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Assessing ecological correlates of avian disease prevalence in the Galapagos Islands using GIS and remote sensing

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ASSESSING ECOLOGICAL CORRELATES OF AVIAN DISEASE PREVALENCE IN THE GALÁPAGOS ISLANDS USING GIS AND REMOTE SENSING

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DEDICATION

This is dedicated to the memory of Robert Duane Siers, or rather to the lack of such a memory; for better or worse, his loss has certainly had profound impacts on the course of my life. To Ardell Marie Ferguson and Frank Ferguson, who have always given me the autonomy and encouragement to make my own mistakes and benefit from my successes. To Lila and Gordon Ellestad, who provided me with fine examples of strength of character. To the Berberichs, who unknowingly fuel my conviction to contribute to the conservation of wild lands and wildlife for future generations. And to my fellow students at UMSL who have helped to smooth my transition to the culture of graduate studies.

TABLE OF CONTENTS

Page

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ABSTRACT

Introduction of exotic species is a major factor contributing to biodiversity loss, particularly in extinction-prone island ecosystems (Vitousek et al. 1997). While the Galapagos archipelago has experienced negative impacts from invasive plants and animals (Snell et al. 2002), its bird community has remained remarkably intact with no recorded extinctions – in contrast to the fate of the avian fauna of other oceanic archipelagos (VanRiper et al. 1986, Savidge 1987, Holdaway 1989, Steadman 1995, Blackburn et al. 2004).

The role of introduced pathogens in species loss is not well understood, but there is evidence that they have contributed to the decline and extinction of species in several island systems (see Wikelski et al. 2004). For island birds in particular, avian malaria and avian poxvirus have contributed to the extinction of several Hawaiian land birds (Warner 1968, Van Riper III et al. 1986, Atkinson et al. 1995). In addition to the other challenges facing island biotas (isolation, various effects of small population size), they may also be more susceptible to introduced pathogens due to immunological naivety (Atkinson et al. 1995).

In recognition of the potential consequences of pathogen introduction to the Galapagos Islands, the Saint Louis Zoo and the University of Missouri–Saint Louis, in cooperation with the Galapagos National Park Service and the Charles Darwin Research Station, implemented an avian disease surveillance program in 2001, with the objective of identifying and monitoring for pathogens that pose risk for native bird populations (Miller et al. 2002, Parker et al. 2006).

The purpose of this thesis is identify environmental factors that might influence the geographic distribution of avian pathogen infection, based on two data sets obtained as a result of these surveillance efforts: 1) seroprevalence data on 10 common poultry pathogens from farm sites within the agricultural zone of Santa Cruz (Chapter 1); and 2) prevalence and intensity

values of microfilarial infections of endangered flightless cormorants and Galápagos penguins (Chapter 2).

Putative correlative factors were obtained from various geographic information system (GIS) and remotes sensing data sets, containing information on temperature, precipitation, water vapor, soil moisture, vegetative density and topography. Results of these analyses provide indications of correlation between pathogen infection measures and various ecological factors which may affect disease transmission. These observations may provide the bases for the formulation of specific hypotheses for more rigorous statistical verification. An understanding of the environmental factors influencing poultry pathogen prevalence may be useful in predicting the consequences of pathogen transmission across the poultry/wildlife interface (Chapter 1). Insight into the geographic distribution of arthropod-vectored microfilarial infections may allow us to predict the spatial distribution of transmission risk should other arthropod-borne pathogens, such as avian malaria or West Nile Virus, be introduced to this ecosystem (Chapter 2).

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

CHAPTER 2

LIST OF APPENDICES

CHAPTER 1: Assessing Ecological Correlates of Poultry Disease Prevalence in the Galapagos Islands with GIS and Remote Sensing

ABSTRACT:

The purpose of this investigation is to identify ecological correlates of pathogen prevalence in the poultry industry of the Galapagos Islands, as part of an assessment of the potential for disease transmission across the poultry-wildlife interface. Seroprevalence data for ten common poultry diseases from seven Galapagos chicken farms were evaluated for correlation with geo-referenced data sets describing climatic and landscape variables which might affect disease dynamics. The results of this study indicate that *Mycoplasma gallisepticum*, Marek's disease virus, infectious laryngotracheitis virus, infectious bronchitis virus (Massachusetts & Connecticut strains) and avian reovirus are highly correlated with each other, and some of these diseases exhibit trends with respect to farm type and increasing prevalence with cooler land surface temperature and narrower diurnal temperature range. Newcastle's disease virus, infectious bursal disease virus, avian encephalomyelitis virus, and avian adenovirus-I were likewise highly correlated with each other, and exhibited varying levels of correlation with climatic variables indicative of moderate dry seasons and low levels of atmospheric water vapor. Prevalences of all pathogens were sporadically correlated with satellite-derived measures of vegetation density taken at different times throughout the year, though the patterns of correlation did not support a link to arthropod vectors. Correlations with topographic values were not observed. Deviations of observed results from predictions prompted the construction of a generalized conceptual model for the relationship between pathogen durability and likelihood of environmental influence on disease incidence, in which: 1) very labile organism do not persist outside the host long enough to demonstrate detectible influence of variations in environmental

factors; 2) organisms with moderate environmental stability may differentially achieve sustained transmission in response to variations in environmental factors; and 3) very durable organisms are relatively impervious to the observed levels of environmental variability and therefore are less likely to reveal patterns of correlation with environmental factors. Understanding the role of environmental influences on the prevalence of these or other pathogens may be important in predicting the spread of diseases if they do cross the poultry-wildlife interface.

INTRODUCTION:

Introduction of exotic species is a major factor contributing to biodiversity loss, particularly in extinction-prone island ecosystems (Vitousek et al. 1997). While the Galapagos archipelago has experienced negative impacts from invasive plants and animals (Snell et al. 2002), its bird community has remained remarkably intact with no recorded extinctions – in contrast to the fate of the avian fauna of other oceanic archipelagos (VanRiper et al. 1986, Savidge 1987, Holdaway 1989, Steadman 1995, Blackburn et al. 2004).

The role of introduced pathogens in species loss is not well understood, but there is evidence that they have contributed to the decline and extinction of species in several island systems (see Wikelski et al. 2004). For island birds in particular, avian malaria and avian poxvirus have contributed to the extinction of several Hawaiian land birds (Warner 1968, Van Riper III et al. 1986, Atkinson et al. 1995). In addition to the other challenges facing island biotas (isolation, various effects of small population size), they may also be more susceptible to introduced pathogens due to immunological naivety (Atkinson et al. 1995).

In recognition of the potential consequences of pathogen introduction to the Galapagos Islands, the Saint Louis Zoo and the University of Missouri–Saint Louis, in cooperation with the

Galapagos National Park Service and the Charles Darwin Research Station, implemented an avian disease surveillance program in 2001, with the objective of identifying and monitoring for pathogens that pose risk for native bird populations (Miller et al. 2002, Parker et al. 2006).

One of the efforts of this program is to identify the risk of disease transmission across the poultry/wildlife interface. Poultry farming occurs on the five human-inhabited islands (Santa Cruz, Isabela, San Cristobal, Floreana and Baltra). While extensive efforts are underway to eradicate other non-native species in the Galapagos (Snell et al. 2002), the removal of all chickens from the archipelago is unlikely due to their nutritional and economic importance for the local human population and the growing tourist industry. The increasing number of chickens in populated regions is resulting in the expansion of the poultry/wildlife interface and the potential for emergence of infectious disease in native species (Gottdenker et al. 2005, Soos et al. in review). In July of 2005 there were ~700 chickens at 12 backyard farms, ~8600 at 3 layer farms, and ~17,000 at 25 broiler farms on the island of Santa Cruz (Soos et al., unpublished; Figure 1). To assess the potential for transmission of disease to the endemic and native bird fauna, testing of domestic chickens for a panel of pathogens has been conducted (Gottdenker et al. 2005, Soos et al. in review) and is continuing, and will be expanded to include testing of wild birds for the same pathogens.

Soos et al. (in review) compared the pathogens found in small-scale backyard farms to those at larger indoor broiler operations. Thirty chickens from each site of seven farm sites (four backyard sites and three broiler sites; Figure 1) were examined for clinical signs of disease and seroprevalence of 13 common poultry pathogens considered to be of risk to endemic and native birds. While there was no evidence for avian influenza virus, *Salmonella typhimurium* or *S. pullorum*, overall seroprevalence was high across both types of farms for the other 10 pathogens

(Table 1). The results clearly indicated higher prevalence of seroreactivity and clinical signs of disease at backyard farms. Given the relatively nonexistent biosecurity measures at these farms, the integration of the free-ranging chickens into the surrounding landscape, and the observations of native birds foraging with or after the chickens at supplemental feedings, it was concluded that backyard farms constitute a larger poultry-wildlife interface and therefore a higher probability of disease spillover into the native avifauna.

While farm type (backyard vs. broiler) accounted for a large portion of the variation in seroprevalence for several of the pathogens examined (MG, ILTV, IBVM&C, ARV, & MDV), it was not a significant predictor of prevalence for NDV, IBDV, AEV or AAVI (see Table 2 for key to abbreviations). Authors noted that, even after farm type was accounted for, there was considerable residual variation. They suggested that this variation might be related to differences in management practices or environmental factors such as geographic area, altitude, and exposure to potential vectors.

In light of these findings, the present work was conducted to determine whether environmental factors (e.g., climate and land cover) account for variation in seroprevalence at these seven farm sites. To this end, measures of correlation between the seroprevalence data from Soos et al. (in review) and environmental variables were considered for ten poultry diseases and six suites of bioclimatic and landscape variables at seven chicken farms in the agriculture zone of the island of Santa Cruz, with the assumption that environmental factors conducive to successful and sustained transmission will be reflected in higher prevalence values. While seven sites is a small sample size for such a correlative analysis, this approach has been taken to identify possible trends which may form the basis for hypotheses to be more rigorously tested.

The discipline of landscape epidemiology seeks to link the spatial distribution of host populations with the transmission dynamics of their pathogens. Spatially variable biotic and abiotic attributes of host and vector habitat, and the distribution of the hosts and vectors themselves, can affect the distribution and abundance of disease-causing organisms. Landscape and climatic factors that can be described in a geo-referenced data set can be assessed for correlation with disease data in a GIS, allowing the identification and mapping of infection risk factors and incidence of disease (Hess et al. 2003).

Climatic factors to be considered in this study include temperature, precipitation, and atmospheric water vapor. Landscape characteristics such as land cover can be an important factor in the distribution of organisms and the dynamics of disease transmission (Curran et al. 2000), and will be considered here through the use of an index of vegetation density (see NDVI in Methods). Topographic variables (elevations, slope & aspect) will also be considered.

Table 2 summarizes the characteristics, threats to wildlife, and factors affecting the likelihood of environmental influence on transmission of the ten pathogens considered in this study. Predictions are made as to the relative likelihood of observing correlations between pathogen prevalence and ecological variables. *These predictions are primarily based on the logic that organisms that are relatively durable outside the host are more likely to be influenced by environmental factors during these periods of horizontal transmission, while more labile organisms are unlikely to survive outside the host long enough to produce a discernable signal of environmental correlation*. Implication of a role for living vectors or reservoirs in transmission also increases the likelihood of environmental influence on prevalence, particularly with respect to landscape variables such as surrounding vegetation density.

METHODS:

Seroprevalence data on the ten pathogens listed in Table 1 were obtained from blood samples of 30 chickens from each of seven farms (Figure 1). See Soos et al. (in review) for a description of collection and serology methods used.

Climate data describing precipitation and atmospheric temperature were obtained from the WorldClim database (http://biogeo.berkeley.edu/gis/data.html; Hijmans et al. 2005), which contains a minimum of 30 years (1960-1990) of monthly temperature (°C) and precipitation (mm) measurements at 30 arc-second resolution (approx. 1km^2). From this data set we considered the following 18 bioclimatic variables: annual mean temperature; mean temperature of the driest quarter; mean temperature of the wettest quarter; temperature annual range; minimum temperature of the coldest month; maximum temperature of the warmest month; temperature seasonality; mean diurnal temperature range; mean temperature of the coldest quarter; mean temperature of the warmest quarter; precipitation in the coldest quarter; precipitation in the warmest quarter; precipitation in the driest quarter; precipitation in the wettest quarter; precipitation seasonality; precipitation in the driest month; precipitation in the wettest month; and annual precipitation.

In addition to data based on weather station records, satellite sensor measurements of environmental and landscape variables were also assessed for correlation with prevalence values, including data on land surface temperature, atmospheric water vapor, and vegetation density.

In laboratory tests, relative humidity has proven to be an influential factor on the survival of viruses on environmental surfaces (Buckland & Tyrell 1962, Mbithi et al. 1992, Abad et al. 1994). It has also been suggested that relative humidity may contribute to the seasonality of viral outbreaks (Enright 1954). Therefore, geographic variation in relative humidity may be correlated with disease prevalences. While remotely sensed data on relative humidity at a meaningful spatial scale are not available, the MODIS sensor aboard the Terra and Aqua satellites provides daily quantification of total precipitable water vapor (amount of water vapor in the atmospheric column, in centimeters), derived from a near-infrared algorithm at 1-km spatial resolution (King et al. 2004). Mean precipitable water vapor was calculated for each of the twelve months preceding the sampling of poultry farms (Aug '04-Jul '05). Pathogen prevalence data were assessed for correlation with the following water vapor values: monthly means; annual mean; annual minimum (mean of lowest month); annual maximum (mean of highest months); range (mean of highest month minus mean of lowest month); index of seasonality (mean of highest month divided by mean of lowest month); and standard deviation of monthly means over the year (as a measure of annual heterogeneity).

While the querying of this data set was prompted by the suggestion of a role for relative humidity in viral persistence, we note that total precipitable water vapor is not the same as relative humidity, which has a temperature component not available here. Additionally, these values are for water vapor in the entire atmospheric column beneath the top of the Earth's atmosphere, and not only at the surface – though the algorithm used to produce these data is more sensitive to water vapor at the earth-atmosphere boundary layer (King et al. 2004).

For temperature variables more accurately defined in time and space, we utilized land surface temperature data sets acquired by the MODIS sensor for the year preceding sampling (Aug '04 – Jul '05). Daily day and night land surface temperatures at 1-kilometer spatial resolution are calculated from thermal infrared emissions, and are accurate to 1 Kelvin (King et al. 2004). As frequent cloud cover impedes the ability to retrieve temperature readings, MODIS Land Surface Temperature data products are available as 8-day composites, which take advantage of the few cloudless opportunities. These composites were used to calculate monthly means. Even with compositing, a few monthly averages were not available for some of the farm sites, so seasonal composites were calculated. Disease prevalences were assessed for correlation with: mean day and night land surface temperatures for the 12 months preceding sampling, the warmest six months (Dec ’04-May ‘05), and the coolest six months (Aug ’04-Nov ‘04 and Jun ’05-Jul ‘05); diurnal temperature range (day temperature minus night temperature) from the annual, warm, and cool period means; and seasonality of day and night land surface temperatures (mean of warmest month divided by mean of coolest month).

