are positive households for the parasite; green dots are negative households.

Figure 16 shows the distribution of the houses with at least one inhabitant who is positive for *T. trichiura* infection in Golden Stream village. The cases are evenly distributed through the village. The northern part of the village contains more positive houses and cases than the southern part of the village.

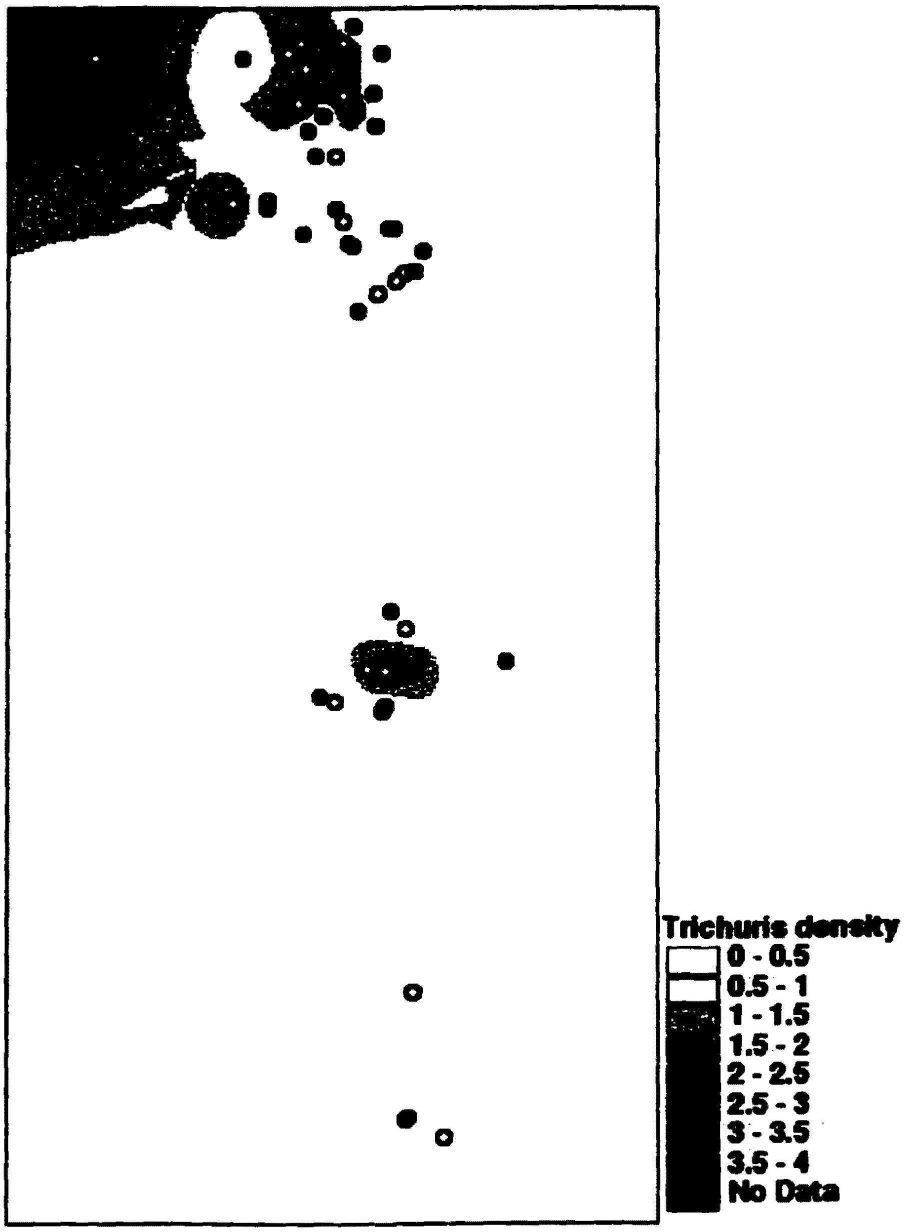

Figure 16.

Contour map showing the number of cases of *Trichuris trichiura* per house in Golden Stream village. Yellow dots are positive households for the parasite; green dots are negative households.

Figure 17 shows the distribution of *S. stercoralis*, a soil-transmitted parasite in Golden Stream village. The parasite was found in only 3 houses, 2 houses in the north and one in the south, with one case per house. The distribution is similar to hookworm. *Strongylodes stercoralis* cases, however, were lower in number.

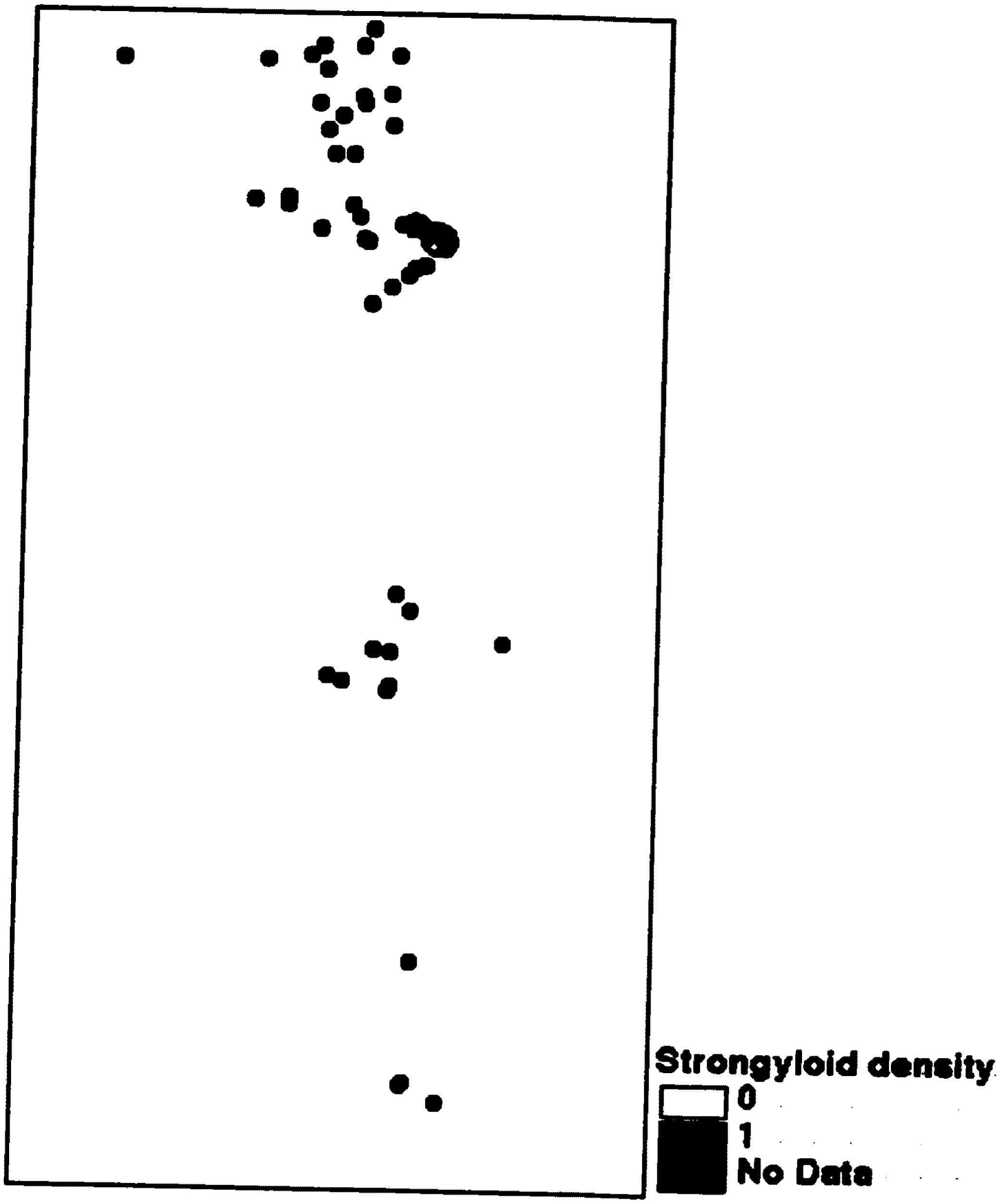

Figure 17.

Contour map showing the number of cases of *Strongyloides stercoralis* per house in Golden Stream. Yellow dots are positive households for the parasite; green dots are negative households.

Figure 18 shows the distribution of *G. lamblia* cases in Golden Stream village. More houses are positive in the northern part of the village than in the south, which is indicated by a red contour.

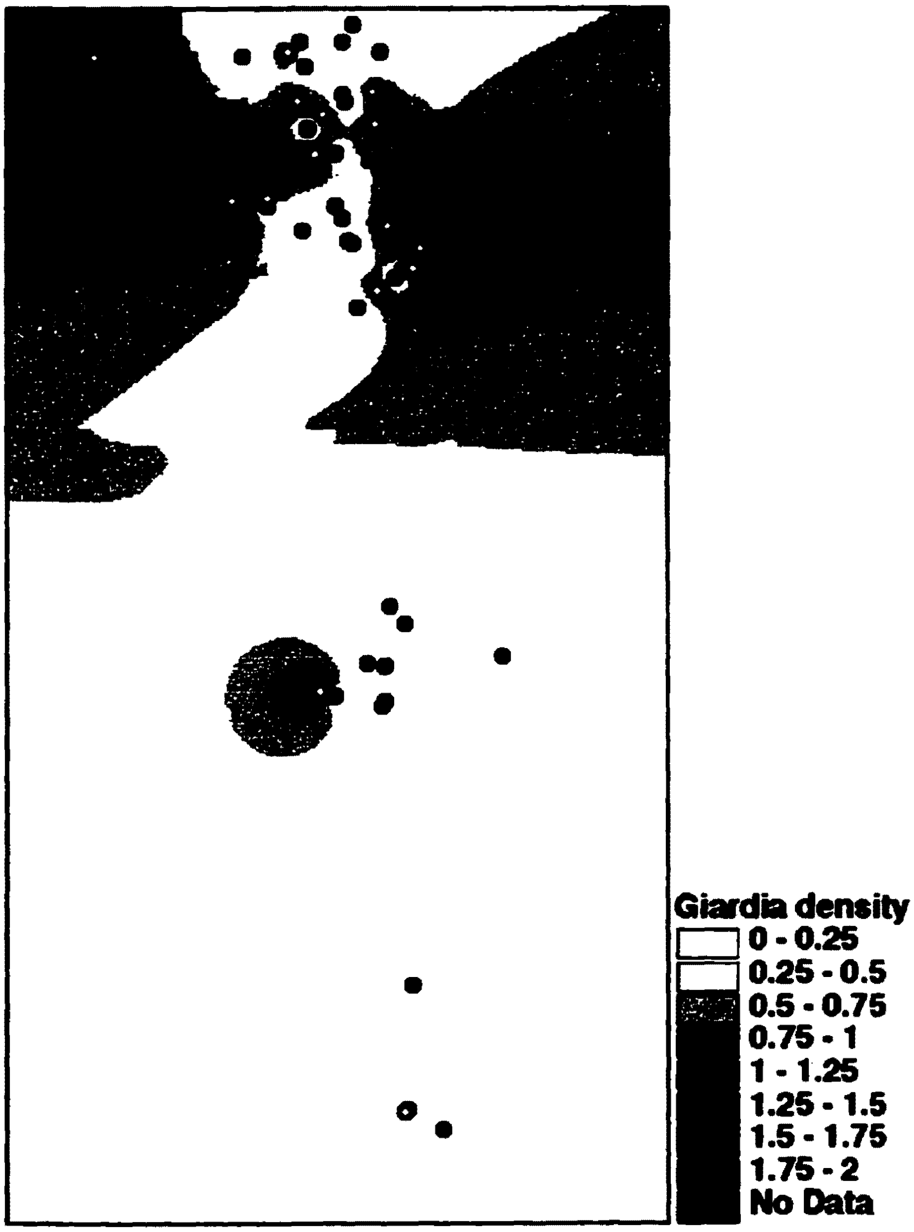

Figure 18.

Contour map showing the number of cases of *G.iardia lamblia* per house in Golden Stream village. Yellow dots are positive households for the parasite; green dots are negative households.

Figure 19 shows the distribution of *E. histolytica* cases in Golden Stream village. The southern part of the village contains more cases than the northern part. Some cases are scattered in the north.

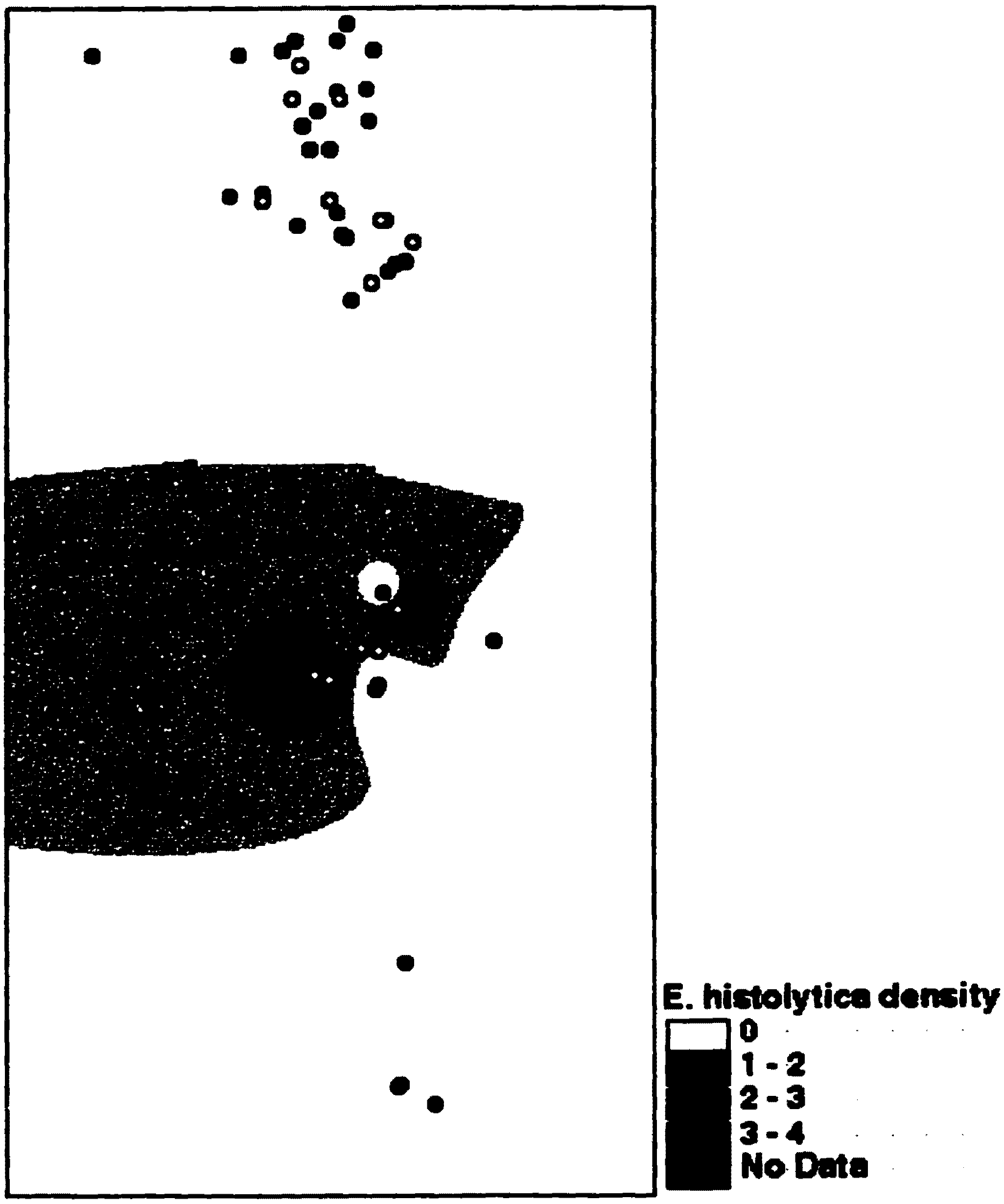

Figure 19.

Contour map showing the number of cases of *Entamoeba histolytica* per house in Golden Stream village. Yellow dots are positive households for the parasite; green dots are negative households.

Figure 20 shows the distribution of *E. coli* cases in Golden Stream village. The southern part of the village has higher number of cases than the northern part. The positive houses are scattered through out the village.

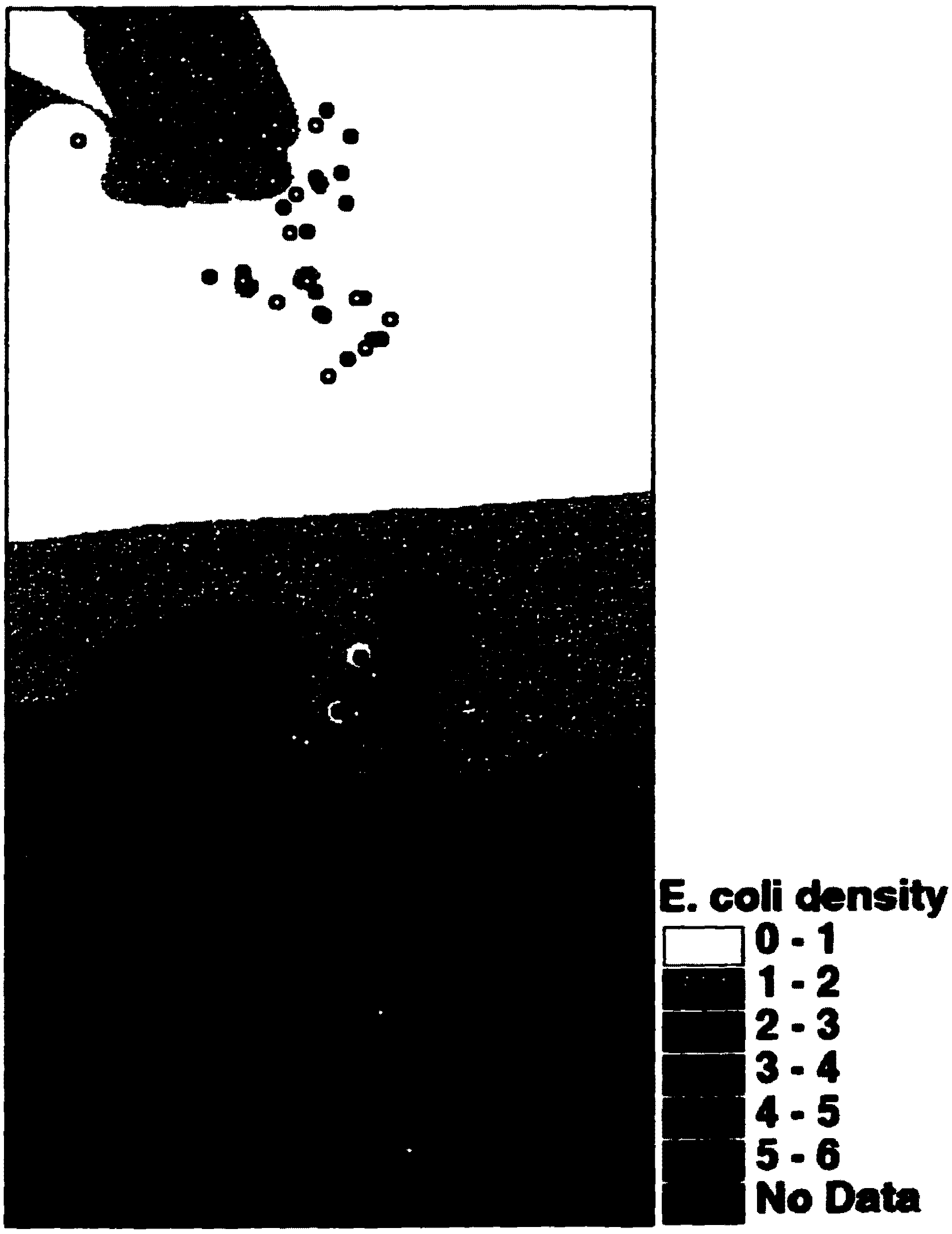

Figure 20.

Contour map showing the number of cases of *Entamoeba coli* per house in Golden Stream village. Yellow dots are positive households for the parasite; green dots are negative households.

Figure 21 shows the distribution of cases per house in Golden Stream village with at least one parasite. Figure 22 shows those households that were positives for helminthic infections in Golden Stream village. Only two houses were negative for any parasite (green dot). The positive cases are evenly distributed through the village. Both maps show similar patterns because helminths are the most common parasites.

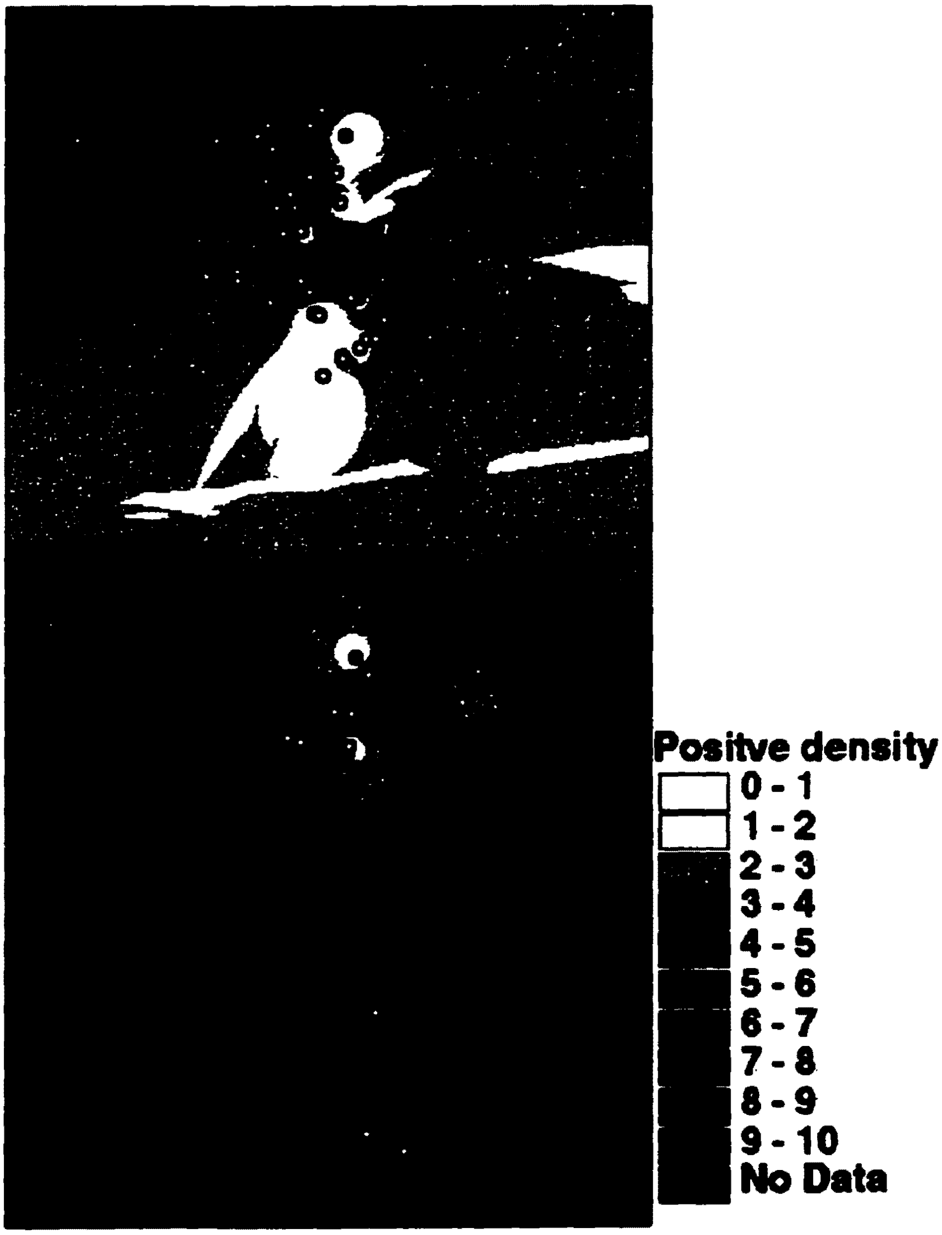

Figure 21.

Contour map showing the number of cases of parasitic infections per house in Golden Stream village. Yellow dots are positive households for the parasites; green dots are negative households.