The primary link between land cover and disease is through the quality and quantity of surrounding arthropod vector habitat. The most important applications of remote sensing to epidemiology have used the Normalized Difference Vegetation Index (NDVI), a measure of the vegetative productivity of an area, as a proxy measure for arthropod vector habitat, with the underlying logic that areas of dense vegetation are likely to provide suitable habitat for arthropod vectors, and that levels of moisture sufficient to support such vegetative structure are also likely to provide the moisture necessary for breeding habitat (for example, of mosquitoes). Similar logic may apply to non-arthropod species which may serve as reservoirs or mechanical vectors, i.e., wild birds may be more abundant in the vicinity of dense vegetative coverage that may serve as refuge. Remotely-sensed NDVI values have been positively correlated with human and veterinary diseases such as: trypanosomiasis through its tsetse fly vector (Rogers 2000); sin nombre virus infections in deer mice (Boone et al. 2000); urinary schistosomiasis via snails (Brooker et al. 2001); Lyme’s disease via ticks (Kitron & Kazmierczak 1997); and mosquito-vectored malaria, filariasis, rift valley fever, eastern equine encephalitis and leishmaniasis (Hay et al. 2000b, Crombie et al. 1999, Anyamba et al. 1999, Moncaya et al. 2000, Thompson et al.

2002). Hay et al. (2000a), Beck et al. (2000), and Correia et al. (2004) review the use of NDVI and other remotely-sensed data in epidemiology. While arthropod vectors are not implicated as intermediate hosts of the pathogens assessed here, there is some evidence that they may act as mechanical vectors. Correlations of prevalence with surrounding vegetation density may also be indicative of other unanticipated relationships.

NDVI data from the MODIS sensor aboard the Aqua and Terra satellites (King et al. 2004) are available at a moderately coarse spatial resolution (250-meter pixels, ~0.063km^2) but with high temporal resolution. Daily measurements are composited and returned every 16 days for nearly continuous monitoring. As the Galapagos archipelago is frequently under cloud cover, compositing is particularly valuable in that it takes advantage of the few clear-sky opportunities. Analyses were conducted on each of the composite datasets for the year preceding the study. Correlations were assessed on the raw pixel values, and on values which were averaged over varying geographic extents, from 0.56 to 22.56 square kilometers surrounding the respective sites. Correlations were also assessed with the mean NDVI for the preceding year, for the wetter months of the preceding year (Jan-May '05), for the drier months (Aug-Dec '04 & Jun-Jul '05), and with an index of seasonality (wet mean / dry mean). These measures were based upon NDVI values averaged over 1.56 square kilometers (an extent similar to the spatial resolution of the other datasets analyzed).

Topographic features may also influence an organism's range. Elevation, slope, and aspect (the direction a slope faces) were assessed for correlation with prevalence data. Elevation may be correlated with prevalence through its links with temperature and precipitation. Slope may affect drainage of surface water. Correlations with aspect may reflect some relationship with exposure to sunlight or winds. These values were based on a digital elevation model (DEM) with 90-meter resolution, produced by the Shuttle Radar Topography Mission (SRTM).

To control for the covariance inherent in the data layers used in this study, they were also submitted to a principal components analysis (PCA), producing derived data layers that are non-correlated and independent. Each of the major data groupings (WorldClim temperature, WorldClim precipitation, SRTM topographic, MODIS NDVI, MODIS land surface temperature, and MODIS water vapor) was subjected to a PCA, with the 2-4 layers representing the majority of the variation being assessed for correlation with disease data. These resulting layers were also submitted to another PCA to diminish redundancy among data sets (hereafter referred to as the "all-layers PCA"), with the resulting principal components also being assessed for correlation with disease prevalence (Appendix II). All components of the all-layers PCA contained significant variation (eigenvalues > 1), so all were considered in the correlative analyses.

WorldClim values were extracted in ESRI ArcGIS 9.1. All MODIS data sets (water vapor, land surface temperature, and NDVI) were obtained from the NASA Land Process Distributed Active Archive Center (LP DAAC), and were pre-processed and interpreted using ERDAS Imagine 9.0. The SRTM digital elevation model was pre-processed in ERDAS Imagine 9.0, and topographic values calculated and extracted in ArcGIS 9.1. PCA was conducted with ERDAS Imagine 9.0.

Additionally, pathogen prevalence was also assessed for correlation with prevalence values of other pathogens recorded in this Soos et al. (in review).

Due to the small number of sample sites (n=7), correlative analysis is necessarily limited to simple bivariate analysis (Pearson's Correlation Coefficient (*r*), 2-tailed, SPSS). Prevalence values for all ten pathogens were assessed for correlation with all ecological and environmental variables listed above (with the exception of aspect, values of which have a circular distribution and were assessed for fit to a quadratic curve). As no assumptions of directionality in any correlations were made *a priori*, P-values reported here are based on two-tailed tests. Should we modify our hypotheses to correctly predict the nature of the relationships investigated, P-values resulting from one-tailed tests would be one-half of those reported here, exhibiting greater statistical significance. Given the low power of analyses based on the small number of sampling sites and the preliminary nature of this assessment, a relatively liberal α of $P \leq 0.10$ was set to indicate potential trends. Corrections of P-values for multiple comparisons (i.e. Bonferroni adjustments) were not conducted, as each comparison of ecological variable to prevalence value may be viewed as an independent hypothesis (Perneger 1998). It is possible that some of the observed correlations may be serendipitous, given the large number of tests, and it is felt that the best approach is to merely describe how the analyses were conducted, particularly given the exploratory nature of the study. Trends noted herein may suggest future hypotheses for more rigorous statistical verification.

Comparisons between our a priori predictions of the level of environmental influence on the prevalence value of each pathogen and the amount of correlation actually observed is difficult to conduct objectively. To reduce some of the subjectivity, assignments of pathogens to "observed" categories were based on the number of statistically significant correlations with components of the "all-layers" PCA (with those correlated factors significant at $p \leq 0.10$ receiving 1 point and at $P \leq 0.05$ receiving 2; scores of 0-1 = Low, 2-3 = Mod., and 4+ = High).

RESULTS:

Results of all correlative analyses are included in Appendix I. Table 3 summarizes the statistically significant relationships observed, with relationships significant at $p \leq 0.05$ indicated in boldface. Observed levels of environmental correlation, for comparison with our *a priori* predictions, are reported in the final column of Table 2. A broad overview of the observed correlations is provided in Table 4, accentuating the similarities in correlations within the subsets of pathogens identified as "Grouping 1" and "Grouping 2" (see below), and the differences between them. Appendix II describes the eigen matrix and eigenvalues produced in conducting the all-layers PCA.

Mycoplasma gallisepticum – Prevalence values for MG were not significantly correlated with any of the WorldClim or topographic variables. The only suggestion of a correlation with MODIS-derived climatic variables is a negative correlation with mean daytime land surface temperatures in the cooler 6 months of the preceding year. Within the NDVI data sets, there was some suggestion of positive correlation with vegetation biomass during the period of peak greenness, but the association was negative with measurements taken at other times of the year. There were no significant correlations with any of the principal components layers. These findings are in keeping with our *a priori* prediction that MG would not be likely to be highly correlated with environmental variables due to its poor ability to persist outside the host. MG prevalence was highly correlated with prevalence values for MDV, ILTV, IBVM&C, and ARV. Soos et al. (in review) found that farm type (backyard vs. broiler) explained 22.4% of the variation in MG prevalence.

Newcastle disease virus – NDV seroprevalence exhibited statistically significant correlations with WorldClim precipitation, MODIS temperature, MODIS total precipitable water vapor, and vegetation density (NDVI) variables. NDV was negatively correlated with precipitation seasonality, and positively correlated with precipitation in the driest month, suggesting increased viral persistence or transmission within geographic areas which undergo more moderate dry seasons. NDV prevalence was negatively associated with mean daytime land surface temperature, particularly during the warmer six-month period within the year prior to sampling (Dec ’04-May ‘05) with a trend toward positive correlation with nighttime temperatures in the cooler periods of the preceding year and negative correlation with diurnal temperature range, suggestive of a positive relationship with moderate and stable temperatures. Total precipitable water vapor values, derived from the MODIS sensor, also exhibited a trend toward negative correlation with NDV prevalence values. Correlations were statistically significant with water vapor measurements taken during several of the months of the year preceding sampling, particularly the month before sampling (Jun ‘05), and for the mean of the entire preceding year. This association is supported by a significant correlation with the 3rd principal component of the water vapor data (primarily derived from measurements from the drier months of the year). In the all-layers PCA, NDV was correlated with the 14th principal component which was primarily derived from the WorldClim temperature principle components, though this component constitutes only a miniscule fraction of the variance present in the data (Appendix II). There was a trend toward positive correlation with NDVI measurements taken during the wetter portion of the year, and negative correlation with those from drier periods, though this signal is relatively weak. Soos et al. (in review) were able to attribute none of the variation in NDV prevalence to farm type, while prevalence did correlate with several climatic and vegetation values (though we make no assumptions of independence among these variables). This is concordant with our prediction that environmental variables may influence NDV prevalence, though the "observed" index of correlations rates it as only moderately correlated with the principal components of these data sets. NDV was also significantly correlated with prevalence of the AEV and IBDV pathogens. Topographic variables showed no evidence of correlation with NDV prevalence.

Marek's disease virus – MDV was not correlated with WorldClim variables, topographic factors, MODIS-derived water vapor measures, nor any of the PCA layers. However, there was a negative correlation with diurnal temperature range, specifically during the warmer period, and a trend toward correlation with lower daytime and higher nighttime temperatures. Several of the NDVI data sets showed significant correlation with MDV prevalence, with a pattern of negative correlation with measurements from drier periods and positive correlations with measurements taken at the peak of greenness. We predicted that MDV would be the most likely pathogen to be influenced by environmental factors due to its remarkable ability to persist outside of the host, but for the most part this did not hold true, with only moderate evidence of environmental influence. Soos et al. (in review) demonstrated that MDV prevalence was largely predicted by farm type, with the pathogen present and moderately prevalent at all backyard sites and absent at all of the broiler sites; perhaps the effect of farm type swamps the ability to detect a stronger environmental signal (see also the discussion of a "generalized conceptual model," to follow). Among the other pathogens studied, MDV was very highly correlated with the prevalence of MG, ILTV, IBVM&C, and ARV.

Infectious laryngotracheitis virus – Neither WorldClim, topography, water vapor measures, nor any of the PCA layers correlated significantly with ILTV prevalence. The most detectable effect of daytime land surface temperature was a negative correlation with mean daytime temperature during the cooler six months of the preceding year, with prevalence higher at the cooler locations. There was some evidence of positive correlation with NDVI measurements taken at peak greenness and negative correlation with NDVI data from drier parts of the year. Soos et al. (in review) demonstrated that farm type (backyard vs. broiler) explained 33.5% of the variation in ILTV prevalence. Our *a priori* hypothesis predicted moderate probability of significant influence of environmental variables on prevalence, but only minimal evidence of environmental influence is reflected here. The most significant correlates of ILTV prevalence were the prevalence values of MG, MDV, IBVM&C, and ARV.

Infectious bronchitis virus – The Massachusetts and Connecticut strains of IBV, which are highly associated with each other, logically exhibit similar patterns in correlating variables. Neither strain can be demonstrated as correlated with WorldClim or topographic variables. However, IBV does show a strong trend toward correlation with low daytime land surface temperatures during the cooler months and negative correlation with diurnal temperature range, suggesting enhanced survival and/or transmission in cooler, more temperature-stable environs. These pathogens also exhibited the greatest amount of correlation with NDVI values throughout the preceding year, with evidence for significant positive correlation with measurements taken at wetter times of the year (Feb-Mar) and negative correlation with values from drier times. While there was no notable association of IBV with MODIS water vapor data when examined directly, there was a correlation of both strains with the 2nd principal component of the water vapor data set (derived from values from the end of the wet season and beginning of the dry season), as well as correlation with the 7th principal component of the all-layers PCA which is largely derived from the water vapor components. Other significant correlates of IBVM & IBVC prevalence appear to be farm type (50.3% and 73.2% of variation explained, per Soos et al.) and prevalence of MG, MDV, and ARV. While the IBV strains were predicted to be highly correlated with environmental variables, they were only moderately so.

Infectious bursal disease virus – Prevalence of IBDV was positively correlated with areas of higher rainfall, particularly in the dry season, being most significantly correlated with lower precipitation seasonality and higher precipitation in the driest month. IBDV is also negatively correlated with water vapor measures from several months of the preceding year, particularly the month prior to sampling (Jun '05), though one of these correlations is anomalously positive. These relationships with precipitation and water vapor are supported by significant correlations with the 1st principal component of the WorldClim precipitation data (derived from annual precipitation and precipitation in the driest month) and the 3rd component of MODIS water vapor data (primarily derived from measurements from the drier months of the year). There was a minimal trend toward negative correlation with NDVI data from drier parts of the year, and positive correlation with values from the wetter period. Consistent with our predictions, IBD exhibits a relatively high number of correlations with climatic variables. Soos et al. were unable to support farm type as an explanatory variable for IBDV. The only pathogens correlated with IBDV prevalence were NDV and ARV.

Avian reovirus – Despite our prediction that ARV's reputation of environmental stability would lend itself to possible ecological correlations, the only observed patterns are: a relatively weak trend toward positive correlation with NDVI measurements from the wet period and negative correlations at drier times; a suggestion of negative correlation with NDVI averaged over the year; and a correlation with the 4th principal component of MODIS water vapor variation, primarily derived from the May '05 measurement, though this measurement itself was not significantly correlated. Soos et al. (in review) attributed 39.8% of the variance in prevalence to farm type, and the prevalences of MG, MDV, IBVM&C were highly linked to ARV prevalence.

Avian encephalomyelitis virus – AEV prevalence exhibited a subtle trend toward positive correlation with precipitation variables and negative correlation with precipitation seasonality within the WorldClim data set. Prevalence was moderately correlated with mean land surface temperature for the year preceding sampling, and there is evidence of an association of prevalence with the 14^{th} component of the all-layers PCA, which is principally derived from the WorldClim temperature components. MODIS water vapor means for four of the preceding twelve months were correlated with prevalence, to include the month before sampling (Jun '05). Given the pathogen's ability to survive outside the host for a moderate period of time, these findings are in keeping with our *a priori* predictions. Soos et al. demonstrated no link between farm type and AEV prevalence. The only correlated pathogen in this data set was NDV.

Avian adenovirus I – With only a weak trend toward negative correlation with NDVI values from drier parts of the year, negative correlation with the 2^{nd} principal component of the WorldClim temperature data (primarily derived from mean temperature of the coldest quarter) and negative correlation with the 4^{th} component of MODIS water vapor data (primarily derived from the May '05 measurements), few ecological variables were found to be correlated with AAVI prevalence, despite our considering a moderate level of correlations likely. Soos et al. (in review) found no link to farm type. The only other correlates of AAVI incidence were prevalence of IBDV and ARV.

DISCUSSION:

These ten pathogens fell into two distinct clusters with respect to correlated factors (Table 4). MG, MDV, ILTV, IBVM&C, and ARV are highly correlated with each other and therefore, logically, demonstrate similar trends toward correlation with possible influencing factors – in this case, MODIS land surface temperature variables, influence of farm type, and pattern of correlation with vegetation indices. On the other hand, NDV, IBDV, AEV, and, to a lesser extent, AAV-I, are likewise highly correlated with each other, and consistent in trends toward correlation with WorldClim precipitation variables, MODIS water vapor variables, patterns of NDVI correlation, and lack of detectable influence of farm type (Soos et al., in review).

Some of these commonalities may lie in viral physiologies. Within the MDV-ILTV-IBV-ARV grouping, all but ARV are enveloped viruses (having a lipid-rich outer covering derived from host cell walls). Of the NDV-IBDV-AEV-AAVI grouping, all but NDV are non-enveloped. Previous laboratory studies demonstrate trends in environmental persistence within enveloped/non-enveloped groupings (Hemmes et al. 1960, Buckland & Tyrell 1962), with some exceptions (Buckland & Tyrell 1962, Mbithi et al. 1992). This seems to be consistent with the evidence here in that, within enveloped/non-enveloped groupings, correlations with environmental variables are similar (and different between groupings) with a few exceptions. The only non-viral pathogen considered here, MG, lacks a cell wall and is bound only by a plasma membrane. Like the majority of the non-enveloped viruses considered here, it appears that this physiology provides little protection in an external environment, as evidenced by little correlation with environmental variables.

The highest levels of correlation observed in this study are between the pathogens themselves, within these two groupings, which warrant caution in attributing prevalence of a particular pathogen to ecological variables. It is plausible that a disease of interest may in fact co-vary with another disease which is environmentally correlated. For example, it is possible that prevalence of only one pathogen, such as NDV, may be truly linked to climatic variables, while IBDV, AEV & AAVI are associated with NDV prevalence and are not, in fact, influenced by environmental factors. In the absence of a clear mechanism of cause and effect, it should also be considered that the correlations between disease prevalences and climatic values may be the result of co-variance with some other factor not addressed in this analysis.

Temperature variables as described by the WorldClim data set were not correlated with prevalence of any of the pathogens considered here. WorldClim precipitation variables were influential in the distribution of prevalence for the NDV, IBDV and AEV, but not for others. Topographic factors (elevation, slope, aspect) exhibited no statistically significant relationships with prevalence data. MODIS-derived NDVI values showed sporadic and varying levels of correlation with prevalence of all pathogens considered here, with the relationship being positive in the drier and negative in the wetter times of the year, a pattern not logically consistent with a link to arthropod vector habitat. This signal would be largely lost if not assessed at multiple spatial scales (out to 22.56 km^2). MODIS-derived land surface temperature variables were influential on the MG-MDV-ILTV-IBVM grouping, with a trend toward higher prevalence in areas with lower temperatures in cooler seasons, and lower diurnal temperature ranges. Cooler temperatures during the warmer months and throughout the year were also implicated in the prevalence of NDV & AEV. MODIS-derived water vapor measures had no influence on the MG-MDV-ILTV-IBV-ARV group of pathogens, but were correlated with prevalence of NDV, IBDV and AEV, particularly for the month preceding sampling, with a weak trend toward correlation with mean water vapor for the entire preceding year. Principal components analysis of the factors being assessed occasionally supported the patterns observed when correlating with the raw data, and sporadically suggested relationships not otherwise observed. As per Soos et al. (in review), the prevalences of pathogens in the MG-MDV-ILTV-IBVM&C-ARV group are significantly influenced by farm type, while those in the NDV-IBDV-AEV-AAVI group are not.

Should such correlations prove to have a legitimate cause-effect relationship, applying regression formulas to georeferenced data sets, such as climate data, may allow us to predict the spatial distribution of prevalence values. For example, linear regression of IBDV against precipitation seasonality yields a regression formula with a slope of -0.045 (percent change in prevalence per change in the unitless coefficient of variation of precipitation) and an intercept of 2.181 ($r^2 = 0.794$, $P = 0.007$, $S_E = 0.140$). Applying the regression formula to the WorldClim precipitation seasonality data yields a map of predicted prevalence distribution throughout the agriculture zone and the archipelago as a whole (Figures 2 & 3). Similarly, regression of NDV against precipitation seasonality yields a slope of -0.045 and an intercept of 1.785 ($r^2 = 0.593$, $P = 0.043$, $S_E = 0.229$), resulting in a predicted distribution reflected in Figures 4 & 5. However, it should be noted that this method assumes that the correlations describe a linear relationship while the true relationship may be non-linear or a threshold response. Certainly it is likely that the relationship is not truly linear in that it is not possible for prevalence to be greater than 1 or less than 0.

If indeed precipitation seasonality is a reliable predictor of the geographic distribution of NDV and IBDV in the Galapagos Islands (and to a lesser extent, AEV and AAVI), it may be encouraging to note that the potential distribution of high prevalences of these diseases appears to be relatively limited (Figures 3 & 5). It must be remembered, however, that this pattern is observed in poultry populations within the agricultural zone. Transmission dynamics in wild multi-species communities within the protected zone may likely be quite dissimilar. Further caution in accepting these predictions is warranted in that they are based on observations at a small geographic scale are being extrapolated far beyond the area that was sampled.

Generalized Conceptual Model – In general, the relative number of environmental correlates observed per pathogen was only loosely consistent with predictions regarding likelihood of observing such correlations. Predictions were very subjective, primarily based on published references as to durability of the pathogen outside of the host, with observed results being based on number of correlations with components of the “all-layers” PCA. Prevalence of Marek’s disease virus, which had one of the strongest records of durability, showed only a moderate level of correlation with environmental variables. Likewise, environmental correlations with NDV prevalence were less than predicted. It is possible that the virions of these viruses are so impervious to the range of environmental values occurring at the sampling sites that there is little detectable signal of impact on prevalence. Another exception, AAVI, was predicted to show moderate correlations with environmental variables but showed relatively few significant relationships. AAVI is non-enveloped, and it is possible that this physiological characteristic, lending to relative lability, led to a diminished influence of environmental factors on prevalence. Perhaps these relationships can be explained by a generalized conceptual model (as illustrated in Figure 6) wherein: 1) very labile organisms fail to persist outside the host long enough to demonstrate any perceptible influence of environmental variation; 2) organisms of intermediate durability persist long enough for environmental variables to differentially affect transmission dynamics; and 3) highly durable organisms are relatively impervious to the environmental conditions, or at least the ranges of values occurring in the current study.

Several caveats must be considered with these data. "Prevalence" values are based on seroreactivity, which does not necessarily reflect the current disease status of the host, only that the host has been exposed to some form of the pathogen at some point in its life, including vaccines. While vaccination is prohibited in the Galapagos Islands, some imported chicks may have been vaccinated in Ecuador, or surreptitiously vaccinated in the Galapagos Islands (see Soos et al., in review, for more discussion of vaccination and seroreactivity in the Galapagos Islands). As mentioned previously, the WorldClim climatic variables considered here are interpolated from ~30-year averages reported by thousands of weather stations around the world; however, the accuracy of these estimates may be weaker in remote islands (Hijmans et al. 2005). A more thorough assessment of these relationships may require installation of data-logging weather stations at farm sites.

This study is a first attempt to identify relationships between disease prevalence and environmental factors in the Galapagos poultry industry. The patterns observed might only apply to the limited time and geographic space sampled here, but will merit future investigation. The first step in describing a biologically meaningful relationship must be to formulate testable hypotheses for the relationships and to test the repeatability of the results and the range of values over which the relationship holds true. A larger sample may begin to illuminate other relationships with the other diseases considered, and provide the statistical strength needed to take an appropriate multivariate analysis approach.

CONCLUSION:

The results obtained support the hypothesis that environmental variables may explain some of the variation in the observed heterogeneity of pathogen prevalence in Galapagos poultry farms. However, the strongest correlations of the majority of the pathogens considered here were with the other organisms within their respective groupings.

In general, the MG-MDV-ILTV-IBVM&C-ARV grouping (predominantly enveloped viruses, with the exception of ARV and the bacterial MG) tended to exhibit: high correlation with prevalences of other pathogens within this group; more correlation with farm type (Soos et al., in review); correlation with remote sensing-derived temperature variables for the year prior to testing, particularly cooler daytime temperatures and narrower diurnal temperature ranges (most marked in MDV, ILTV, & IBVM&C); and negative correlation with vegetation density measurements taken during dry times of the year, with the relationship being positive only with the data recorded at the peak of greenness.

As for the NDV-IBDV-AEV-AAVI grouping (all non-enveloped viruses except for NDV), prevalences tended to not be correlated with farm type (Soos et al., in prep) but rather exhibited correlations with interpolated climate variables reflective of moderate dry seasons, and negative correlations with water vapor factors. Correlations with these climatic factors were most apparent with NDV, IBDV, and AEV. NDV and AEV also displayed some correlation with cooler daytime temperatures. Sporadic correlations with vegetation density measurements were largely negative with those taken at drier periods and positive during wetter periods (Mar-Jun).

While management practices are likely to be the first and best line of defense against poultry disease spillover into wildlife populations, environmental factors may contribute to the relative prevalence of diseases, and therefore the likelihood of transmission across the poultry/wildlife interface. Methods such as those described in this paper may prove useful for identifying links between environmental variables and disease processes.

It seems unlikely that the correlations suggested here will have much influence on the management of the poultry industry on Santa Cruz and other Galapagos Islands. While the demand for poultry products is growing, the locations of chicken farming efforts are strictly limited by the boundaries of the National Park (Figure 1). Should the ecological correlates of pathogen prevalence be substantiated as environmental predictors of increased disease risk, management implications might include encouragement of poultry farming in lower-risk areas. However, concentration of poultry-farms in lower-risk zones may also pose new risks as density of farms increases.

Of the pathogens considered here, spillover of Newcastle's disease virus into wild populations appears to have the greatest potential for significant ecological impact. Understanding the role of environmental influences on the prevalence of NDV or other introduced pathogens may be important in predicting and controlling the spread of disease if it does cross the poultry-wildlife interface.

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Table 1. Poultry pathogen characteristics, threats to wildlife, and factors affecting likelihood of environmental influence on transmission.

Pathogen & Family	Prevalence & Pathogenicity	Non-poultry birds affected	Galapagos species at risk	Vectors & Reservoirs	Modes & Characteristics of Transmission	Persistence Outside Host	Pred.	Obs.
Mycoplasma Gallisepticum (MG) Mycoplasmataceae	Common bacterial pathogen of poultry, colonizes mucosal surfaces[y]; respiratory signs with inflammation and lesions of the respiratory tract[f]; may be present but not cause disease until triggered by stress[f]	Narrow host range[y]; wild Galliformes, ducks & geese[f]; wild passeriformes, piciformes, apodiformes, columbiformes[e]; American groundfinches, house sparrows[e]	Darwin's finches, mockingbirds, Galapagos doves, dark-billed cickoos and yellow warblers[e]	Fomites[†]	Vertical transmission possible, but primarily horizontal, via direct contact or contaminated airborne dust, droplets, feathers[f]	Devoid of cell wall, bound by plasma membrane only[y]; seldom survives outside host for more than a few days, susceptible to common disinfectants[fy]; carrier birds thought to be essential for continued transmission[fy]	Low	Low
Newcastle's Disease Virus (NDV) Paramyxoviridae	Respiratory, gastrointestinal and neurological signs[f]; birds may die suddenly, die after prolonged illness, develop disease and recover, or exhibit no signs of infection[b]; sudden deaths often first sign of infection[d]	Pet birds[a]; anseriformes, psittaciformes, strigiformes, columbiformes, passeriformes[b]; natural or experimental infection demonstrated in +230 species in 27 orders[c]; damage to natural populations of cormorants & pelicans[d]	Flightless cormorants, brown pelicans, Galapagos penguins, lava gulls, finches, mockingbirds, pintails[e]	Some evidence that infected migratory birds may transmit disease[ab]; greatest potential for transmission through humans and their equipment such as boots, tools, caging, etc.[a]; insects, rodents and wild birds may act as mechanical vectors[b]	Shed in feces and respiratory secretions, chronically infected birds may shed for over a year[b]	Enveloped; virions relatively stable, can persist outside host for up to 19 weeks, but can be inactivated at high temps and sunlight[b]	High	Mod.
Marek's Disease Virus (MDV) Herpesviridae	Occurs worldwide with practially all poultry stocks having been exposed[f]; tumor inducing virus, infiltration of nerve and organ tissues by lymphoid cellsb; survivors latently infected[b]	Little evidence for transmissibility to non-galliformes[gh]; lesions suggestive of MDV observed in a great horned owl[i]	Barn owl, short-eared owl, Galapagos penguin[ej]	Testing showed darkling beetles may passively carry the virus, but litter mites, mosquitoes & coccidial oocysts did not[m]	Spread via feces or fomites, but primarily via feather follicle dander[b]	Enveloped; unusually stable outside the host, particularly for a herpesvirus[b]; can remain infective for several months at 20-25°C and for years at 4°C[k]; continual shedding and hardiness of virus make it persistent in flocks[k]; seasonal variation in incidence, higher in winter, attributed to reduced air circulation[l]	High	Mod.
Infectious Laryngotracheitis Virus (ILTV) Herpesviridae	Difficult breathing, coughing, gasping, expectoration of bloody exudates[f]; most outbreaks affect broilers 4 weeks or older, but all age groups susceptible[f]	No information	No information	Fomites[b]	Primarily by inhalation of contaminated respiratory secretions[b]; Survivors resistant, but may become carriers, can shed for long periods[f]; latent infection may be reactivated by stress[f]	Enveloped; moderately stable outside host, though susceptible to sunlight and disinfectants[bf]	Mod.	Low
Infectious Bronchitis Virus - Mass. & Conn. Strains (IBVM & IBVC) Coronaviridae	Acute infections characterized by respiratory signs & sever renal disease[f]; great ability to mutate, strain ID difficult[f];	Racing pigeons[n]	Galapagos doves[e]	No information	Highly contagious[f]; inhalation of aerosolized respiratory secretions expelled by infected, coughing chickens[f]; infection can occur over long distances and can spread rapidly through a flock[f]; survivors remain carriers for months[f]	Enveloped; virions may persist on contaminated premises for 4 weeks under favorable conditions, but fairly easily destroyed by disinfectants[f]	High	Mod.
Infectious Bursal Disease (IBDV) Birnaviridae	Highly infectious in young chickens, causing necrosis of bursa resulting in immune suppression[bf]; anorexia, diarrhea, vent picking, tremling, loss of coordination[bf]; survivors may have permanent immune system damage[bo]	Naturally occurring infections of turkeys and ducks recorded[o]	Lava gulls[e]	Free-ranging birds, rodents, arthropods could be mechanical vectors[b]; isolated from dead rats[p] and mealworms[q]; isolated from mosquitoes in chicken areas, but isolate noninfective[r]	Direct contact with feces or ocular and respiratory secretions, or indirect contact via litter, food, water or fomites[bf]; infected birds shed virus for up to 2 weeks[f]; no evidence of a true carrier state in recovered birds[bo]	Non-enveloped; hardy & persistent, resistent to most disinfectants and environmental factors[f]; virions found to remain infectious for 122 days in litter and 52 days in food and water[b]; sanitation programs rarely successful[f]	High	High
Avian Reovirus (ARV) Reoviridae	Infections occur worldwide in chickens & turkeys, causing viral arthritis, stunting syndromes, respiratory & enteric disease, & malabsorption syndromes[bf]	Geese & mucovy ducks in Hungary[st]; woodcocks in North America, though infection not related to poultry strains[u]	White-heeked pintail[e]	Vectors not implicated on transmission[f]	Shed primarily in feces, has been experimentally transmitted orally, intratracheally & intramuscularly[b]; survivors latently infected, known to persist in birds for +280 days[bf]	Non-enveloped; virions stable in organic matter and respiratory secretions, resistant to many environmental factors[bf]	Mod.	Low
Avian Encephalomyelitis Virus (AEV) Picornaviridae	Tremors of the head and neck, ataxia progressing to paralysis[f]; outbreaks usually affect 1- to 3-week chicks, adults usually show no signs[f]; multi-age farms more likely to be infected[f]	Pheasants, quails, turkeys[uv]; experimentally transmitted to ducklings, guinea fowl, & pigeon hatchlings[f]	Uncertain; antibodies found in waved albatross[w]	Fomites[f]	Via feces[f]	Non-enveloped; virions survive in feces for at least 4 weeks, fairly resistant to environmental conditions[f]	Mod.	Mod.
Avian Adenovirus (AAVI) Adenoviridae	Ubiquitous in fowl, primarily as secondary pathogens causing disease in birds already compromised[x]	Serotypes recovered from turkeys, pigeons, budgerigars, mallards; probable recoveries from guinea fowl, pheasants, kestrels, herring gulls, frogmouths, and several psittacines[x]	Flightless cormorants, waved albatross, boobies, pintails, lava gulls and terns[e]	Fomites[x]	All excretions, titers highest in feces[x]; mostly by direct fecal/oral contact, but also aerial contact over short distances[x]; vertical transmission important[x]; survivors latently infected and may shed intermittently[b]	Non-enveloped; relatively resistant to physical and chemical environmental factors[f]	Mod.	Low

Pred. = Prediction of relative likelihood that environmental factors could influence prevalence, largely based on reports of extended persistence outside host.