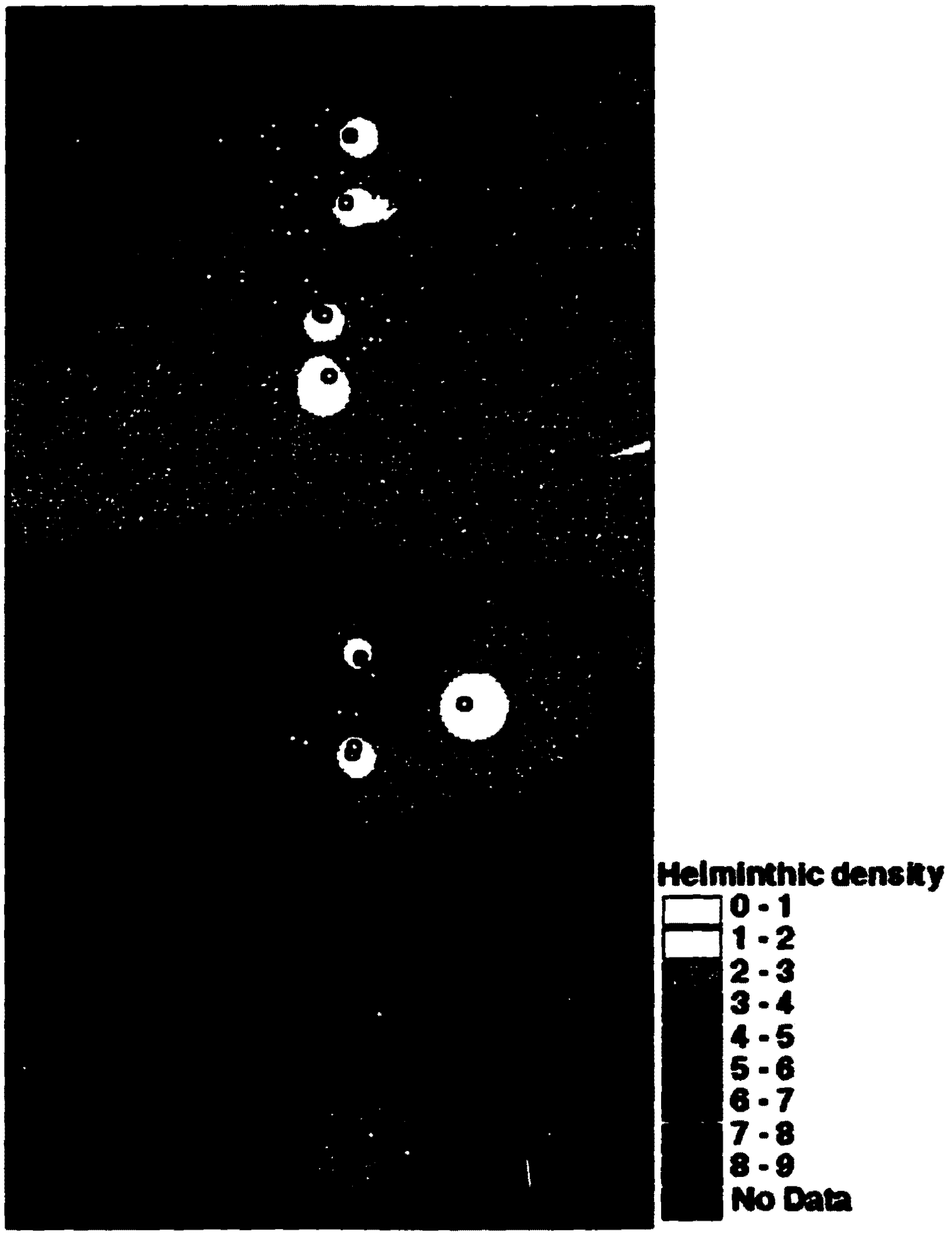

Figure 22.

Contour map showing the number of cases of helminthic infections per house in Golden Stream village. Yellow dots are positive households for the parasites; green dots are negative households.

Figure 23 shows the distribution of protozoan infections. The positive houses are scattered through out the village, but the southern part of the village had a higher number of cases per household than the northern part.

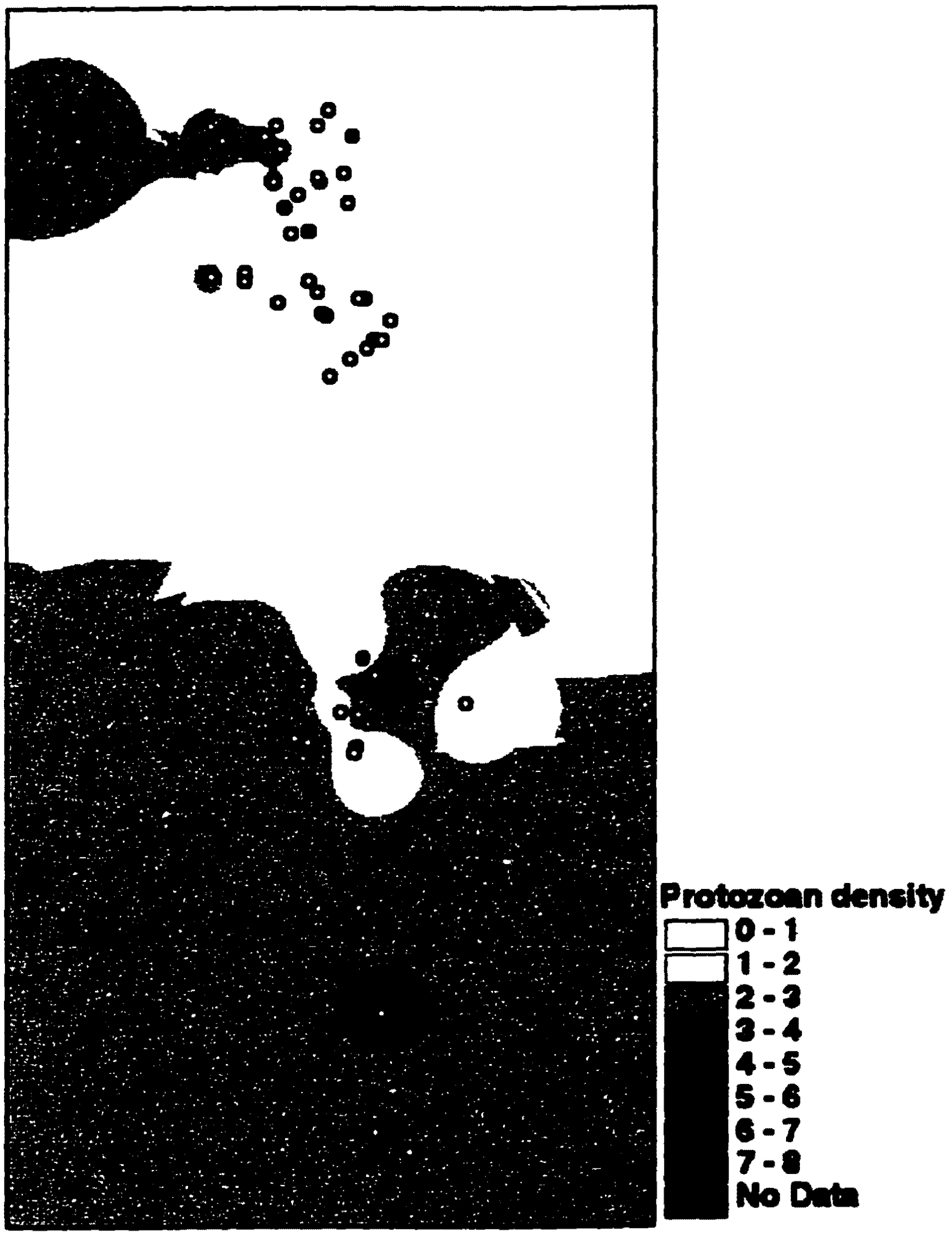

Figure 23.

Contour map showing the number of cases of protozoan infections per house in Golden Stream village. Yellow dots are positive households for the parasites; green dots are negative households.

Figure 24 shows the location of houses in Medina Bank village plotted on Landsat Thematic Mapper image. Most of the houses are on the right side of southern highway. The other side of the village is a logging area (blue color). There were 21 houses in the village.

Figure 25 is a contour map based on number of people per house. The number per household was higher in the northern area of the village, near a stream.

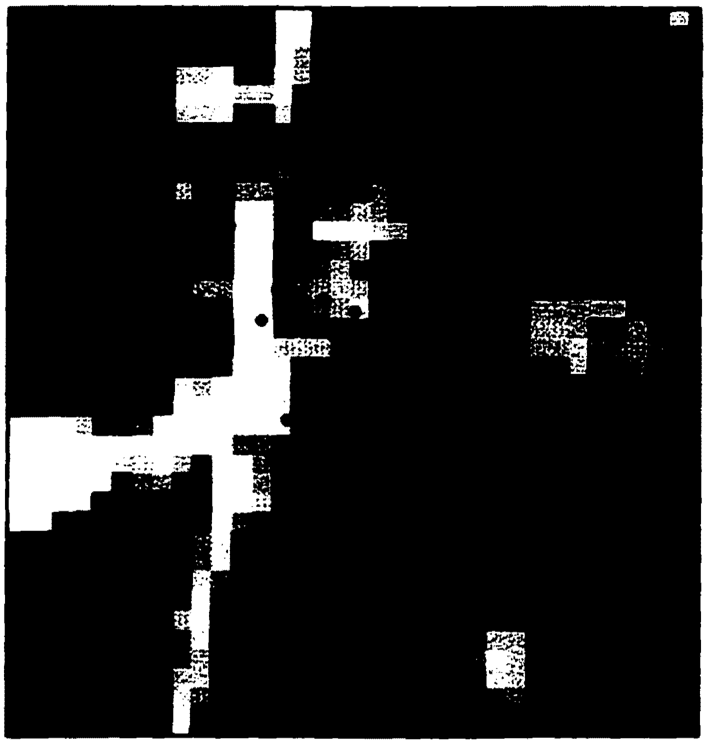

Figure 24.

Location of houses in Medina Bank village.
House locations are plotted on a Landsat Thematic image.

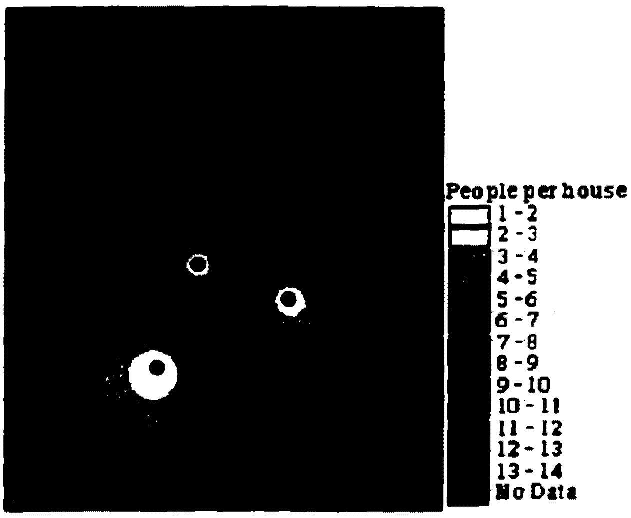

Figure 25.

Contour map showing the number of people
per house in Medina Bank village.

Figure 26 shows the distribution of *A. lumbricoides* infection in Medina Bank village. Most households had positive cases, only 5 houses in the southeast area of the village were negative.

Figure 27 shows the distribution of hookworm infections in Medina Bank. The distribution of positive houses for hookworm is similar to the distribution of *A. lumbricoides*, but higher in both numbers of positive houses and cases; only 3 houses were negative.

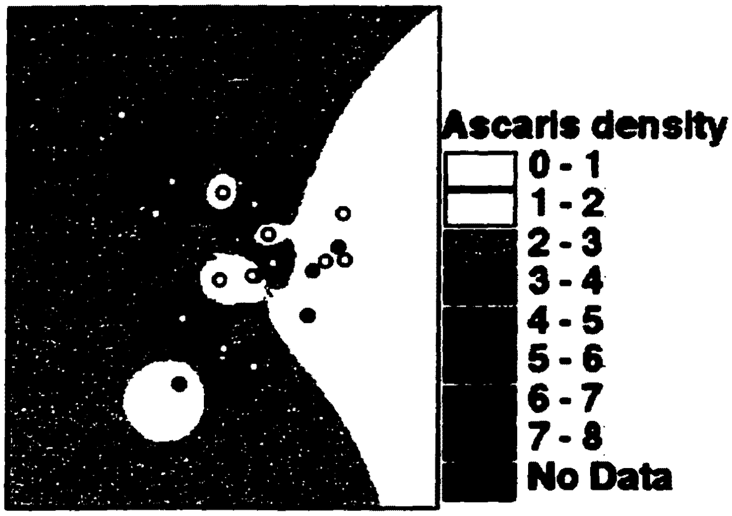

Figure 26.

Contour map showing the number of cases of *A. lumbricoides* per house in Medina Bank village. Yellow dots are positive households for the parasite; green dots are negative households.

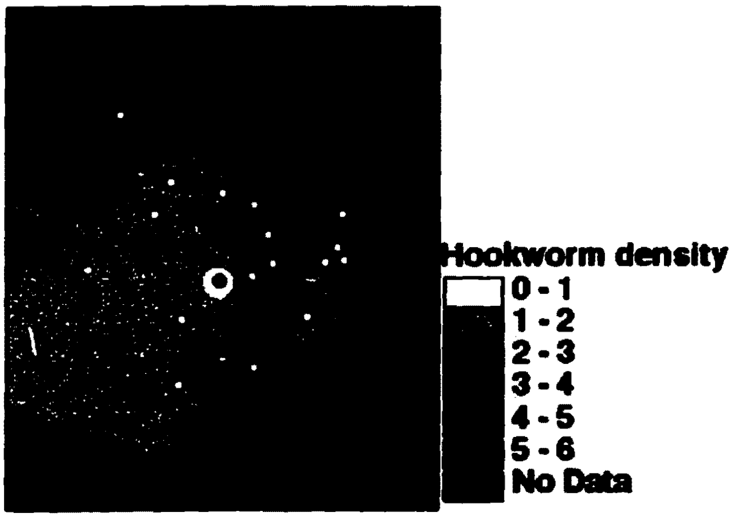

Figure 27.

Contour map showing the number of cases of hookworm per house in Medina Bank village. Yellow dots are positive households for the parasite; green dots are negative households.

Figure 28 shows the distribution of *T. trichiura* cases in Medina Bank. More cases occurred in houses on the east than on the west.