Obs. = Relative amount of environmental correlations observed, based on statistically significant relationships with all-layers PCA components (see Methods).

† = Fomites are inanimate objects infected with pathogens that may act as agents of transmission

References: a-Alexander 1997; b-Ritchie 1995; c-Kaleta & Baldauf 1988; d-Glaser et al. 1999; e-Gottdenker et al.; f-Charlton 1990; g-Cho & Kenzy 1975; h-Lesnik et al. 1981; i-Halliwell 1971; j-Miller et al. 2001; k-Calnek & Witter 1997; l-Purchase 1985; m-Witter 1972; n-Barr et al. 1988; o-Luikert & Saif 1997; p-Okoye & Uche 1986; q-Snedeker et al. 1967; r-Howie & Thorsen 1981; s-Wobeser 1997; t-Palya et al. 2003; u-Van Steenis 1971; v-Calnek 1997; w-Padilla et al. 2003; x-McFerren 1997; y-Kleven 1997

Table 2. Correlates of pathogen prevalence in Santa Cruz, Galapagos, poultry farms

a. Correlates of *Mycoplasma gallisepticum* (MG) prevalence (p<0.10; **p<0.05**)

Correlated Factors	*r*	p
Other pathogens		
MDV	**0.809**	**0.005**
ILTV	**0.841**	**0.002**
IBVM	**0.690**	**0.027**
IBVC	**0.643**	**0.045**
ARV	**0.763**	**0.010**
MODIS Land Surface Temperature Variables		
Daytime mean, cooler months	-0.718	0.069
MODIS NDVI Variables		
NDVI 8/29/04 (10.56-22.56 km2; max=22.56km2)	**-0.891**	**0.007**
NDVI 3/6/05 (1.56-10.56 km2; max=5.06km2)	**0.833**	**0.020**
NDVI 4/7/05 (0.06-5.06 km2; max=1.56km2)	**-0.767**	**0.044**
NDVI 5/9/05 (5.06-10.56 km2; max=5.06km2)	-0.727	0.064
NDVI 5/25/05 (5.06-10.56 km2; max=5.06km2)	-0.738	0.059

b. Correlates of Newcastle disease virus (NDV) prevalence (p<0.10; **p<0.05**)

Correlated Factors	*r*	p
Other Pathogens		
AEV	**0.830**	**0.003**
IBDV	0.565	0.089
WORLDCLIM Precipitation Variables		
Precipitation seasonality	**-0.770**	**0.043**
Precipitation in driest month	0.721	0.068
MODIS Total Precipitable Water Vapor Variables		
Water vapor 8/04	**-0.850**	**0.015**
Water vapor 9/04	**-0.970**	**0.000**
Water vapor 12/04	-0.693	0.084
Water vapor 1/05	**-0.808**	**0.028**
Water vapor 6/05	**-0.840**	**0.018**
Water vapor yearly mean	-0.716	0.070
MODIS Land Surface Temperature Variables		
Daytime mean, warmer months	**-0.861**	**0.013**
MODIS NDVI Variables		
NDVI 1/1/05 (10.56-22.56 km2; max=10.56km2)	-0.711	0.073
NDVI 3/6/05 (22.56km2)	**0.840**	**0.018**
NDVI 4/23/05 (0.06-1.56, 10.56km2; max=1.56km2)	**0.801**	**0.030**
NDVI 6/10/05 (0.06-0.56km2; max=0.56km2)	**0.882**	**0.009**
Principal Components		
Water vapor PC3	-0.788	0.035
All layers PC6	0.700	0.080
All layers PC14	**-0.877**	**0.010**

c. Correlates of Marek's disease virus (MDV) prevalence (p<0.10; **p<0.05**)

Correlated Factors	*r*	p
Other Pathogens		
MG	**0.809**	**0.005**
ILTV	**0.866**	**0.001**
IBVM	**0.952**	**0.000**
IBVC	**0.935**	**0.000**
ARV	**0.794**	**0.006**
MODIS Land Surface Temperature Variables		
Daytime mean, cooler months	-0.740	0.057
Diurnal temperature range, warmer months	**-0.810**	**0.027**
MODIS NDVI Variables		
NDVI 8/13/04 (1.56-22.56km2; max=10.56km2)	-0.710	0.074
NDVI 8/29/04 (22.56km2)	-0.685	0.089
NDVI 9/30/04 (5.06-22.56km2; max=10.56km2)	**-0.796**	**0.032**
NDVI 10/16/04 (5.06-22.56km2; max=22.56km2)	-0.749	0.052
NDVI 11/1/04 (1.56-22.56km2; max=22.56km2)	-0.723	0.064
NDVI 11/17/04 (5.06-22.56km2; max=5.06km2)	**-0.948**	**0.001**
NDVI 12/19/04 (10.56-22.56km2; max=22.56km2)	-0.714	0.072
NDVI 1/17/05 (22.56km2)	-0.703	0.078
NDVI 2/2/05 (0.06, 10.56-22.56km2; max=22.56km2)	**0.803**	**0.030**
NDVI 3/6/05 (0.06-10.56km2; max=0.56km2)	**0.981**	**0.000**
NDVI 5/25/05 (22.56km2)	-0.722	0.067
NDVI 7/12/05 (0.56-22.56km2; max=1.56km2)	**-0.781**	**0.038**
NDVI 7/28/05 (22.56km2)	**-0.762**	**0.046**
NDVI yearly mean	-0.674	0.097
NDVI dry season mean	-0.704	0.077
NDVI seasonality	0.720	0.068
Principal Components		
Water vapor PC2	-0.672	0.098
All-layers PC7	**0.766**	**0.044**

d. Correlates of infectious laryngotracheitis virus (ILTV) prevalence (p<0.10; **p<0.05**)

Correlated Factors	*r*	p
Other Pathogens		
MG	**0.841**	**0.002**
MDV	**0.866**	**0.001**
IBVM	**0.802**	**0.005**
IBVC	**0.831**	**0.003**
ARV	**0.902**	**0.000**
MODIS Land Surface Temperature Variables		
Daytime mean, yearly	**-0.783**	**0.037**
Daytime seasonality	0.738	0.059
MODIS NDVI Variables		
NDVI 8/29/04 (10.56-22.56km2; max=10.56km2)	**-0.842**	**0.018**
NDVI 9/30/04 (5.06-22.56km2; max=5.06km2)	**-0.791**	**0.034**
NDVI 10/16/04 (5.06-22.56km2; max=5.06km2)	-0.734	0.060
NDVI 11/17/04 (5.06-22.56km2; max=5.06km2)	**-0.776**	**0.040**
NDVI 1/17/05 (22.56km2)	-0.737	0.059
NDVI 3/6/05 (0.56-10.56km2; max=10.56km2)	**0.878**	**0.009**
NDVI 3/22/05 (5.06km2)	-0.705	0.077
NDVI 4/7/05 (1.56km2)	-0.699	0.081
NDVI 5/25/05 (5.06-22.56km2; max=10.56km2)	-0.735	0.060
NDVI 7/28/05 (22.56km2)	**-0.766**	**0.045**
NDVI yearly mean	-0.685	0.089

e. Correlates of infectious bronchitis virus - Mass. strain (IBVM) prevalence (p<0.10; **p<0.05**)

Correlated Factors	*r*	p
Other Pathogens		
MG	**0.690**	**0.027**
MDV	**0.952**	**0.000**
ILTV	**0.802**	**0.005**
IBVC	**0.973**	**0.000**
ARV	**0.733**	**0.016**
MODIS Land Surface Temperature Variables		
Daytime land surface temperature, cooler mos.	**-0.807**	**0.028**
Nighttime land surface temperature, yearly mean	0.699	0.081
Land surface diurnal temperature range, yearly mean	-0.720	0.068
Land surface diurnal temp. range, warmer mos.	**-0.777**	**0.040**
Land surface diurnal temp. range, cooler mos.	**-0.799**	**0.031**
MODIS NDVI Variables		
NDVI 8/13/04 (0.06-22.56km2; max=10.56km2)	**-0.804**	**0.029**
NDVI 9/30/04 (5.06-22.56km2; max=10.56km2)	**-0.877**	**0.010**
NDVI 10/16/04 (1.56-22.56km2; max=22.56km2)	**-0.875**	**0.010**
NDVI 11/1/04 (0.56-22.56km2; max=22.56km2)	**-0.833**	**0.020**
NDVI 11/17/04 (1.56-22.56km2; max=10.56km2)	**-0.973**	**0.000**
NDVI 12/19/04 (5.06-22.56km2; max=22.56km2)	**-0.770**	**0.043**
NDVI 1/17/05 (22.56km2)	**-0.788**	**0.035**
NDVI 2/2/05 (0.06, 10.56-22.56km2; max=0.06km2)	**0.761**	**0.047**
NDVI 3/6/05 (0.06-10.56km2; max=0.56km2)	**0.922**	**0.003**
NDVI 5/25/05 (22.56km2)	-0.744	0.055
NDVI 7/12/05 (0.06-22.56km2; max=1.56km2)	**-0.833**	**0.008**
NDVI 7/28/05 (22.56km2)	-0.796	0.032
NDVI yearly mean	-0.726	0.065
NDVI dry season mean	**-0.802**	**0.030**
NDVI seasonality	**0.841**	**0.018**
Principal Components		
NDVI PC1	-0.711	0.073
NDVI PC2	0.676	0.095
Water vapor PC2	**-0.788**	**0.036**
All-layers PC1	0.730	0.063
All-layers PC7	**0.857**	**0.014**

f. Correlates of infectious bronchitis virus - Conn. strain (IBVC) prevalence (p<0.10; **p<0.05**)

Correlated Factors	*r*	p
Other Pathogens		
MG	**0.644**	**0.045**
MDV	**0.935**	**0.000**
ILTV	**0.831**	**0.003**
IBVM	**0.973**	**0.000**
ARV	**0.813**	**0.004**
MODIS Land Surface Temperature Variables		
Mean daytime land surface temperature, cooler mos.	-0.739	0.058
Mean nighttime land surface temperature, yearly	0.690	0.086
Land surface diurnal temp. range, yearly	**-0.770**	**0.040**
Land surface diurnal temp. range, warmer mos.	-0.718	0.069
Diurnal land surface temp. range, cooler mos.	**-0.794**	**0.033**
MODIS NDVI Variables		
NDVI 8/13/04 (0.06-22.56 km2; max=10.56km2)	**-0.761**	**0.047**
NDVI 9/30/04 (0.06, 5.06-22.56 km2; max=10.56km2)	**-0.912**	**0.004**
NDVI 10/16/04 (5.06-22.56 km2; max=22.56km2)	**-0.853**	**0.015**
NDVI 11/1/04 (0.56-22.56 km2; max=22.56km2)	**-0.786**	**0.036**
NDVI 11/17/04 (1.56-22.56 km2; max=5.06km2)	**-0.948**	**0.001**
NDVI 12/19/04 (22.56km2)	-0.689	0.087
NDVI 1/17/05 (0.06, 10.56-22.56 km2; max=22.56km2)	**-0.876**	**0.010**
NDVI 2/2/05 (0.06, 10.56-22.56 km2; max=22.56km2)	**0.777**	**0.040**
NDVI 3/6/05 (0.06-10.56 km2; max=0.56km2)	**0.887**	**0.008**
NDVI 5/25/05 (10.56-22.56km2; max=22.56km2)	**-0.799**	**0.031**
NDVI 6/10/05 (22.56km2)	-0.682	0.092
NDVI 7/12/05 (0.06-22.56km2; max=0.56km2)	**-0.835**	**0.019**
NDVI 7/28/05 (22.56km2)	-0.743	0.055
NDVI yearly mean	-0.724	0.066
NDVI dry season mean	**-0.771**	**0.042**
NDVI seasonality	**0.800**	**0.031**
Principal Components		
NDVI PC1	-0.696	0.083
Water vapor PC2	**-0.766**	**0.045**
All layers PC1	0.714	0.072
All layers PC7	**0.811**	**0.027**

g. Correlates of infectious bursal disease virus (IBDV) prevalence (p<0.10; **p<0.05**)

Correlated Factors	*r*	p
Other Pathogens		
AAVI	**0.767**	**0.010**
NDV	0.565	0.089
WORLDCLIM Precipitation Variables		
Precipitation in coldest quarter	0.719	0.069
Precipitation in warmest quarter	0.704	0.078
Precipitation in driest quarter	0.736	0.059
Precipitation in driest month	**0.822**	**0.023**
Annual precipitation	0.713	0.072
Precipitation seasonality	**-0.891**	**0.007**
MODIS Total Precipitable Water Vapor Variables		
Water vapor 8/04	-0.687	0.088
Water vapor 9/04	**-0.772**	**0.042**
Water vapor 12/04	-0.701	0.079
Water vapor 3/05	**0.814**	**0.026**
Water vapor 6/05	**-0.866**	**0.012**
MODIS NDVI Variables		
NDVI 9/14/04 (0.56-10.56 km2; max=5.06km2)	**-0.880**	**0.009**
NDVI 11/17/04 (0.06km2)	0.677	0.095
NDVI 1/1/05 (1.56-10.56 km2; max=10.56km2)	**-0.825**	**0.022**
NDVI 3/6/05 (22.56km2)	**0.793**	**0.033**
NDVI 4/23/05 (0.06-1.56 km2; max=1.56km2)	**0.866**	**0.012**
NDVI 5/9/05 (0.56km2)	0.715	0.071
NDVI 7/28/05 (5.06km2)	0.706	0.076
Principal Components		
WORLDCLIM Precipitation PC1	**-0.772**	**0.042**
Water Vapor PC3	**-0.855**	**0.014**
All-layers PC6	0.684	0.090
All-layers PC10	0.738	0.058
All-layers PC14	**-0.731**	**0.062**

h. Correlates of avian reovirus (ARV) prevalence (p<0.10; **p<0.05**)

Correlated Factors	*r*	p
Other Pathogens		
MG	**0.763**	**0.010**
MDV	**0.794**	**0.006**
ILTV	**0.902**	**0.000**
IBVM	**0.733**	**0.016**
IBVC	**0.813**	**0.004**
AAVI	0.584	0.077
WORLDCLIM Precipitation Variables		
Precipitation in the wettest quarter	0.669	0.100
MODIS NDVI Variables		
NDVI 8/29/04 (5.06-22.56 km2; max=22.56km2)	**-0.904**	**0.005**
NDVI 9/14/04 (22.56km2)	**-0.893**	**0.007**
NDVI 9/30/04 (0.06-22.56 km2; max=5.06km2)	**-0.871**	**0.011**
NDVI 1/17/05 (22.56km2)	**-0.791**	**0.034**
NDVI 2/2/05 (22.56km2)	**0.784**	**0.037**
NDVI 3/6/05 (0.06-22.56 km2; max=10.56km2)	**0.860**	**0.013**
NDVI 3/22/05 (5.06km2)	**-0.799**	**0.039**
NDVI 5/25/05 (0.56-22.56 km2; max=10.56km2)	**-0.941**	**0.002**
NDVI 6/10/05 (22.56km2)	**-0.774**	**0.041**
NDVI yearly mean	-0.686	0.089
Principal Components		
NDVI PC1	-0.685	0.090
Water vapor PC4	**-0.768**	**0.044**
All-layers PC1	0.672	0.098

i. Correlates of avian encephalomyelitis virus (AEV) prevalence (p<0.10; **p<0.05**)

Correlated Factors	*r*	p
Other Pathogens		
NDV	**0.830**	**0.003**
WORLDCLIM Precipitation Variables		
Annual Precipitation	0.690	0.087
Precipitationin the coldest quarter	0.674	0.097
Precipitationin the warmest quarter	0.677	0.095
Precipitation in the driest quarter	0.712	0.072
Precipitation in the driest month	0.724	0.066
Precipitation seasonality	-0.699	0.081
MODIS Total Precipitable Water Vapor Variables		
Water vapor 8/04	**-0.827**	**0.022**
Water vapor 9/04	-0.707	0.076
Water vapor 1/05	**-0.808**	**0.028**
Water vapor 6/05	**-0.756**	**0.049**
MODIS Land Surface Temperature Variables		
Daytime land surface temperature yearly mean	-0.753	0.051
MODIS NDVI Variables		
NDVI 1/1/05 (5.06-22.56 km2; max=5.06km2)	-0.723	0.066
NDVI 6/10/05 (0.56-1.56 km2; max=0.56km2)	**0.817**	**0.025**
Principal Components		
Topographic Variables PC2	0.679	0.093
All-layers PC9	0.704	0.077
All-layers PC14	**-0.873**	**0.010**

j. Correlates of avian adenovirus I (AAVI) prevalence (p<0.10; **p<0.05**)

Correlated Factors	*r*	p
Other Pathogens		
IBDV	**0.767**	**0.010**
ARV	0.584	0.077
MODIS NDVI Variables		
NDVI 9/14/04 (0.56-22.56 km2; max=10.56km2)	**-0.895**	**0.006**
NDVI 3/22/05 (0.06-1.56 km2; max=1.56km2)	**-0.872**	**0.010**
NDVI 4/23/05 (0.06-0.56 km2; max=0.06km2)	0.724	0.066
Principal Components		
WORLDCLIM Temperature PC2	**-0.816**	**0.025**
NDVI PC3	0.746	0.054
Water vapor PC4	**-0.856**	**0.014**
All-layers PC3	0.710	0.074

Table 3. Overview of correlations observed. Note similarities within pathogen groups and differences between them.

Grouping	PATHOGEN	NDV	IBDV	AEV	AAVI	MDV	ILTV	IBVM	IBVC	ARV	MG
1	NDV		+	**+**							
	IBDV	+			**+**						
	AEV	**+**									
	AAVI		**+**							+	
2	MDV						**+**	**+**	**+**	**+**	**+**
	ILTV					**+**		**+**	**+**	**+**	**+**
	IBVM					**+**	**+**		**+**	**+**	**+**
	IBVC					**+**	**+**	**+**		**+**	**+**
	ARV				+	**+**	**+**	**+**	**+**		**+**
	MG					**+**	**+**	**+**	**+**	**+**	
Data Set:		Other Pathogens									

Grouping	PATHOGEN	Annual Mean Temp	Mean Temp Driest Qtr	Mean Temp Wettest Qtr	Temp Annual Range	Min Temp Coldest Mo	Max Temp Warmest Mo	Temp Seasonality	Mean Diurnal Temp Range	Mean Temp Coldest Qtr	Mean Temp Warmest Qtr	Precip Coldest Qtr	Precip Warmest Qtr	Precip Driest Qtr	Precip Wettest Qtr	Precip Driest Mo	Precip Wettest Mo	Annual Precip	Precip Seasonality
1	NDV															+			**-**
	IBDV											+	+	+		**+**		+	**-**
	AEV											+	+	+		+		+	-
	AAVI																		
2	MDV																		
	ILTV																		
	IBVM																		
	IBVC																		
	ARV														+				
	MG																		
Data Set:		WorldClim Temp										WorldClim Precip							

Grouping	PATHOGEN	Mean Day LST, 12 Months	Mean Day LST, Warm Mos	Mean Day LST Cool Mos	Mean Night LST, 12 Months	Mean Night LST, Warm Mos	Mean Night LST, Cool Mos	Diurnal Range, 12 Mos	Diurnal Range, Warm Mos	Diurnal Range, Cool Mos	Day LST Seasonality	Night LST Seasonality	Elevation	Slope	Aspect
1	NDV		**-**												
	IBDV														
	AEV	-													
	AAVI														
2	MDV			-					**-**						
	ILTV	**-**									+				
	IBVM			**-**	+			-	**-**	**-**					
	IBVC			-	+			**-**	-	**-**					
	ARV														
	MG			-											
Data Set:		MODIS Land Surface Temp											Topo		

Grouping	PATHOGEN	August 2004	September 2004	October 2004	November 2004	December 2004	January 2005	February 2005	March 2005	April 2005	May 2005	June 2005	July 2005	Mean, 12 Months	Mean, Min Month	Mean, Max Month	Mean, Annual Range	Mean Seasonality	St.Dev., 12-Mo Mean
1	NDV	**-**	**-**			-	**-**					**-**		-					
	IBDV	-	**-**			-			**+**			**-**							
	AEV	**-**	-				**-**					**-**							
	AAVI																		
2	MDV																		
	ILTV																		
	IBVM																		
	IBVC																		
	ARV																		
	MG																		
Data Set:		MODIS Total Precipitable Water Vapor																	

Grouping	PATHOGEN	August 13, 2004	August 29, 2004	September 14, 2004	September 30, 2004	October 16, 2004	November 1, 2004	November 17, 2004	December 3, 2004	December 19, 2004	January 1, 2005	January 17, 2005	February 2, 2005	February 18, 2005
1	NDV										-			
	IBDV			**-**				+			**-**			
	AEV										-			
	AAVI			-										
2	MDV	-	-		**-**	-	-	**-**		-		-	**+**	
	ILTV		**-**		**-**	-		**-**				-		
	IBVM	**-**			**-**	**-**	**-**	**-**		**-**		**-**	**+**	
	IBVC	**-**			**-**	**-**	**-**	**-**		-		-	**+**	
	ARV		**-**	**-**	**-**							**-**	**+**	
	MG		**-**											
Data Set:		MODIS Normalized Difference Vegetation Index (NDVI)												

Grouping	PATHOGEN	March 6, 2005	March 22, 2205	April 7, 2005	April 23, 2005	May 9, 2005	May 25, 2005	June 10, 2005	June 26, 2005	July 12, 2005	July 28, 2005	Mean for Year	Mean, Wet Season	Mean, Dry Season	Seasonality Index
1	NDV	**+**			**+**			**+**							
	IBDV	**+**			**+**	+					+				
	AEV							**+**							
	AAVI		**-**		**+**										
2	MDV	**+**					-			**-**	**-**	-		-	+
	ILTV	**+**	-	-			-				**-**	-			
	IBVM	**+**					-			**-**	-	-		**-**	**+**
	IBVC	**+**					**-**	-		**-**	-	-		**-**	**+**
	ARV	**+**	**-**				**-**	**-**				-			
	MG	**+**		**-**		-	-								
Data Set:		MODIS Normalized Difference Vegetation Index (NDVI)													

Grouping	PATHOGEN	WorldClim Temp PC1	WorldClim Temp PC2	WorldClim Precip PC1	WorldClim Precip PC2	Topo Variables PC1	Topo Variables PC2	NDVI PC1	NDVI PC2	NDVI PC3	NDVI PC4	LST PC1	LST PC2	Water Vapor PC1	Water Vapor PC2	Water Vapor PC3	Water Vapor PC4
1	NDV														-		
	IBDV			**-**											**-**		
	AEV						+										
	AAVI		**-**							+							**-**
2	MDV													-			
	ILTV																
	IBVM							-	+					**-**			
	IBVC							-						**-**			
	ARV							-									**-**
	MG																
Data Set:		Data Set Principal Components															

Grouping	PATHOGEN	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11	PC12	PC13	PC14	PC15	PC16	Effect of Farm Type	
1	NDV						+								**-**				Enveloped
	IBDV						+				+				**-**				Non-Enveloped
	AEV									+					**-**				Non-Enveloped
	AAVI			+															Non-Enveloped
2	MDV							**+**										X	Enveloped
	ILTV																	X	Enveloped
	IBVM	+						**+**										X	Enveloped
	IBVC	+						**+**										X	Enveloped
	ARV	+																X	Non-Enveloped
	MG																	X	Plasma membrane only
Data Set:		All-Layers PCA Components																	Physiology

+ = Positive correlation at P ≤ 0.05; + = positive correlation at P ≤ 0.10; **-** = negative correlation at P ≤ 0.05; - = negative correlation at P ≤ 0.10

X = Significant effect of farm type (higher in backyard than in broiler) per Soos et al. (in review)

FIGURES:

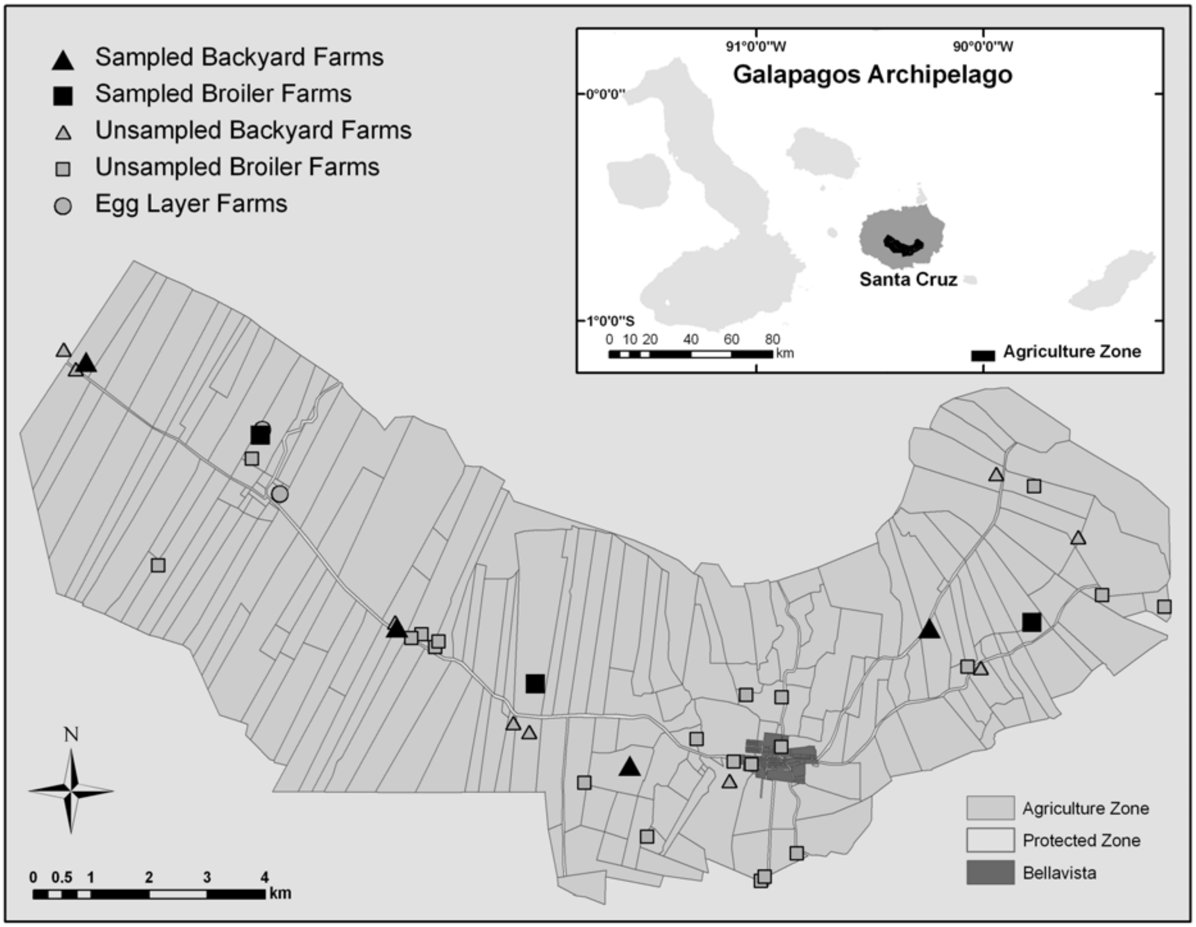

Figure 1. Distribution of sampled and unsampled broiler, backyard and layer chicken farms throughout the agriculture zone of Santa Cruz. Delineations within the agriculture zone represent property lines. Inset: location of Santa Cruz and its agriculture zone within the Galapagos archipelago.

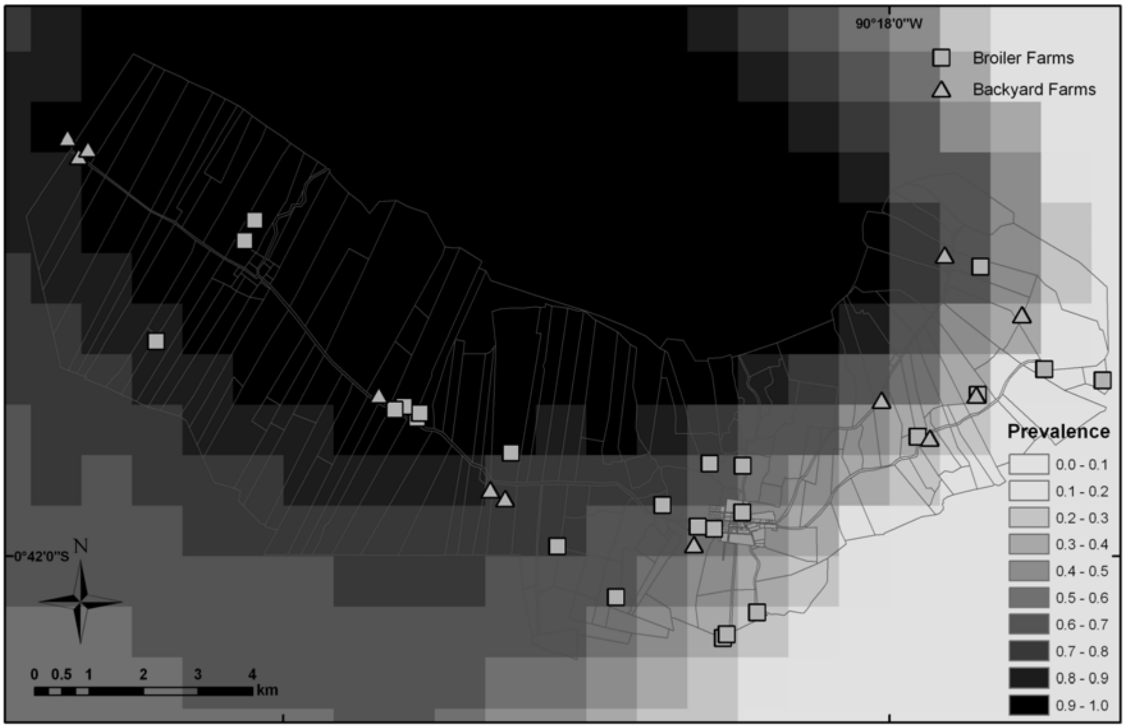

Figure 2. Distribution of prevalence of infectious bursal disease virus predicted by precipitation seasonality (r^2=0.794, P=0.007, S_E=0.140, m=-0.045, b=2.181) throughout agriculture zone.