Figure 29 shows the distribution of *G. lamblia* cases in Medina Bank. Cases were distributed through out the village

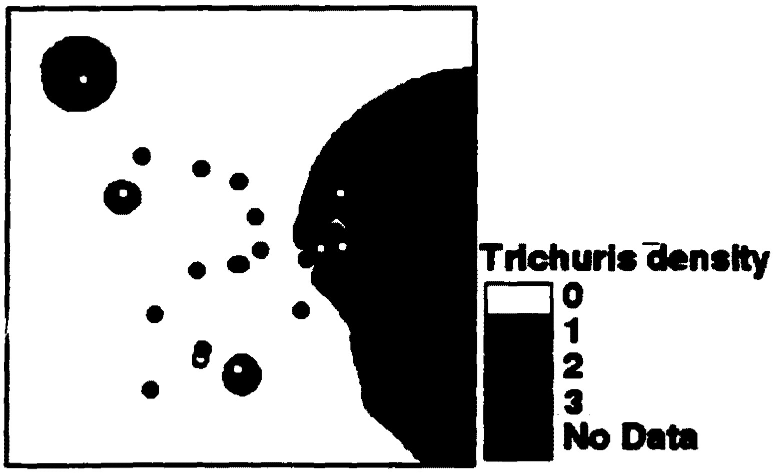

Figure 28.

Contour map showing the number of cases of *T. trichiura* per house in Medina Bank village. Yellow dots are positive households for the parasite; green dots are negative households.

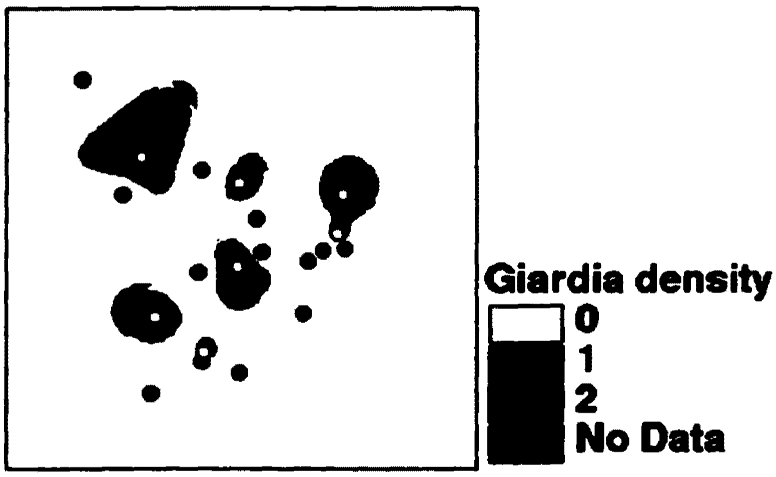

Figure 29.

Contour map showing the number of cases of *G. lamblia* per house in Medina Bank village. Yellow dots are positive households for the parasite; green dots are negative households.

Figure 30 shows the distribution of *E. histolytica* cases in Medina Bank village. There were 4 houses with one case in each house.

Figure 31 shows the distribution of *E. coli* cases in Medina bank village. The positive cases were located in the northern part of the village.

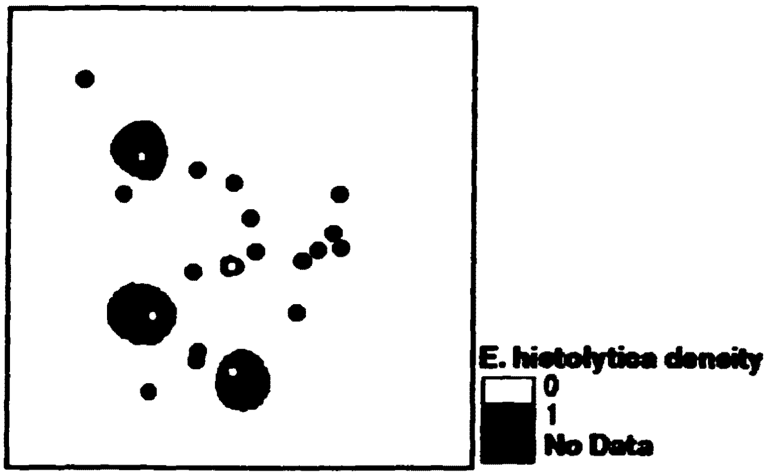

Figure 30.

Contour map showing the number of cases of *E. histolytica* per house in Medina Bank village. Yellow dots are positive households for the parasite; green dots are negative households.

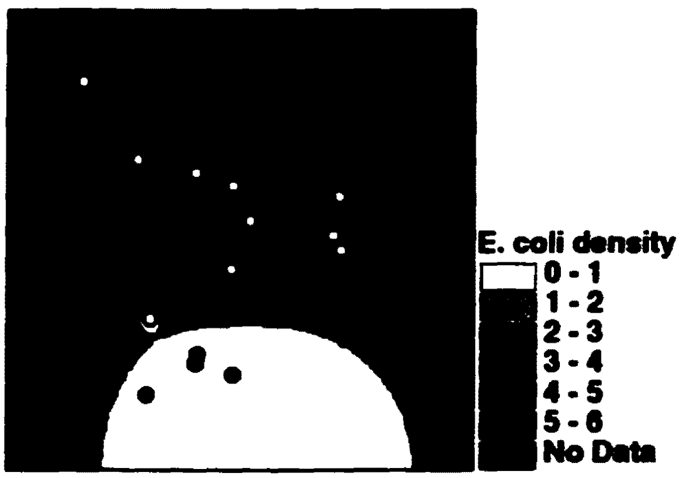

Figure 31.

Contour map showing the number of cases of *E. coli* per house in Medina Bank village. Yellow dots are positive households for the parasite; green dots are negative households.

Figures 32 and 33 show the distribution cases that were positive for parasites and for helminth parasites, respectively. All but one house had a resident with a parasite infection. The helminths are a subset of parasitic infections, so the distribution is similar with one negative house.

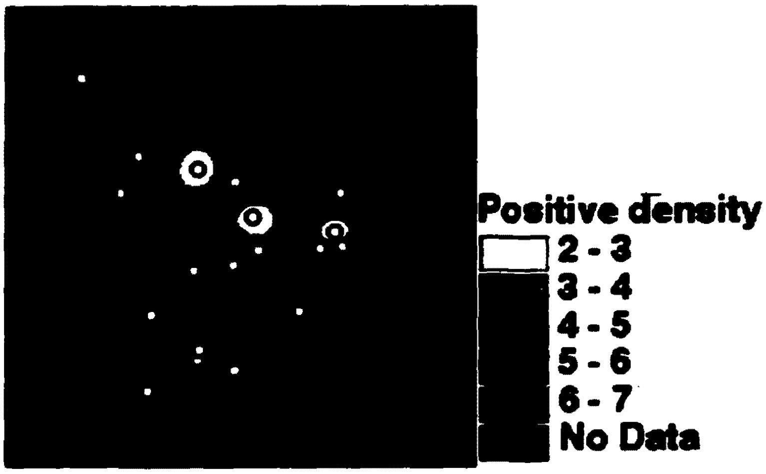

Figure 32.

Contour map showing the number of cases of parasitic infections per house in Medina Bank village. Yellow dots are positive households for the parasites; green dots are negative households.

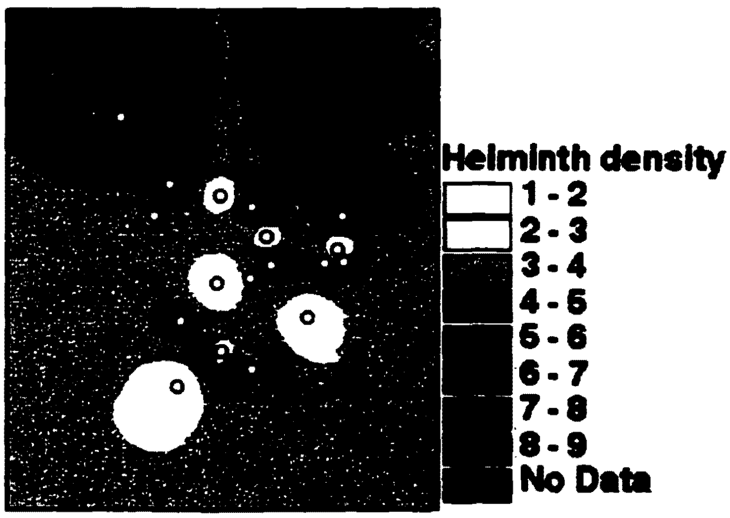

Figure 33.

Contour map showing the number of cases of helminthic infections per house in Medina Bank village. Yellow dots are positive households for the parasites; green dots are negative households.

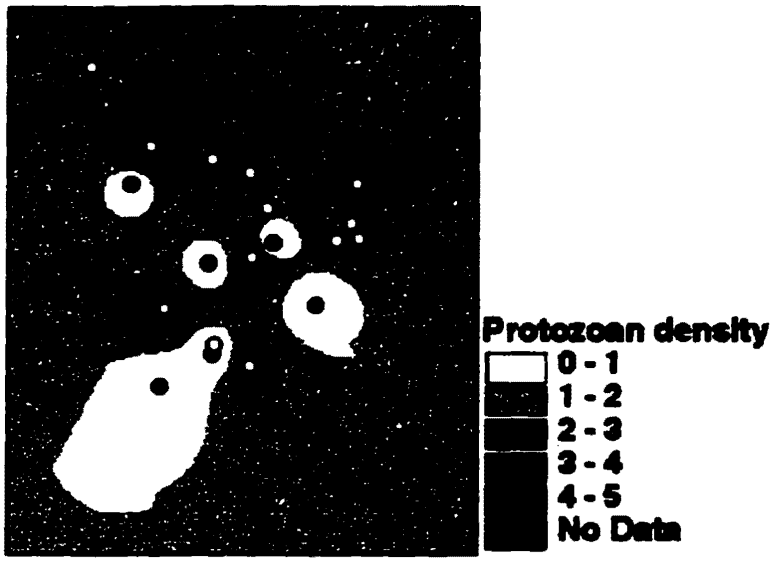

Figure 34.

Contour map showing the number of cases of protozoan infections per house in Medina Bank village. Yellow dots are positive households for the parasites; green dots are negative households.

Figure 34 shows the distribution of protozoan cases in Medina Bank. The cases were evenly distributed through the village. The average number of cases was 1-2 per house, the highest was 4-5 per house.

Figure 35 shows the location of houses of San Marcos village. The village is located off the southern highway, approximately 2 miles on a secondary gravel road. There is a stream which most of the villagers used for laundering in the north of the village. There are 26 houses and only 4 toilets.

Figure 36 demonstrates a population density of the San Marcos village, which is higher in the northeast and the southwest area of the village. A stream is located in the northeast. One house in the southwest area had 17 members living in 3 cottages.

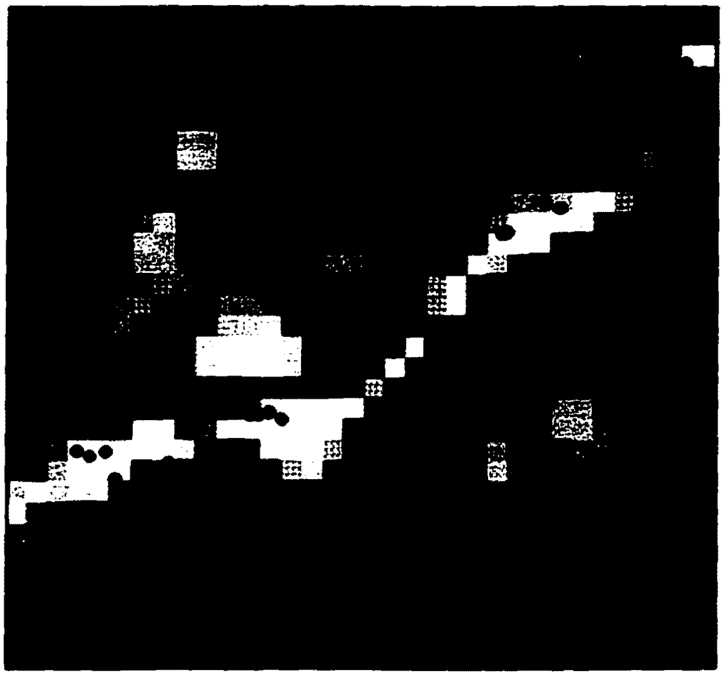

Figure 35.

Location of houses in San Marcos village
Plotted on Thematic Mapper image.

Figure 36.

Contour map of people per house in San Marcos village.

Figure 37 shows the distribution of *A. lumbricoides* cases in San Marcos village. The cases were scattered throughout the village. There were 4 houses without infections.

Figure 38 shows the distribution of hookworm in San Marcos village. Every house in the village had hookworm infections. The distribution of cases was high in the northeast and the southwest areas of the village.