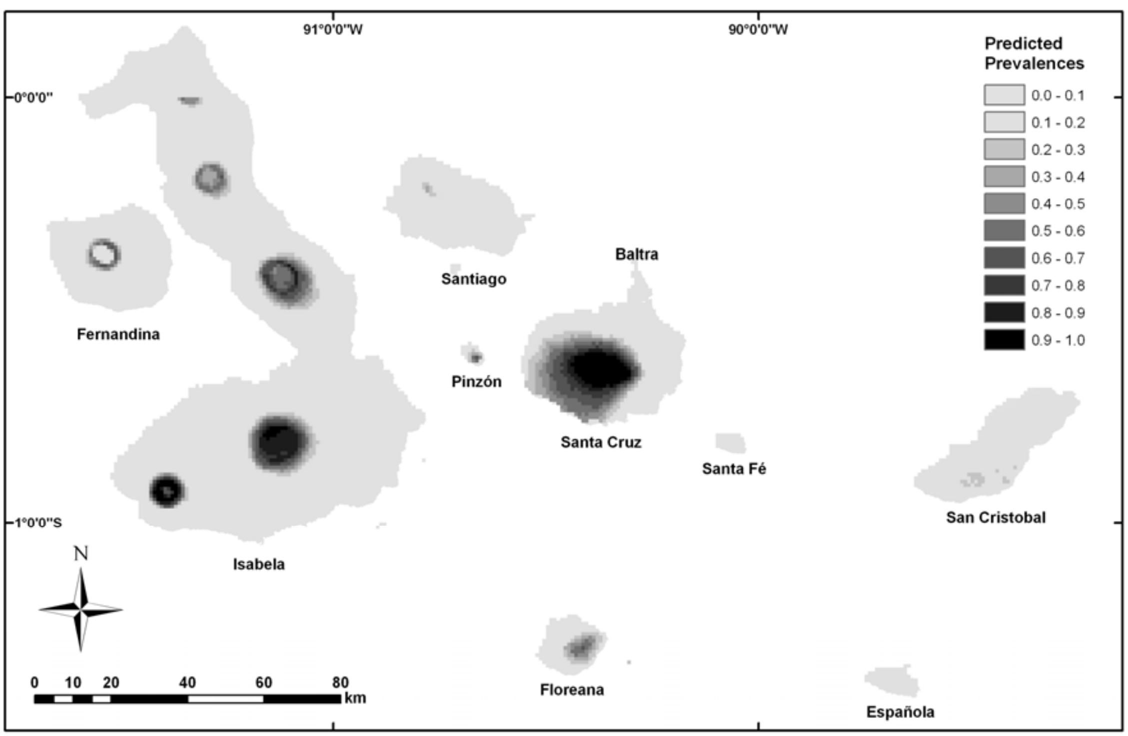

Figure 3. Distribution of prevalence of infectious bursal disease virus predicted by precipitation seasonality (r^2=0.794, P=0.007, S_E=0.140, m=-0.045, b=2.181) throughout archipelago.

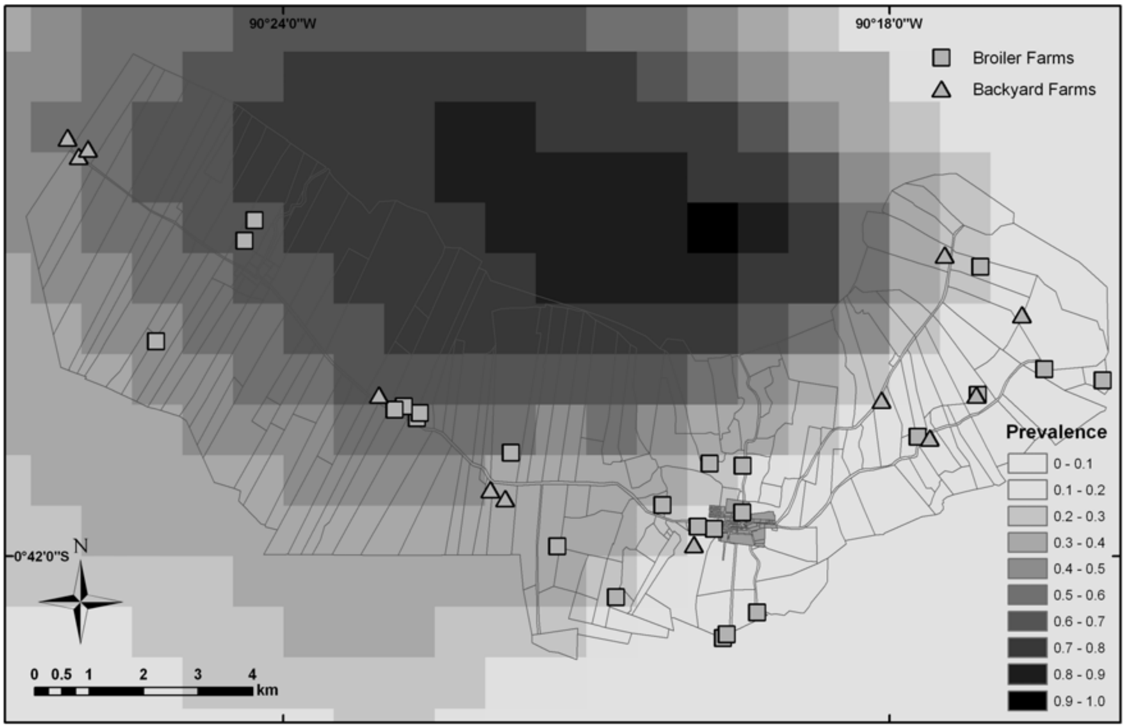

Figure 4. Distribution of prevalence of Newcastle's disease virus predicted by precipitation seasonality (r^2=0.593, P=0.043, S_E=0.229, m=-0.045, b=1.785) throughout agriculture zone.

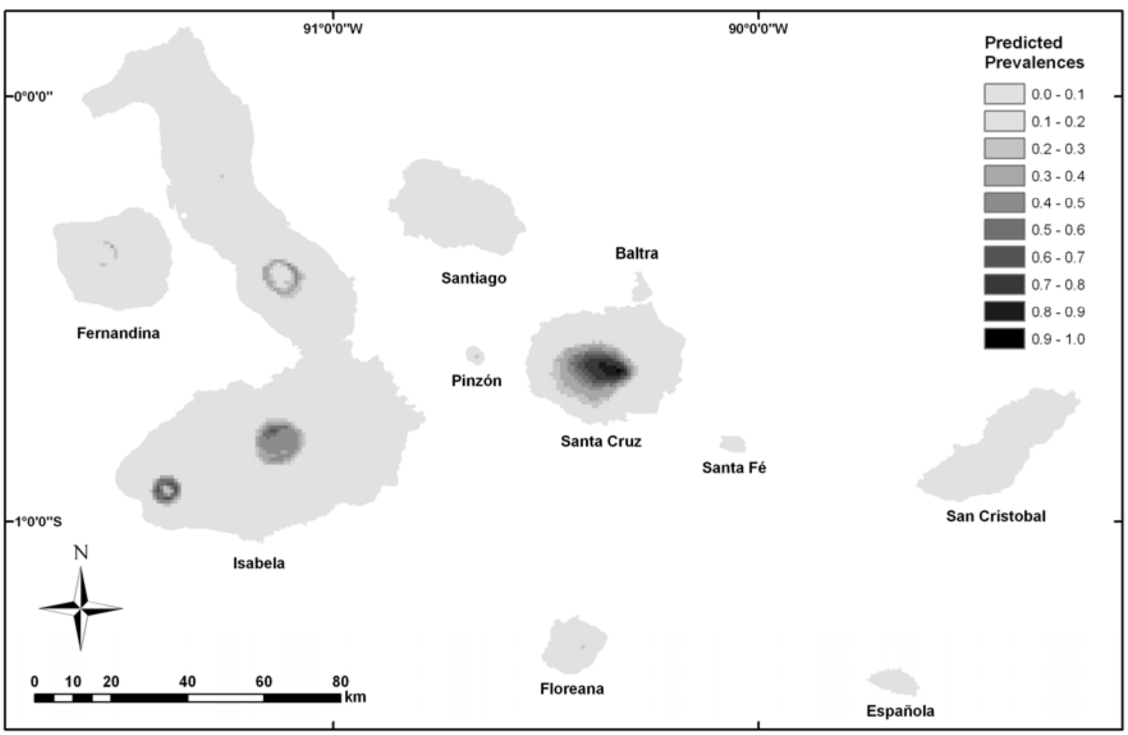

Figure 5. Distribution of prevalence of Newcastle's disease virus predicted by precipitation seasonality (r^2=0.593, P=0.043, S_E=0.229, m=-0.045, b=1.785) throughout archipelago.

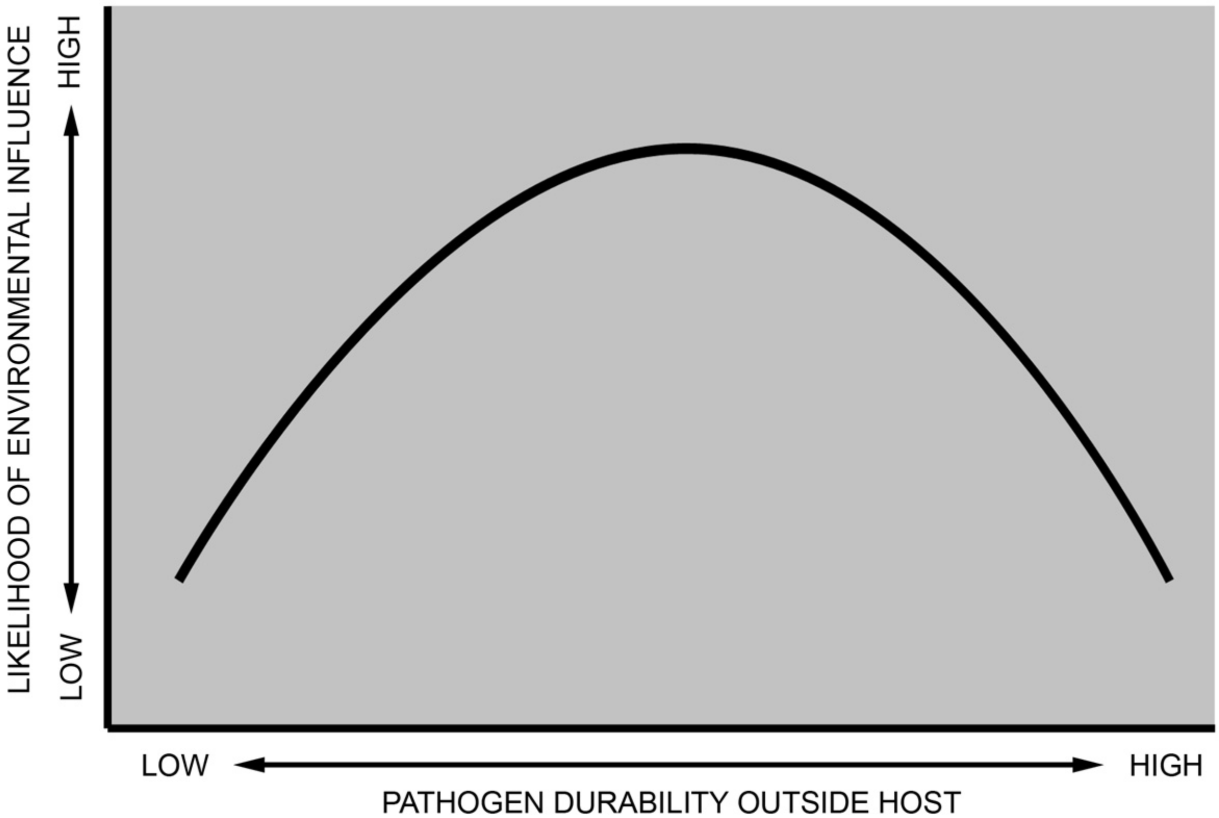

Figure 6. Generalized conceptual model of the likelihood of environmental influence on prevalence of a pathogen as a function of the organism's ability to persist outside the host.

Appendix I. Correlations by pathogen.

Table 1. Correlations of *Mycoplasma Gallisepticum* (MG) prevalence with environmental variables (†).

Pathogen Prevalence		r	P
MG	r	---	
NDV	r	0.531	0.114
MDV	r	**0.809*** **	**0.005**
ILTV	r	**0.841*** **	**0.002**
IBVM	r	**0.690** **	**0.027**
IBVC	r	**0.643** **	**0.045**
IBDV	r	0.143	0.694
ARV	r	**0.763*** **	**0.010**
AEV	r	0.514	0.128
AAVI	r	0.153	0.673

WORLDCLIM Temperature		r	P
Annual Mean Temp	r	-0.257	0.578
Mean Temp, Driest Qtr	r	-0.346	0.447
Mean Temp, Wettest Qtr	r	-0.346	0.448
Temp Annual Range	r	0.339	0.457
Min Temp, Coldest Month	r	-0.285	0.535
Max Temp, Warmest Month	r	-0.131	0.780
Temp Seasonality	r	0.162	0.728
Mean Diurnal Temp Range	r	0.060	0.899
Mean Temp, Coldest Qtr	r	0.267	0.563
Mean Temp, Warmest Qtr	r	0.249	0.591

WORLDCLIM Precipitation		r	P
Precip, Coldest Qtr	r	0.127	0.786
Precip, Warmest Qtr	r	0.101	0.830
Precip, Driest Qtr	r	0.123	0.792
Precip, Wettest Qtr	r	0.386	0.392
Precip Seasonality	r	-0.192	0.68
Precip, Driest Month	r	0.139	0.766
Precip, Wettest Month	r	0.034	0.943
Annual Precipitation	r	0.107	0.819

MODIS Water Vapor		r	P
Mean, August 2004	r	-0.004	0.992
Mean, September 2004	r	-0.395	0.380
Mean, October 2004	r	-0.304	0.507
Mean , November 2004	r	-0.247	0.593
Mean, December 2004	r	0.254	0.582
Mean, January 2005	r	-0.473	0.284
Mean, February 2005	r	0.027	0.954
Mean, March 2005	r	-0.014	0.977
Mean, April 2005	r	-0.514	0.238
Mean, May 2005	r	-0.439	0.324
Mean, June 2005	r	-0.011	0.981
Mean, July 2005	r	-0.135	0.773
Mean, 12 Months	r	-0.390	0.387
Mean, Min Month	r	-0.530	0.221
Mean, Max Month	r	-0.514	0.238
Mean, Annual Range	r	0.013	0.977
Mean Seasonality	r	0.133	0.777
12-Month Mean, Std. Dev.	r	-0.052	0.912

MODIS Land Surface Temp		r	P
Mean Day LST, 12 Months	r	-0.222	0.632
Mean Day LST, 6 Warmer Mos.	r	-0.335	0.462
Mean Day LST, 6 Cooler Mos.	r	**-0.718***	**0.069**
Mean Night LST, 12 Months	r	0.065	0.891
Mean Night LST, 6 Warmer Mos.	r	0.470	0.287
Mean Night LST, 6 Cooler Months	r	-0.302	0.511
Diurnal Range, 12 Mos.	r	-0.214	0.645
Diurnal Range, Warm Mos.	r	-0.529	0.222
Diurnal Range, Cool Mos.	r	-0.335	0.462
Day LST Seasonality	r	0.650	0.114
Night LST Seasonality	r	0.470	0.287