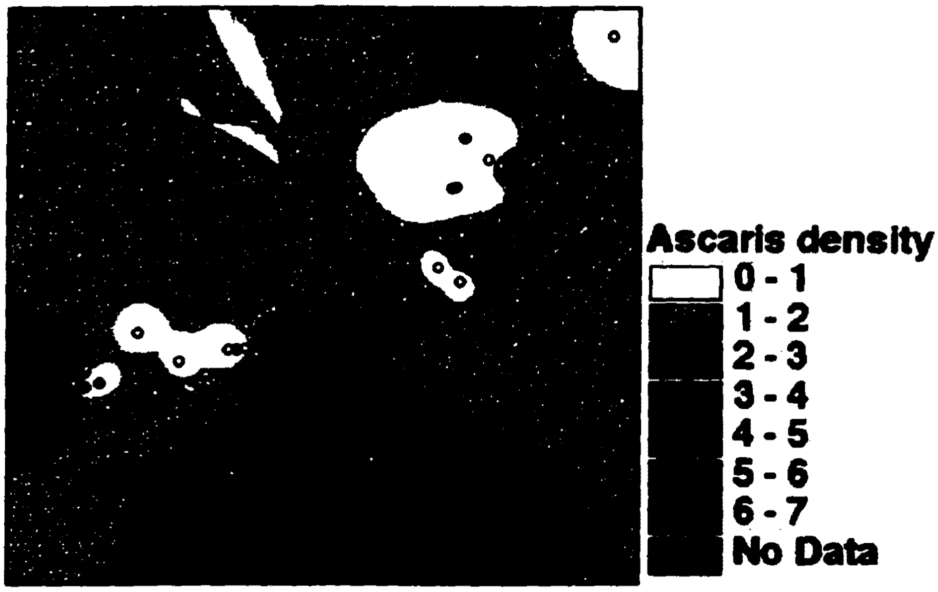

Figure 37.

Contour map showing the number of cases of *A. lumbricoides* per house in San Marcos village. Yellow dots are positive for the parasite; green dots are negative.

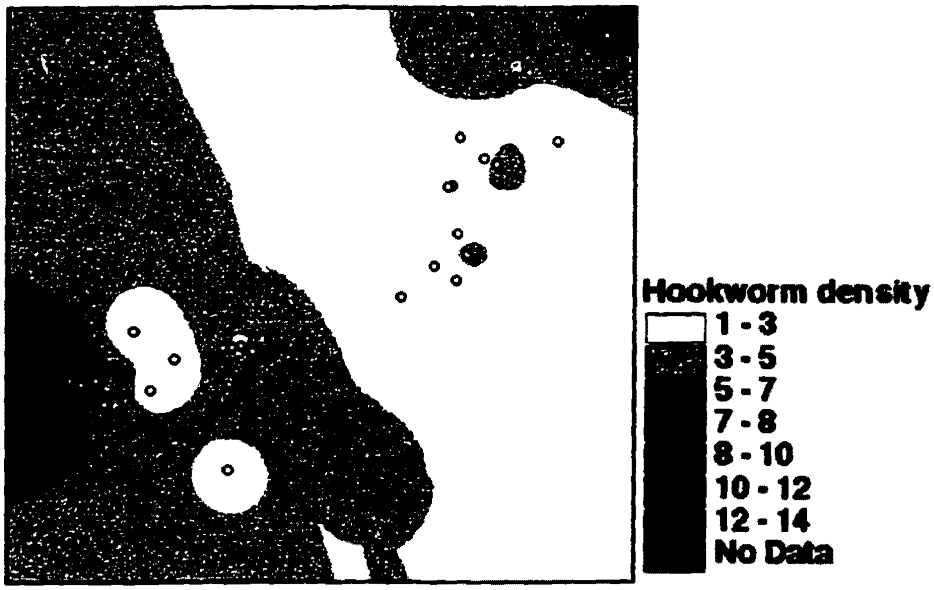

Figure 38.

Contour map showing the number of cases of hookworm per house in San Marcos village. Yellow dots are positive for the parasite; green dots are negative.

Figure 39 shows the distribution of *T. trichiura* cases in San Marcos village. The cases were distributed through the village, but the number of cases in the southeast was higher.

Figure 40 shows the distribution of *S. stercoralis* cases in San Marcos village. There were two cases in two houses with a yellow label.

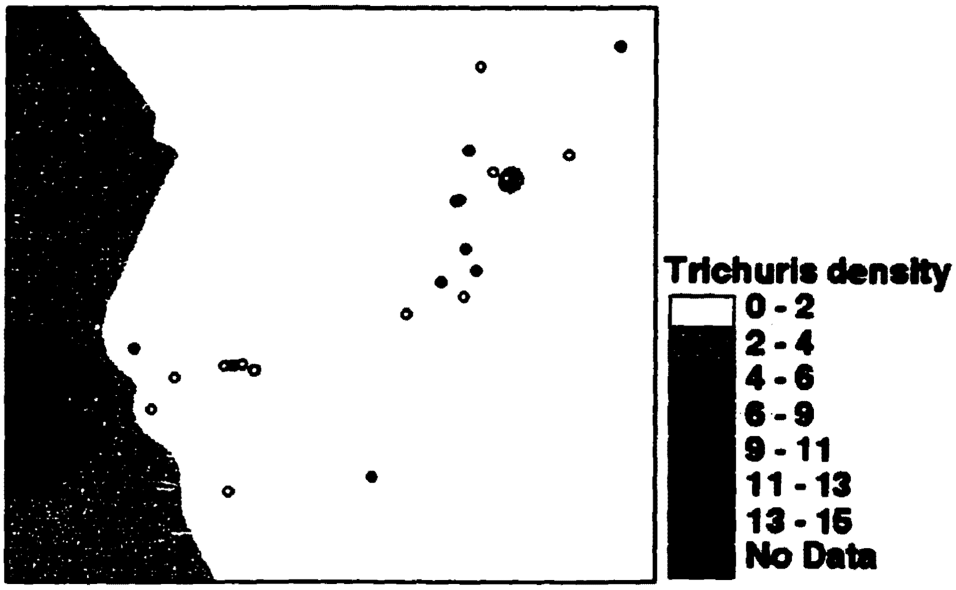

Figure 39.

Contour map showing the number of cases of *T. trichiura* per house in San Marcos village. Yellow dots are positive for the parasite; green dots are negative.

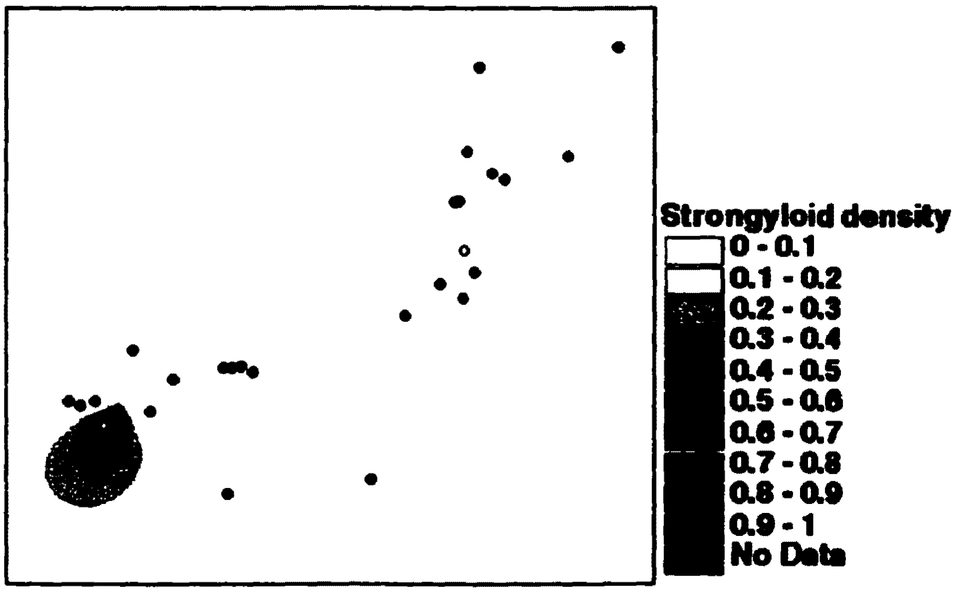

Figure 40.

Contour map showing the number of cases of *S. stercoralis* per house in San Marcos village. Yellow dots are positive for the parasite; green dots are negative.

Figure 41 shows the distribution of *G. lamblia* cases in San Marcos village. The cases were scattered through the village. The higher number of cases is indicated in the red contour.

Figure 42 shows the distribution of *E. histolytica* cases in San Marcos village. The cases ranged 1 to 2 per house. The northeast had only 2 infected houses, but a higher number of cases per house.

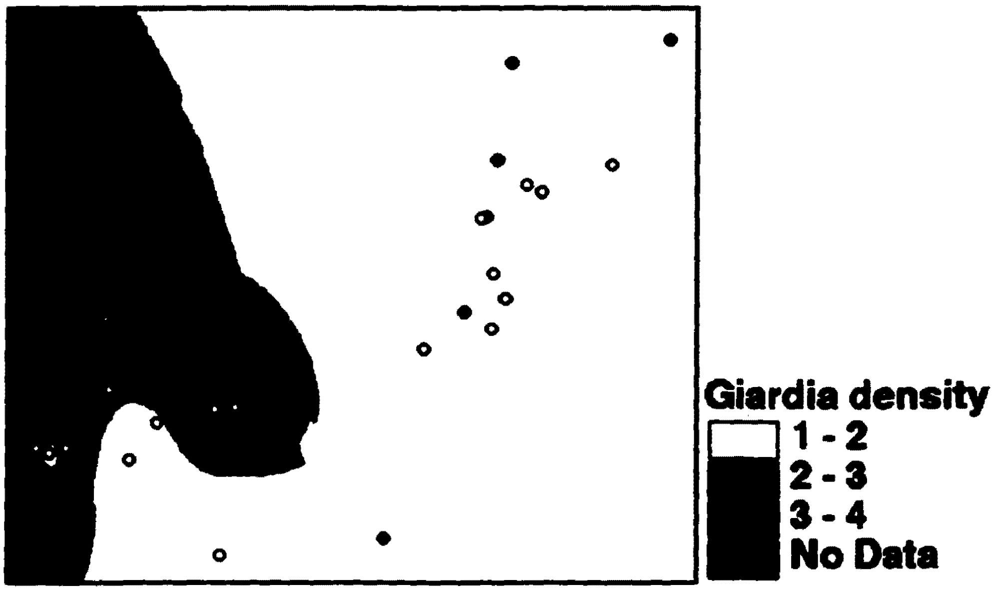

Figure 41.

Contour map showing the number of cases of *G. lamblia* per house in San Marcos village. Yellow dots are positive for the parasite; green dots are negative.

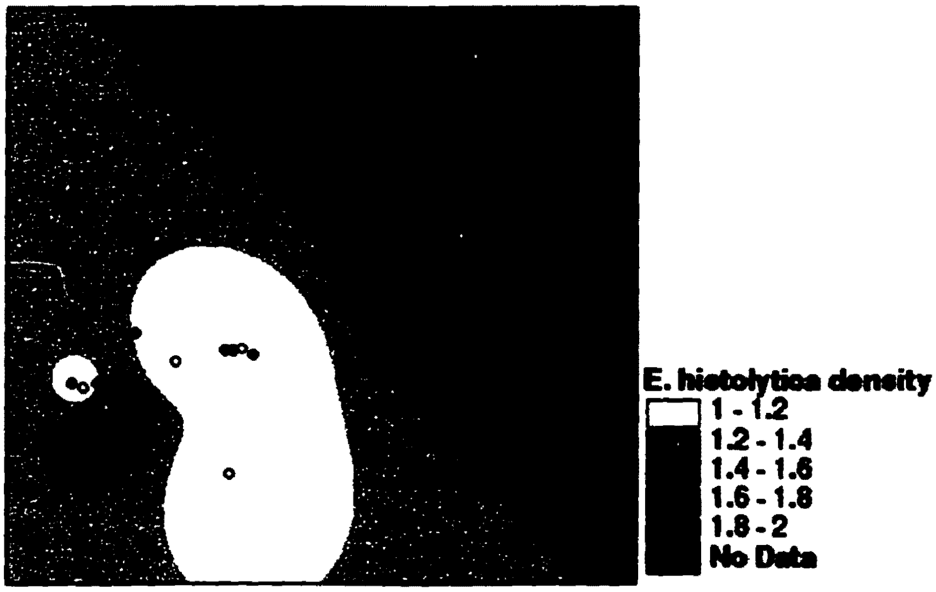

Figure 42.

Contour map showing the number of cases of *E. histolytica* per house in San Marcos village. Yellow dots are positive for the parasite; green dots are negative.

Figure 42 shows the distribution of *E. coli* cases pe households in San Marcos village. The cases were evenly distributed but there was a with a greater number of infections in the northeast. One house had 5 infections in the southeast section of the village.

Figures 44 and 45 show the distribution of all parasitic infections per house in San Marcos village. Every household had at least one member positive for a parasite, and all houses had at least one member infected with hookworm.

Figure 46 shows the distribution of positive cases of protozoan infection in San Marcos. The cases were evenly distributed through the village.

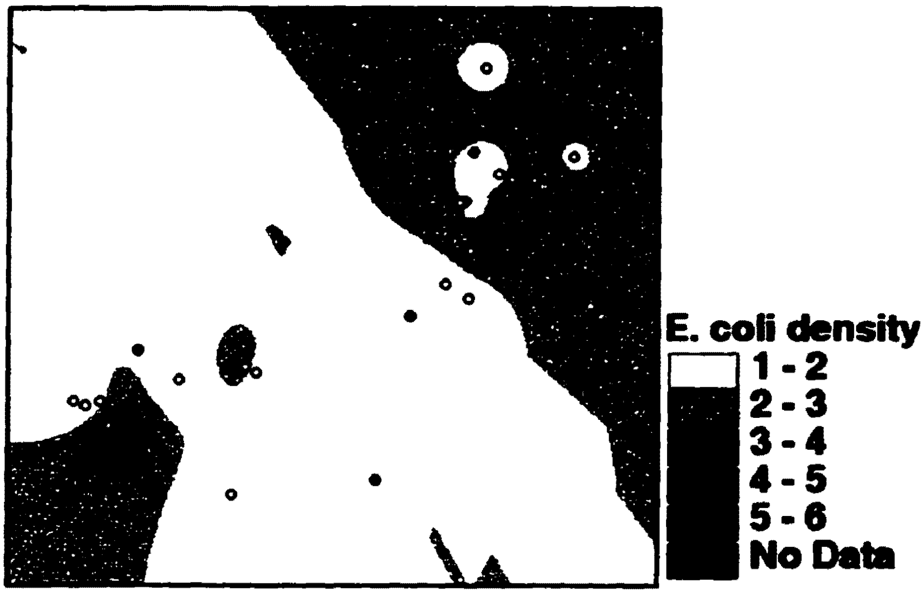

Figure 43.

Contour map showing the number of cases of *E. coli* per house in San Marcos village. Yellow dots are positive for the parasite; green dots are negative.

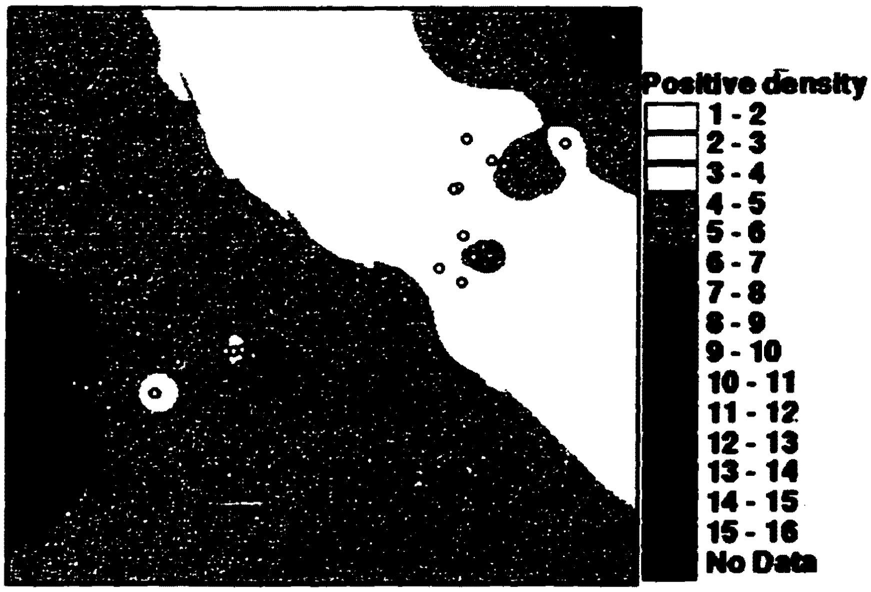

Figure 44.

Contour map showing the number of cases of parasitic infections per house in San Marcos village. Yellow dots are positive for the parasites; green dots are negative.

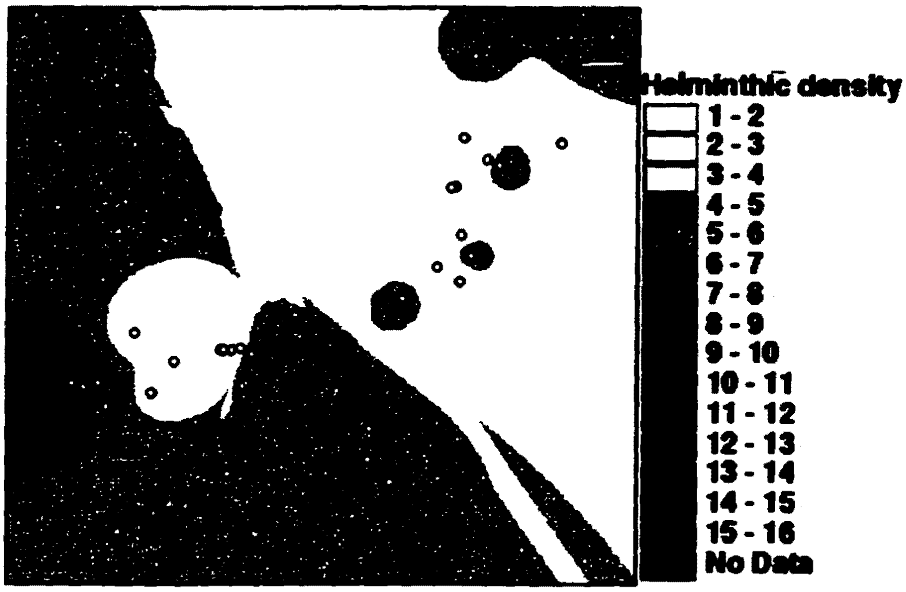

Figure 45.

Contour map showing the number of cases of helminthic infections per house in San Marcos village. Yellow dots are positive for the parasites; green dots are negative.

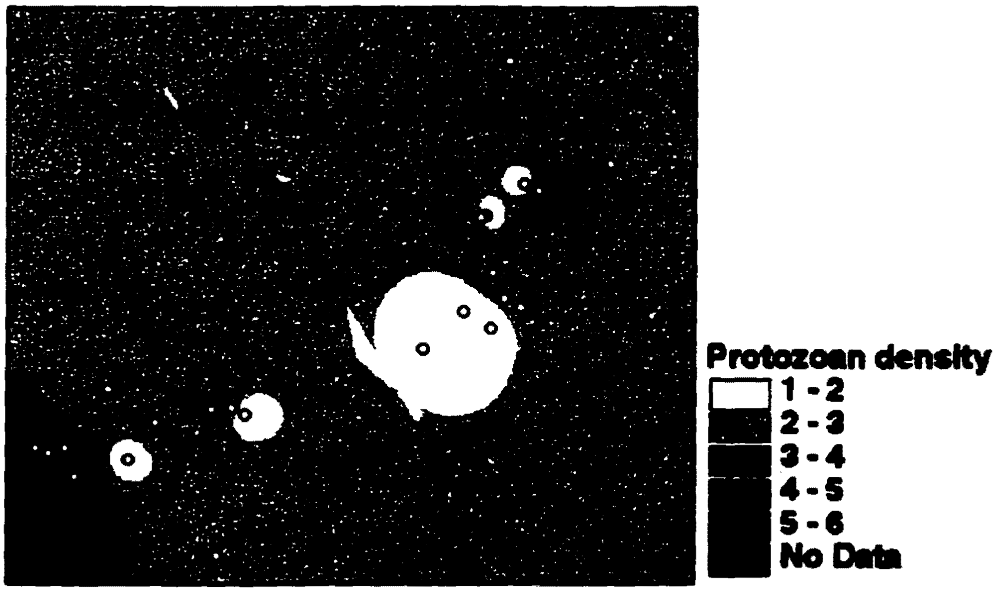

Figure 46.

Contour map showing the number of cases of protozoan infections per house in San Marcos village. Yellow dots are positive for the parasites; green dots are negative.

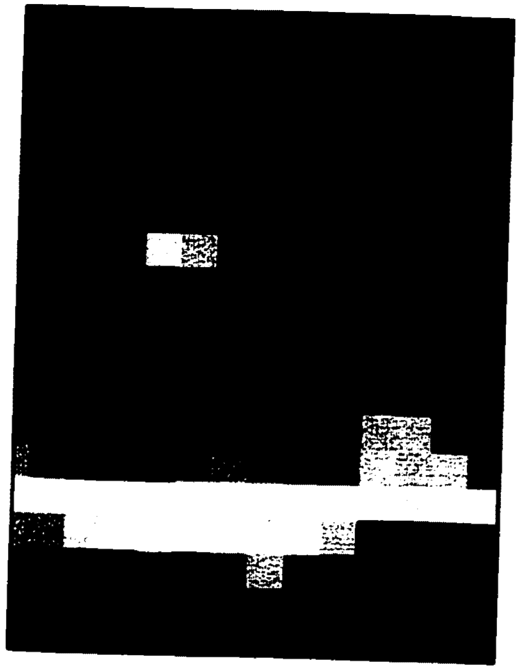

Figure 47.

Location of houses in Bladden village
Plotted on Thematic Mapper image.

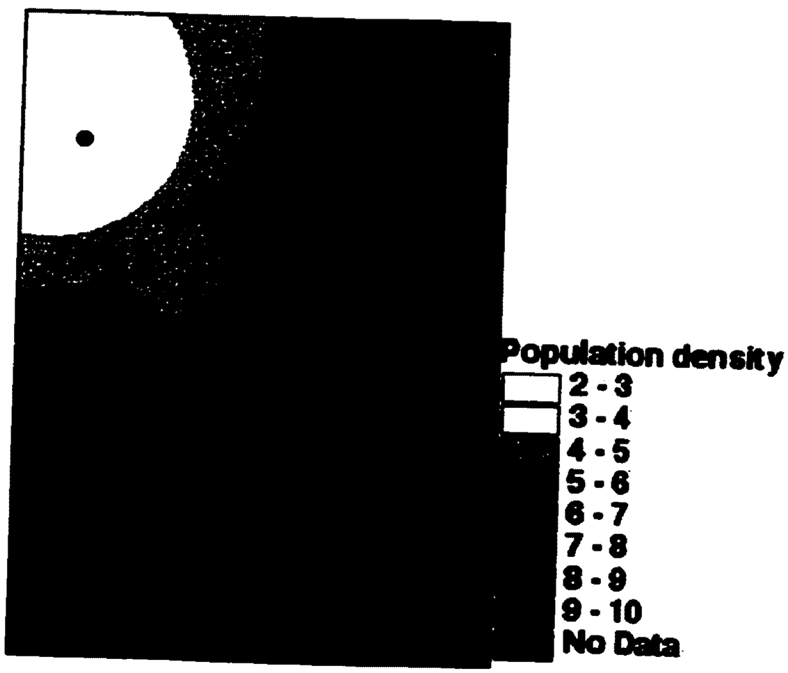

Figure 48.

Contour map of the people per house in Bladden village.

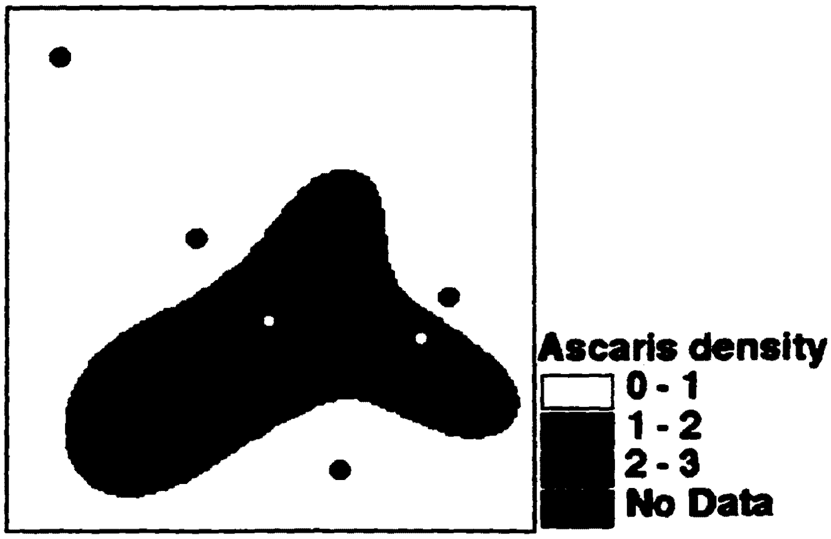

Figure 49.

Contour map showing the number of cases of *A. lumbricoides* per house in Bladden village. Yellow dots are positive for the parasite; green dots are negative.

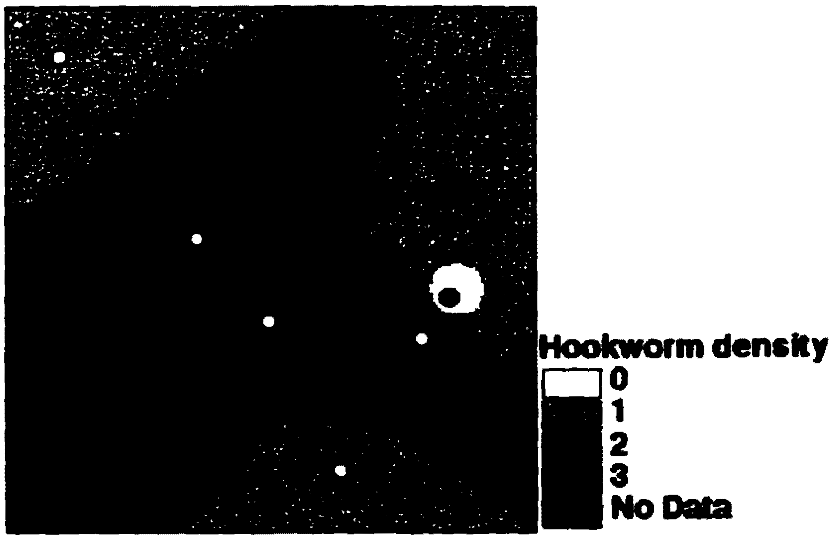

Figure 50.