Data Set Princ. Comp.		r	P
WORLDCLIM Temp PC1	r	0.076	0.872
WORLDCLIM Temp PC2	r	0.137	0.769
WORLDCLIM Precip PC1	r	0.127	0.786
WORLDCLIM Precip PC2	r	-0.263	0.569
Topographic Variables PC1	r	-0.231	0.618
Topographic Variables PC2	r	0.003	0.994
MODIS NDVI PC1	r	-0.575	0.177
MODIS NDVI PC2	r	0.177	0.704
MODIS NDVI PC3	r	0.218	0.638
MODIS NDVI PC4	r	-0.025	0.957
MODIS LST PC1	r	-0.171	0.714
MODIS LST PC2	r	-0.184	0.693
MODIS Water Vapor PC1	r	0.333	0.466
MODIS Water Vapor PC2	r	-0.405	0.368
MODIS Water Vapor PC3	r	-0.035	0.941
MODIS Water Vapor PC4	r	-0.302	0.511

All-Layers PCA Comp.		r	P
PC1	r	0.550	0.200
PC2	r	-0.082	0.862
PC3	r	0.056	0.905
PC4	r	-0.083	0.860
PC5	r	0.044	0.925
PC6	r	0.062	0.895
PC7	r	0.420	0.348
PC8	r	-0.209	0.653
PC9	r	-0.107	0.820
PC10	r	-0.307	0.504
PC11	r	0.227	0.625
PC12	r	0.315	0.491
PC13	r	-0.118	0.801
PC14	r	-0.240	0.605
PC15	r	-0.420	0.348
PC16	r	0.049	0.917

NDVI (sq.km.)		0.063	0.56	1.56	5.06	10.56	22.56
August 13, 2004	r	-0.490	-0.477	-0.483	-0.507	-0.523	-0.500
	P	0.264	0.280	0.273	0.245	0.228	0.253
August 29, 2004	r	0.302	0.013	-0.231	-0.518	**-.790** **	**-.891*** **
	P	0.511	0.978	0.618	0.234	**0.034**	**0.007**
September 14, 2004	r	-0.297	-0.514	-0.506	-0.394	-0.384	-0.653
	P	0.518	0.238	0.247	0.382	0.395	0.112
September 30, 2004	r	-0.372	-0.343	-0.369	-0.540	-0.573	-0.582
	P	0.411	0.452	0.416	0.210	0.179	0.171
October 16, 2004	r	0.277	-0.207	-0.331	-0.485	-0.511	-0.514
	P	0.548	0.656	0.468	0.270	0.241	0.237
November 1, 2004	r	-0.363	-0.402	-0.442	-0.457	-0.460	-0.455
	P	0.424	0.371	0.321	0.303	0.299	0.305
November 17, 2004	r	0.164	0.069	-0.190	-0.580	-0.653	-0.669
	P	0.726	0.883	0.684	0.172	0.111	0.100
December 3, 2004	r	0.328	0.153	0.051	0.158	0.352	0.313
	P	0.473	0.743	0.913	0.736	0.439	0.494
December 19, 2004	r	-0.138	0.074	0.040	-0.226	-0.380	-0.558
	P	0.768	0.875	0.932	0.626	0.400	0.193
January 1, 2005	r	0.465	0.570	-0.004	-0.071	0.034	0.216
	P	0.293	0.182	0.994	0.880	0.942	0.642
January 17, 2005	r	0.123	0.218	0.349	0.257	-0.019	-0.495
	P	0.793	0.639	0.443	0.578	0.967	0.259
February 2, 2005	r	0.454	0.333	0.256	0.410	0.551	0.625
	P	0.306	0.465	0.580	0.361	0.200	0.133
February 18, 2005	r	0.168	0.248	0.271	0.373	0.468	0.453
	P	0.719	0.592	0.557	0.409	0.290	0.307
March 6, 2005	r	0.575	0.720*	**.781** **	**.833** **	**.798** **	0.663
	P	0.177	0.068	**0.038**	**0.020**	**0.031**	0.105
March 22, 2205	r	-0.203	0.152	-0.056	-0.706	-0.605	-0.642
	P	0.663	0.746	0.906	0.076	0.150	0.120
April 7, 2005	r	**-.756** **	**-0.685***	**-.767** **	**-0.692***	-0.642	-0.524
	P	**0.049**	**0.089**	**0.044**	**0.085**	0.120	0.228
April 23, 2005	r	-0.013	0.084	-0.007	-0.230	-0.075	-0.074
	P	0.979	0.858	0.988	0.620	0.874	0.875
May 9, 2005	r	-0.317	-0.267	-0.572	**-0.727***	**-0.697***	-0.508
	P	0.488	0.563	0.180	**0.064**	**0.082**	0.244
May 25, 2005	r	-0.543	-0.563	-0.640	**-0.738***	**-0.706***	-0.651
	P	0.207	0.188	0.122	**0.059**	**0.076**	0.113
June 10, 2005	r	-0.119	0.277	0.277	-0.081	-0.275	-0.438
	P	0.800	0.548	0.547	0.862	0.551	0.325
June 26, 2005	r	-0.351	-0.318	-0.305	-0.328	-0.350	-0.384
	P	0.440	0.487	0.507	0.473	0.442	0.395
July 12, 2005	r	-0.360	-0.491	-0.533	-0.505	-0.475	-0.458
	P	0.428	0.264	0.218	0.247	0.281	0.301
July 28, 2005	r	-0.455	-0.417	-0.579	-0.374	-0.489	-0.661
	P	0.304	0.352	0.174	0.409	0.266	0.106
Mean for Year	r			-0.535			
	P			0.216			
Mean, Wet Season	r			-0.368			
	P			0.417			
Mean, Dry Season	r			-0.479			
	P			0.277			
Seasonality Index	r			0.447			
	P			0.314			

Topographic		r	P
Elevation	r	0.154	0.742
Slope	r	0.567	0.184
Aspect ††	r^2	0.255	0.556

† Pearson's Correlation Coefficient (*r*); †† Quadratic regression (r^2)
* Significant at the 0.10 level (2-tailed); ** Significant at the 0.05 level (2-tailed); *** Significant at the 0.01 level (2-tailed).

Appendix I. Correlations by pathogen.

Table 2. Correlations of Newcastle's disease virus (NDV) prevalence with environmental variables (†).

Pathogen Prevalence	r	P
MG	0.531	0.114
NDV	---	
MDV	0.405	0.245
ILTV	0.418	0.229
IBVM	0.408	0.242
IBVC	0.391	0.264
IBDV	0.565*	0.089
ARV	0.394	0.259
AEV	0.830***	0.003
AAVI	0.390	0.265

WORLDCLIM Temperature	r	P
Annual Mean Temp	-0.152	0.745
Mean Temp, Driest Qtr	-0.249	0.590
Mean Temp, Wettest Qtr	-0.188	0.686
Temp Annual Range	0.210	0.652
Min Temp, Coldest Month	-0.114	0.808
Max Temp, Warmest Month	0.118	0.802
Temp Seasonality	0.131	0.780
Mean Diurnal Temp Range	0.073	0.876
Mean Temp, Coldest Qtr	-0.146	0.754
Mean Temp, Warmest Qtr	-0.141	0.762

WORLDCLIM Precipitation	r	P
Precip, Coldest Qtr	0.635	0.126
Precip, Warmest Qtr	0.620	0.138
Precip, Driest Qtr	0.661	0.106
Precip, Wettest Qtr	0.215	0.643
Precip Seasonality	-0.770**	0.043
Precip, Driest Month	0.721*	0.068
Precip, Wettest Month	0.587	0.166
Annual Precipitation	0.631	0.128

MODIS Water Vapor	r	P
Mean, August 2004	-0.850**	0.015
Mean, September 2004	-0.970***	0.000
Mean, October 2004	-0.547	0.203
Mean, November 2004	-0.251	0.588
Mean, December 2004	-0.693*	0.084
Mean, January 2005	-0.808**	0.028
Mean, February 2005	-0.151	0.747
Mean, March 2005	0.559	0.192
Mean, April 2005	-0.361	0.427
Mean, May 2005	-0.311	0.497
Mean, June 2005	-0.840**	0.018
Mean, July 2005	0.286	0.533
Mean, 12 Months	-0.716*	0.070
Mean, Min Month	-0.369	0.416
Mean, Max Month	-0.361	0.427
Mean, Annual Range	0.007	0.988
Mean Seasonality	0.093	0.844
12-Month Mean, Std. Dev.	0.160	0.732

MODIS Land Surface Temp	r	P
Mean Day LST, 12 Months	-0.595	0.158
Mean Day LST, 6 Warmer Mos.	-0.861**	0.013
Mean Day LST, 6 Cooler Mos.	-0.176	0.706
Mean Night LST, 12 Months	0.200	0.667
Mean Night LST, 6 Warmer Mos.	-0.180	0.699
Mean Night LST, 6 Cooler Months	0.592	0.161
Diurnal Range, 12 Mos.	-0.590	0.163
Diurnal Range, Warm Mos.	-0.290	0.528
Diurnal Range, Cool Mos.	-0.541	0.210
Day LST Seasonality	-0.133	0.777
Night LST Seasonality	-0.578	0.174

Data Set Princ. Comp.	r	P
WORLDCLIM Temp PC1	-0.050	0.915
WORLDCLIM Temp PC2	-0.260	0.573
WORLDCLIM Precip PC1	-0.592	0.161
WORLDCLIM Precip PC2	0.544	0.207
Topographic Variables PC1	0.144	0.759
Topographic Variables PC2	0.090	0.847
MODIS NDVI PC1	0.182	0.696
MODIS NDVI PC2	-0.435	0.329
MODIS NDVI PC3	0.004	0.994
MODIS NDVI PC4	0.301	0.513
MODIS LST PC1	0.381	0.399
MODIS LST PC2	0.368	0.417
MODIS Water Vapor PC1	-0.179	0.700
MODIS Water Vapor PC2	0.094	0.841
MODIS Water Vapor PC3	-.788**	0.035
MODIS Water Vapor PC4	-0.521	0.230

All-Layers PCA Comp.	r	P
PC1	-0.224	0.630
PC2	-0.454	0.306
PC3	0.215	0.644
PC4	0.342	0.453
PC5	0.062	0.895
PC6	0.700*	0.080
PC7	0.169	0.717
PC8	-0.415	0.355
PC9	0.335	0.463
PC10	0.604	0.151
PC11	-0.047	0.920
PC12	-0.551	0.200
PC13	0.382	0.398
PC14	-.877***	0.010
PC15	0.522	0.229
PC16	0.681	0.092

NDVI (sq.km.)		0.063	0.56	1.56	5.06	10.56	22.56
August 13, 2004	r	0.237	0.242	0.231	0.214	0.202	0.212
	P	0.609	0.600	0.618	0.644	0.664	0.648
August 29, 2004	r	-0.632	-0.609	-0.536	-0.427	-0.509	-0.505
	P	0.127	0.146	0.215	0.339	0.243	0.247
September 14, 2004	r	-0.193	-0.369	-0.484	-0.487	-0.442	-0.416
	P	0.678	0.416	0.272	0.267	0.321	0.353
September 30, 2004	r	0.145	0.152	0.196	0.037	-0.031	-0.079
	P	0.756	0.745	0.674	0.938	0.947	0.866
October 16, 2004	r	-0.528	-0.011	0.022	0.042	0.070	0.059
	P	0.224	0.982	0.963	0.928	0.882	0.899
November 1, 2004	r	0.052	0.146	0.182	0.187	0.185	0.178
	P	0.912	0.755	0.696	0.689	0.691	0.703
November 17, 2004	r	0.387	0.463	0.346	-0.057	-0.394	-0.444
	P	0.391	0.296	0.447	0.904	0.381	0.319
December 3, 2004	r	-0.469	-0.240	-0.235	-0.453	-0.473	-0.513
	P	0.288	0.605	0.612	0.307	0.284	0.239
December 19, 2004	r	0.593	0.541	0.430	0.281	0.241	0.268
	P	0.160	0.210	0.335	0.542	0.603	0.561
January 1, 2005	r	0.052	0.171	-0.316	-0.659	-0.711*	-0.684*
	P	0.912	0.714	0.489	0.108	0.073	0.090
January 17, 2005	r	-0.102	0.113	0.146	-0.104	-0.286	-0.512
	P	0.828	0.810	0.755	0.825	0.535	0.240
February 2, 2005	r	-0.007	-0.040	-0.149	-0.120	-0.046	0.139
	P	0.988	0.932	0.750	0.798	0.923	0.766
February 18, 2005	r	-0.157	-0.135	-0.154	-0.172	-0.180	-0.097
	P	0.738	0.773	0.742	0.712	0.699	0.836
March 6, 2005	r	0.277	0.170	0.102	0.164	0.360	.840**
	P	0.548	0.716	0.827	0.725	0.427	0.018
March 22, 2205	r	-0.225	-0.135	-0.139	0.131	0.499	0.477
	P	0.627	0.772	0.766	0.780	0.255	0.279
April 7, 2005	r	0.091	0.204	0.124	0.166	0.259	0.471
	P	0.846	0.661	0.791	0.722	0.575	0.286
April 23, 2005	r	0.714*	.798**	.801**	0.726*	0.709*	0.641
	P	0.071	0.031	0.030	0.065	0.074	0.121
May 9, 2005	r	0.212	0.499	0.398	0.097	0.196	0.356
	P	0.647	0.255	0.377	0.836	0.673	0.433
May 25, 2005	r	0.002	-0.002	-0.040	-0.201	-0.248	-0.191
	P	0.997	0.997	0.933	0.665	0.592	0.682
June 10, 2005	r	.863**	.882***	0.643	0.168	-0.072	-0.151
	P	0.012	0.009	0.120	0.718	0.878	0.747
June 26, 2005	r	0.213	0.184	0.169	0.157	0.148	0.120
	P	0.647	0.693	0.717	0.736	0.751	0.797
July 12, 2005	r	0.052	0.116	0.142	0.248	0.302	0.289
	P	0.912	0.804	0.761	0.592	0.511	0.530
July 28, 2005	r	-0.213	0.259	0.352	0.586	0.545	0.206
	P	0.646	0.575	0.439	0.167	0.206	0.657
Mean for Year	r			0.330			
	P			0.469			
Mean, Wet Season	r			0.365			
	P			0.421			
Mean, Dry Season	r			0.249			
	P			0.590			
Seasonality Index	r			-0.161			
	P			0.730			

Topographic		
Elevation	r	0.113
	P	0.810
Slope	r	-0.301
	P	0.513
Aspect ††	r^2	0.098
	P	0.813

† Pearson's Correlation Coefficient (r); †† Quadratic regression (r^2)
* Significant at the 0.10 level (2-tailed); ** Significant at the 0.05 level (2-tailed); *** Significant at the 0.01 level (2-tailed).

Appendix I. Correlations by pathogen.

Table 3. Correlations of Marek's disease virus (MDV) prevalence with environmental variables (†).