Contour map showing the number of cases of hookworm per house in Bladden village. Yellow dots are positive for the parasite; green dots are negative.

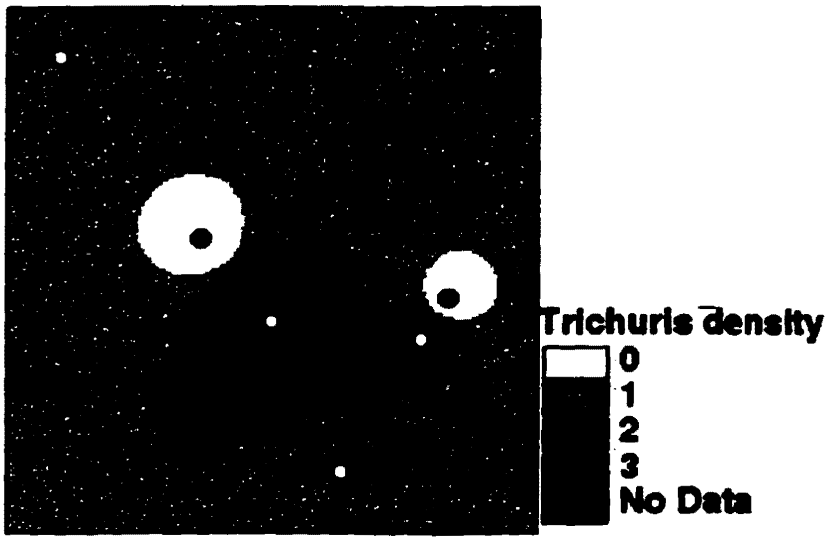

Figure 51.

Contour map showing the number of cases of *T. trichiura* per house in Bladden village. Yellow dots are positive for the parasite; green dots are negative.

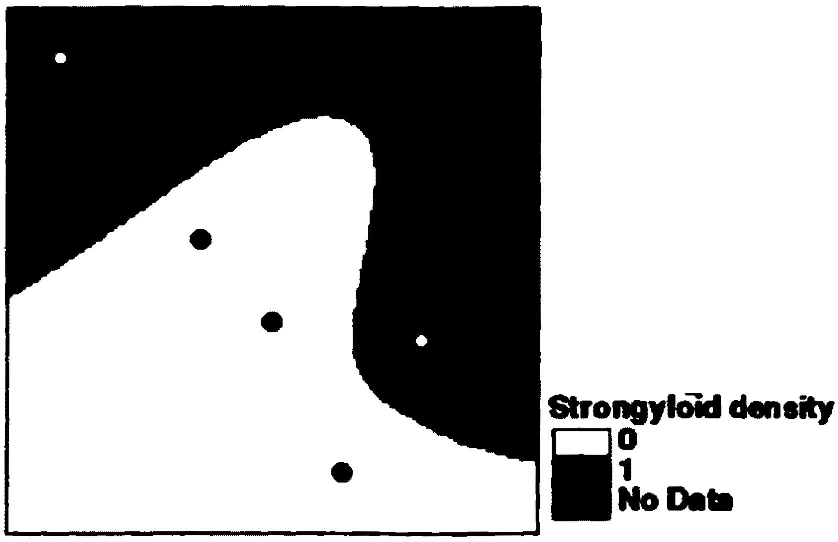

Figure 52.

Contour map showing the number of cases of *S. stercoralis* per house in Bladden village. Yellow dots are positive for the parasite; green dots are negative.

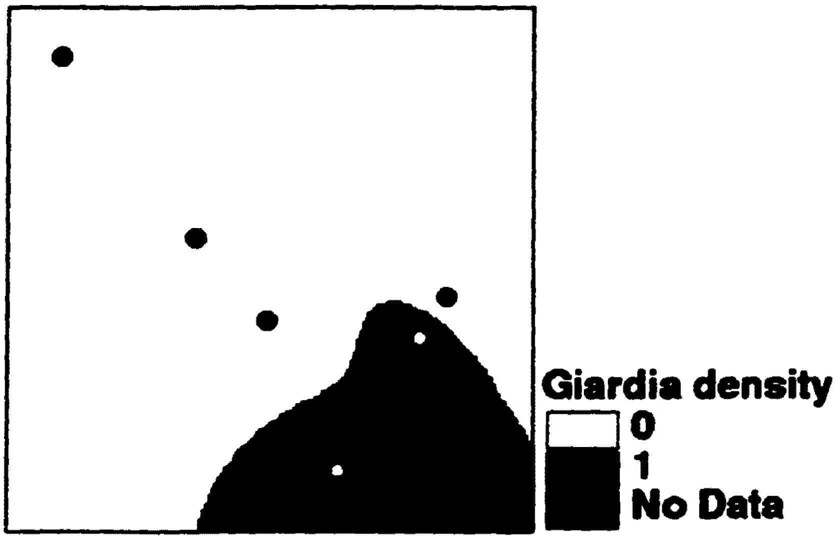

Figure 53.

Contour map showing the number of cases of *G. lamblia* per house in Bladden village. Yellow dots are positive for the parasite; green dots are negative.

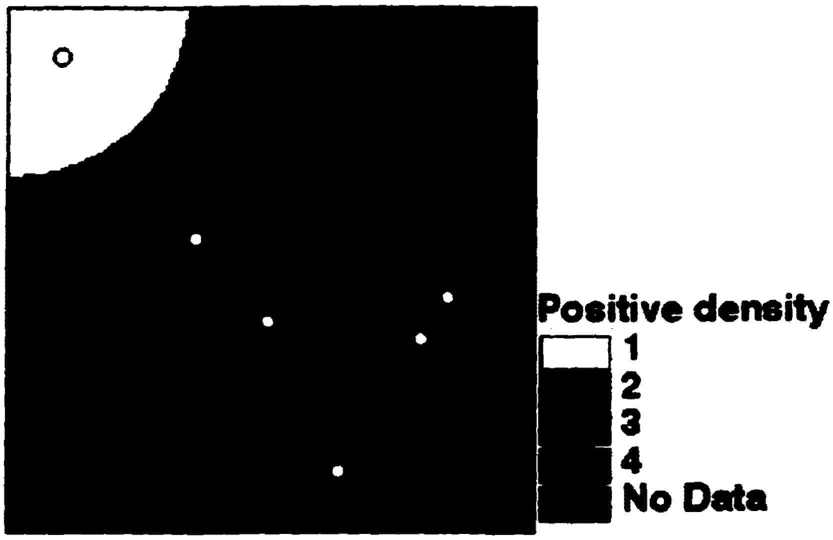

Figure 54.

Contour map showing the number of cases of parasitic infections per house in Bladden village. Yellow dots are positive for the parasites; green dots are negative.

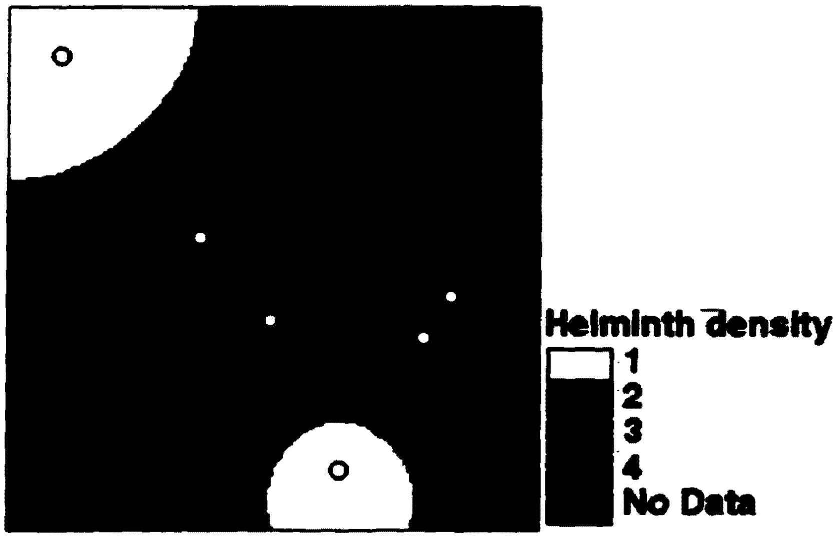

Figure 55.

Contour map showing the number of cases of helminthic infections per house in Bladden village. Yellow dots are positive for the parasites; green dots are negative.

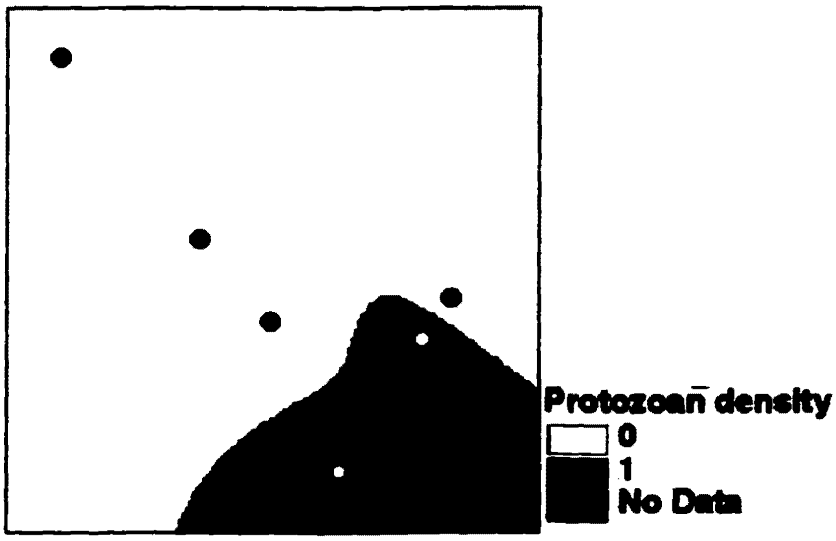

Figure 56.

Contour map showing the number of cases of protozoan infections per house in Bladden village. Yellow dots are positive for the parasites; green dots are negative.

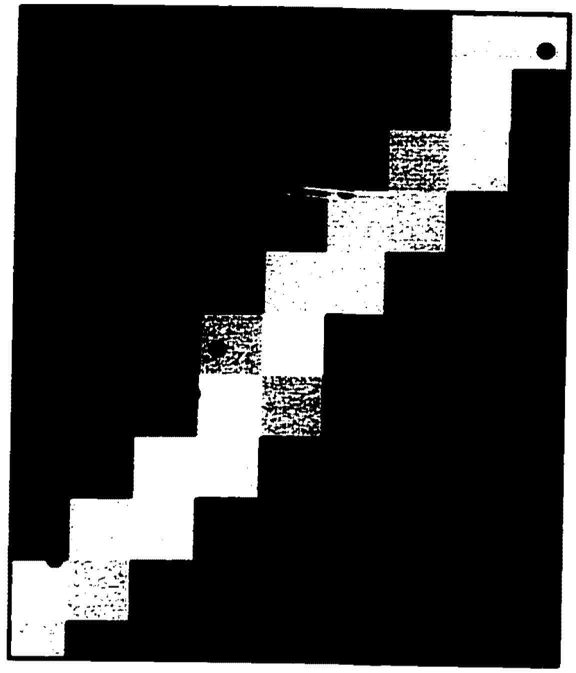

Figure 57.

Location of houses in Tambran
plotted on Thematic Mapper image.

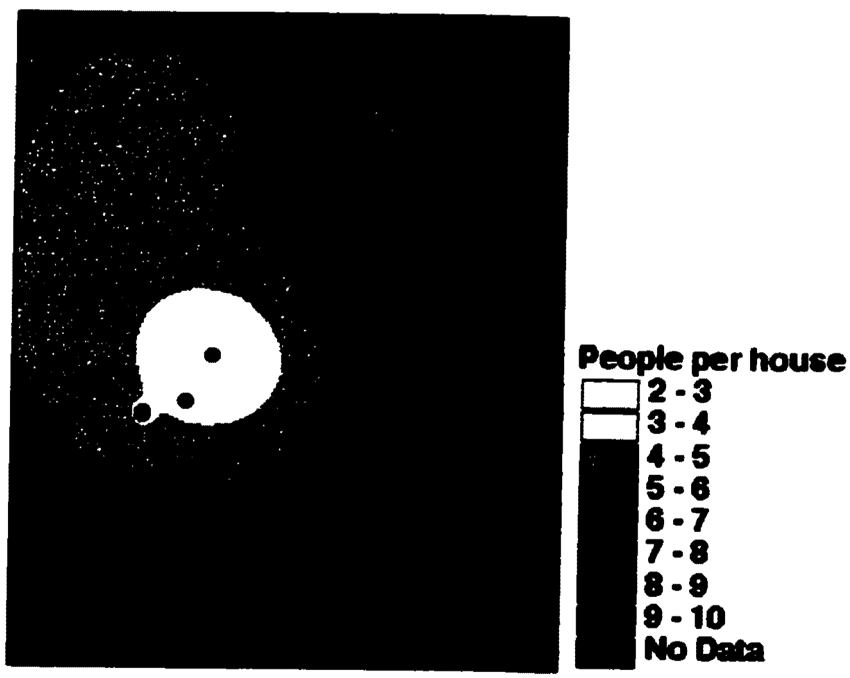

Figure 58.

Contour map of people per house in Tambran village.

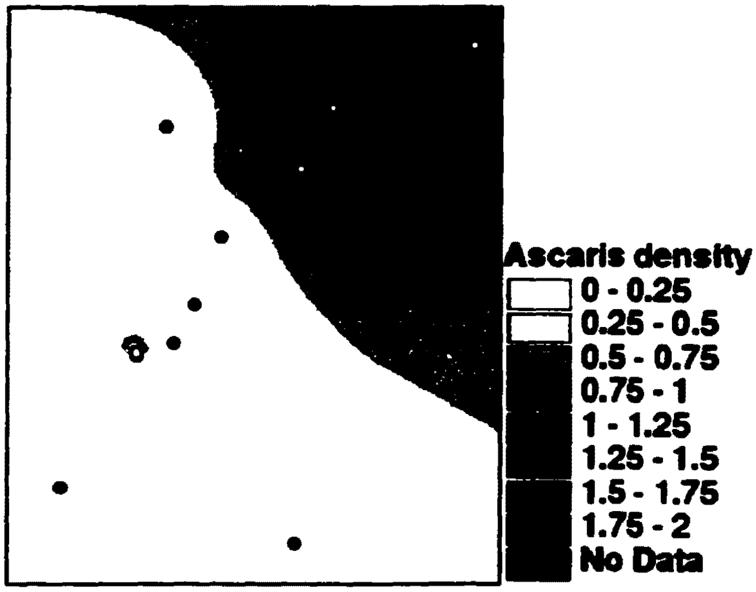

Figure 59.

Contour map showing the number of cases of *A. lumbricoides* per house in Tambran village. Yellow dots are positive for the parasite; green dots are negative.

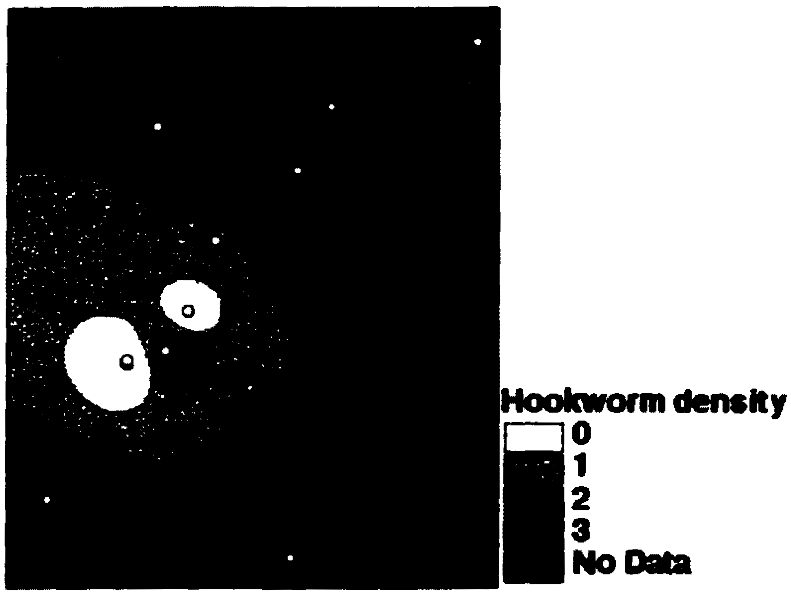

Figure 60.

Contour map showing the number of cases of hookworm per house in Tambran village. Yellow dots are positive for the parasite; green dots are negative.

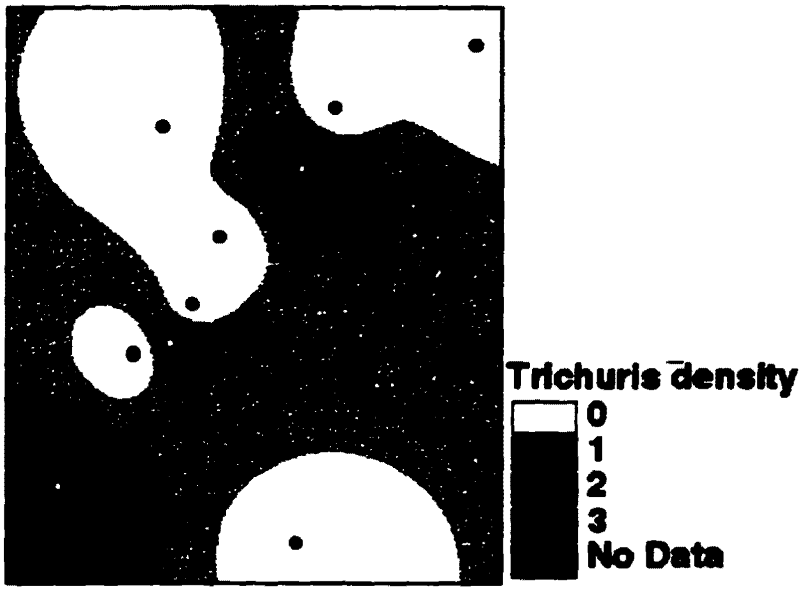

Figure 61.

Contour map showing the number of cases of *T. trichiura* per house in Tambran village. Yellow dots are positive for the parasite; green dots are negative.

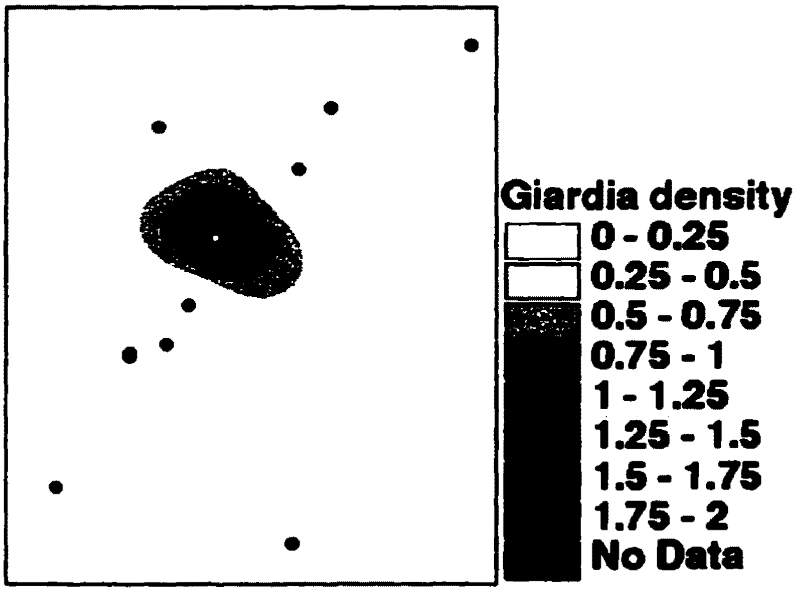

Figure 62.

Contour map showing the number of cases of *G. lamblia* per house in Tambran village. Yellow dots are positive for the parasite; green dots are negative.

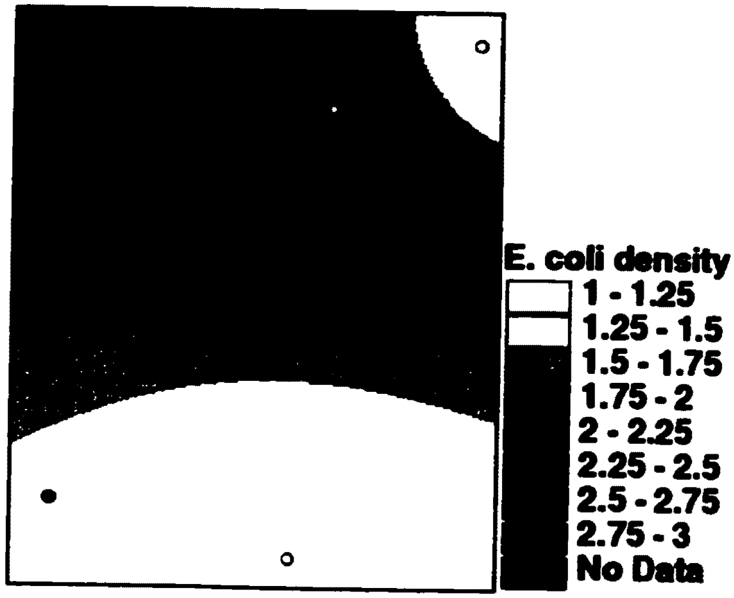

Figure 63.

Contour map showing the number of cases of *E. coli* per house in Tambran village. Yellow dots are positive for the parasite; green dots are negative.

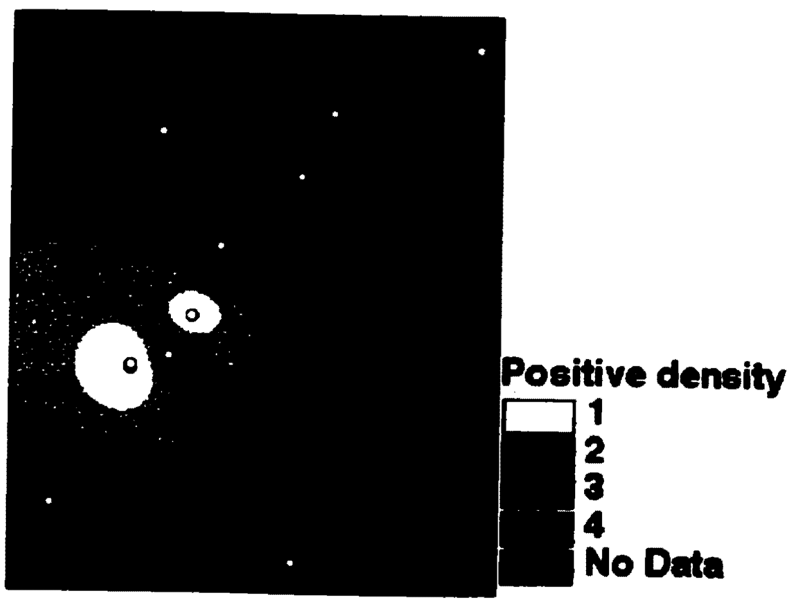

Figure 64.

Contour map showing the number of cases of parasitic infections per house in Tambran village. Yellow dots are positive for the parasites; green dots are negative.

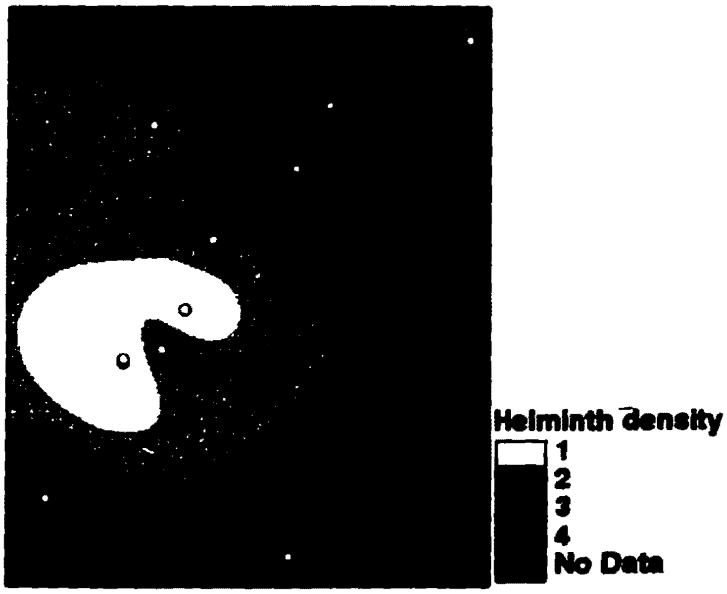

Figure 65.

Contour map showing the number of cases of helminthic infections per house in Tambran village. Yellow dots are positive for the parasites; green dots are negative.

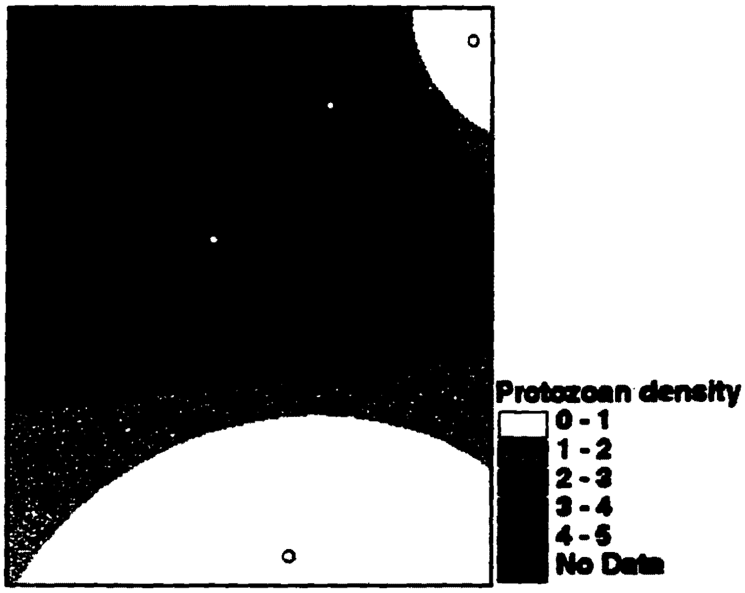

Figure 66.

Contour map showing the number of cases of protozoan infections per house in Tambran village. Yellow dots are positive for the parasites; green dots are negative.