Pathogen Prevalence	r	P
MG	0.809***	0.005
NDV	0.405	0.245
MDV	---	
ILTV	0.866***	0.001
IBVM	0.952***	0.000
IBVC	0.935***	0.000
IBDV	0.245	0.495
ARV	0.794***	0.006
AEV	0.448	0.194
AAVI	0.189	0.601

WORLDCLIM Temperature	r	P
Annual Mean Temp	0.148	0.751
Mean Temp, Driest Qtr	0.013	0.978
Mean Temp, Wettest Qtr	0.100	0.831
Temp Annual Range	-0.011	0.982
Min Temp, Coldest Month	0.130	0.781
Max Temp, Warmest Month	0.386	0.392
Temp Seasonality	-0.205	0.659
Mean Diurnal Temp Range	-0.329	0.471
Mean Temp, Coldest Qtr	0.144	0.758
Mean Temp, Warmest Qtr	0.189	0.684

WORLDCLIM Precipitation	r	P
Precip, Coldest Qtr	-0.088	0.851
Precip, Warmest Qtr	-0.088	0.852
Precip, Driest Qtr	-0.077	0.869
Precip, Wettest Qtr	0.467	0.29
Precip Seasonality	-0.05	0.916
Precip, Driest Month	-0.028	0.952
Precip, Wettest Month	-0.144	0.758
Annual Precipitation	-0.089	0.849

MODIS Water Vapor	r	P
Mean, August 2004	0.113	0.809
Mean, September 2004	-0.185	0.692
Mean, October 2004	0.066	0.888
Mean , November 2004	-0.204	0.660
Mean, December 2004	0.178	0.703
Mean, January 2005	-0.078	0.867
Mean, February 2005	0.298	0.517
Mean, March 2005	0.392	0.384
Mean, April 2005	-0.009	0.985
Mean, May 2005	-0.189	0.684
Mean, June 2005	-0.114	0.808
Mean, July 2005	-0.097	0.836
Mean, 12 Months	0.120	0.797
Mean, Min Month	-0.240	0.604
Mean, Max Month	-0.009	0.985
Mean, Annual Range	0.165	0.723
Mean Seasonality	0.193	0.679
12-Month Mean, Std. Dev.	0.204	0.660

MODIS Land Surface Temp	r	P
Mean Day LST, 12 Months	-0.249	0.590
Mean Day LST, 6 Warmer Mos.	-0.495	0.259
Mean Day LST, 6 Cooler Mos.	-0.740*	0.057
Mean Night LST, 12 Months	0.621	0.136
Mean Night LST, 6 Warmer Mos.	0.732	0.062
Mean Night LST, 6 Cooler Months	0.111	0.813
Diurnal Range, 12 Mos.	-0.580	0.173
Diurnal Range, Warm Mos.	-0.810**	0.027
Diurnal Range, Cool Mos.	-0.637	0.124
Day LST Seasonality	0.591	0.162
Night LST Seasonality	0.273	0.553

Data Set Princ. Comp.	r	P
WORLDCLIM Temp PC1	0.474	0.283
WORLDCLIM Temp PC2	0.328	0.472
WORLDCLIM Precip PC1	0.242	0.600
WORLDCLIM Precip PC2	-0.414	0.356
Topographic Variables PC1	-0.543	0.208
Topographic Variables PC2	-0.055	0.907
MODIS NDVI PC1	-0.654	0.111
MODIS NDVI PC2	0.519	0.233
MODIS NDVI PC3	0.119	0.800
MODIS NDVI PC4	-0.453	0.307
MODIS LST PC1	-0.607	0.148
MODIS LST PC2	-0.611	0.145
MODIS Water Vapor PC1	0.557	0.194
MODIS Water Vapor PC2	-0.672*	0.098
MODIS Water Vapor PC3	-0.249	0.590
MODIS Water Vapor PC4	-0.463	0.295

All-Layers PCA Comp.	r	P
PC1	0.660	0.107
PC2	0.263	0.569
PC3	-0.229	0.622
PC4	-0.524	0.228
PC5	-0.191	0.681
PC6	0.353	0.438
PC7	.766**	0.044
PC8	-0.422	0.346
PC9	-0.301	0.512
PC10	-0.199	0.669
PC11	0.268	0.562
PC12	0.169	0.718
PC13	-0.542	0.209
PC14	-0.360	0.427
PC15	-0.309	0.500
PC16	0.008	0.987

NDVI (sq.km.)		0.063	0.56	1.56	5.06	10.56	22.56
August 13, 2004	r	-0.586	-0.642	-0.676*	-0.695*	-0.710*	-0.693*
	P	0.167	0.120	0.096	0.083	0.074	0.084
August 29, 2004	r	0.070	0.148	0.044	-0.163	-0.546	-0.685*
	P	0.881	0.751	0.926	0.728	0.205	0.089
September 14, 2004	r	0.006	-0.324	-0.389	-0.290	-0.327	-0.653
	P	0.990	0.478	0.388	0.528	0.473	0.112
September 30, 2004	r	-0.592	-0.499	-0.525	-.766**	-.796**	-.772**
	P	0.161	0.254	0.226	0.044	0.032	0.042
October 16, 2004	r	0.233	-0.435	-0.526	-0.681*	-0.724*	-0.749*
	P	0.615	0.329	0.225	0.092	0.066	0.052
November 1, 2004	r	-0.557	-0.623	-0.678*	-0.696*	-0.716*	-0.723*
	P	0.194	0.135	0.094	0.083	0.070	0.064
November 17, 2004	r	-0.174	-0.410	-0.641	-.948***	-.944***	-.896***
	P	0.709	0.361	0.121	0.001	0.001	0.006
December 3, 2004	r	0.318	0.560	0.453	0.435	0.479	0.388
	P	0.486	0.191	0.308	0.329	0.277	0.390
December 19, 2004	r	-0.428	-0.372	-0.375	-0.589	-0.677*	-0.714*
	P	0.339	0.411	0.408	0.164	0.095	0.072
January 1, 2005	r	0.025	0.056	-0.440	-0.431	-0.294	0.004
	P	0.957	0.904	0.323	0.334	0.522	0.994
January 17, 2005	r	-0.420	-0.258	-0.215	-0.320	-0.444	-0.703*
	P	0.348	0.576	0.644	0.485	0.318	0.078
February 2, 2005	r	0.697*	0.560	0.509	0.651	.756**	.803**
	P	0.082	0.191	0.243	0.114	0.049	0.030
February 18, 2005	r	0.405	0.468	0.467	0.575	0.656	0.622
	P	0.367	0.289	0.290	0.177	0.110	0.136
March 6, 2005	r	.848**	.981***	.956***	.953***	.894***	0.617
	P	0.016	0.000	0.001	0.001	0.007	0.140
March 22, 2205	r	-0.086	0.218	0.104	-0.486	-0.573	-0.523
	P	0.854	0.639	0.825	0.269	0.179	0.228
April 7, 2005	r	-0.475	-0.444	-0.510	-0.361	-0.218	-0.188
	P	0.281	0.318	0.242	0.426	0.639	0.686
April 23, 2005	r	0.012	0.258	0.230	0.064	0.193	0.083
	P	0.979	0.577	0.620	0.891	0.679	0.859
May 9, 2005	r	0.141	0.097	-0.361	-0.493	-0.505	-0.471
	P	0.763	0.836	0.427	0.261	0.248	0.286
May 25, 2005	r	-0.298	-0.314	-0.459	-0.627	-0.660	-0.722*
	P	0.516	0.494	0.301	0.132	0.107	0.067
June 10, 2005	r	-0.195	0.208	0.150	-0.110	-0.319	-0.505
	P	0.675	0.655	0.748	0.815	0.486	0.248
June 26, 2005	r	-0.579	-0.550	-0.520	-0.524	-0.552	-0.590
	P	0.173	0.201	0.231	0.227	0.199	0.163
July 12, 2005	r	-0.605	-0.745*	-.781**	-0.734*	-0.699*	-0.675*
	P	0.150	0.055	0.038	0.060	0.081	0.096
July 28, 2005	r	-0.521	-0.424	-0.291	-0.166	-0.371	-.762**
	P	0.231	0.344	0.527	0.722	0.412	0.046
Mean for Year	r			-0.674*			
	P			0.097			
Mean, Wet Season	r			-0.163			
	P			0.728			
Mean, Dry Season	r			-0.704*			
	P			0.077			
Seasonality Index	r			0.720*			
	P			0.068			

Topographic		
Elevation	r	-0.195
	P	0.674
Slope	r	0.260
	P	0.573
Aspect ††	r^2	0.242
	P	0.574

† Pearson's Correlation Coefficient (*r*); †† Quadratic regression (r^2)
* Significant at the 0.10 level (2-tailed); ** Significant at the 0.05 level (2-tailed); *** Significant at the 0.01 level (2-tailed).

Appendix I. Correlations by pathogen.

Table 4. Correlations of infectious laryngotracheitis virus (ILTV) prevalence with environmental variables (†).

Pathogen Prevalence	r	P
MG	**0.841*** **	**0.002**
NDV	0.418	0.229
MDV	**0.866*** **	**0.001**
ILTV	---	
IBVM	**0.802*** **	**0.005**
IBVC	**0.831*** **	**0.003**
IBDV	0.381	0.277
ARV	**0.902*** **	**0.000**
AEV	0.538	0.109
AAVI	0.305	0.392

WORLDCLIM Temperature	r	P
Annual Mean Temp	-0.385	0.304
Mean Temp, Driest Qtr	-0.504	0.248
Mean Temp, Wettest Qtr	-0.421	0.347
Temp Annual Range	0.495	0.259
Min Temp, Coldest Month	-0.399	0.375
Max Temp, Warmest Month	-0.314	0.774
Temp Seasonality	0.323	0.480
Mean Diurnal Temp Range	0.201	0.665
Mean Temp, Coldest Qtr	-0.386	0.393
Mean Temp, Warmest Qtr	-0.351	0.441

WORLDCLIM Precipitation	r	P
Precip, Coldest Qtr	0.318	0.487
Precip, Warmest Qtr	0.318	0.488
Precip, Driest Qtr	0.311	0.497
Precip, Wettest Qtr	0.32	0.483
Precip Seasonality	-0.342	0.453
Precip, Driest Month	0.313	0.494
Precip, Wettest Month	0.265	0.566
Annual Precipitation	0.313	0.495

MODIS Water Vapor	r	P
Mean, August 2004	-0.073	0.876
Mean, September 2004	-0.226	0.626
Mean, October 2004	0.206	0.657
Mean , November 2004	0.173	0.711
Mean, December 2004	0.014	0.976
Mean, January 2005	-0.344	0.450
Mean, February 2005	-0.229	0.621
Mean, March 2005	0.353	0.437
Mean, April 2005	-0.481	0.275
Mean, May 2005	0.059	0.900
Mean, June 2005	-0.070	0.881
Mean, July 2005	0.293	0.524
Mean, 12 Months	-0.114	0.808
Mean, Min Month	-0.016	0.972
Mean, Max Month	-0.481	0.275
Mean, Annual Range	-0.329	0.471
Mean Seasonality	-0.268	0.561
12-Month Mean, Std. Dev.	-0.309	0.500

MODIS Land Surface Temp	r	P
Mean Day LST, 12 Months	-0.515	0.237
Mean Day LST, 6 Warmer Mos.	-0.248	0.592
Mean Day LST, 6 Cooler Mos.	**-0.783** **	0.037
Mean Night LST, 12 Months	0.185	0.691
Mean Night LST, 6 Warmer Mos.	0.358	0.430
Mean Night LST, 6 Cooler Months	-0.055	0.907
Diurnal Range, 12 Mos.	-0.518	0.234
Diurnal Range, Warm Mos.	-0.399	0.375
Diurnal Range, Cool Mos.	-0.555	0.196
Day LST Seasonality	**0.738***	0.059
Night LST Seasonality	0.231	0.618

Data Set Princ. Comp.	r	P
WORLDCLIM Temp PC1	0.158	0.735
WORLDCLIM Temp PC2	0.188	0.687
WORLDCLIM Precip PC1	-0.040	0.931
WORLDCLIM Precip PC2	-0.145	0.756
Topographic Variables PC1	-0.316	0.490
Topographic Variables PC2	0.158	0.736
MODIS NDVI PC1	-0.562	0.189
MODIS NDVI PC2	0.423	0.345
MODIS NDVI PC3	0.334	0.464
MODIS NDVI PC4	0.039	0.933
MODIS LST PC1	-0.360	0.428
MODIS LST PC2	-0.291	0.527
MODIS Water Vapor PC1	0.219	0.637
MODIS Water Vapor PC2	-0.431	0.334
MODIS Water Vapor PC3	-0.267	0.563
MODIS Water Vapor PC4	-0.534	0.217

All-Layers PCA Comp.	r	P
PC1	0.584	0.168
PC2	0.306	0.504
PC3	0.089	0.850
PC4	-0.059	0.901
PC5	0.101	0.830
PC6	0.300	0.514
PC7	0.396	0.380
PC8	-0.611	0.145
PC9	-0.046	0.923
PC10	-0.249	0.590
PC11	0.005	0.992
PC12	-0.023	0.960
PC13	-0.323	0.480
PC14	-0.387	0.391
PC15	-0.566	0.186
PC16	-0.247	0.594

NDVI (sq.km.)		0.063	0.56	1.56	5.06	10.56	22.56
August 13, 2004	r	-0.496	-0.530	-0.559	-0.572	-0.566	-0.531
	P	0.258	0.221	0.193	0.180	0.185	0.220
August 29, 2004	r	0.132	-0.104	-0.366	-0.584	**-.842** **	**-.826** **
	P	0.778	0.825	0.419	0.168	**0.018**	**0.022**
September 14, 2004	r	-0.303	-0.553	-0.553	-0.486	-0.434	-0.631
	P	0.509	0.197	0.198	0.269	0.330	0.128
September 30, 2004	r	-0.472	-0.411	-0.488	**-.791** **	**-.786** **	**-0.682***
	P	0.284	0.360	0.267	**0.034**	**0.036**	**0.091**
October 16, 2004	r	0.192	-0.570	-0.660	**-0.734***	**-0.712***	**-0.672***
	P	0.680	0.181	0.107	**0.060**	**0.072**	**0.098**
November 1, 2004	r	-0.294	-0.374	-0.437	-0.460	-0.485	-0.502
	P	0.522	0.408	0.327	0.299	0.270	0.251
November 17, 2004	r	0.154	-0.090	-0.357	**-.776** **	**-0.741***	**-0.721***
	P	0.742	0.848	0.431	**0.040**	**0.057**	**0.068**
December 3, 2004	r	0.466	0.230	0.066	0.118	0.299	0.313
	P	0.292	0.620	0.889	0.800	0.515	0.494
December 19, 2004	r	-0.075	0.043	0.058	-0.183	-0.326	-0.518
	P	0.873	0.926	0.903	0.695	0.475	0.234
January 1, 2005	r	0.279	0.216	-0.275	-0.324	-0.225	-0.085
	P	0.545	0.642	0.550	0.478	0.628	0.857
January 17, 2005	r	-0.337	-0.243	-0.136	-0.217	-0.434	**-0.737***
	P	0.460	0.600	0.772	0.639	0.331	**0.059**
February 2, 2005	r	0.372	0.157	0.090	0.258	0.429	0.572
	P	0.411	0.737	0.848	0.576	0.337	0.180
February 18, 2005	r	-0.030	0.076	0.088	0.222	0.333	0.328
	P	0.949	0.872	0.852	0.633	0.465	0.473
March 6, 2005	r	0.638	**0.739***	**.768** **	**.867** **	**.878*** **	0.642
	P	0.123	**0.058**	**0.044**	**0.012**	**0.009**	0.120
March 22, 2205	r	-0.019	0.313	-0.005	**-0.705***	-0.652	-0.555
	P	0.968	0.494	0.992	**0.077**	0.112	0.196
April 7, 2005	r	-0.613	-0.659	**-0.699***	-0.632	-0.493	-0.404
	P	0.143	0.107	**0.081**	0.128	0.260	0.368
April 23, 2005	r	0.199	0.276	0.175	-0.155	-0.110	-0.208
	P	0.668	0.549	0.708	0.740	0.815	0.654
May 9, 2005	r	-0.169	-0.094	-0.374	-0.462	-0.453	-0.330
	P	0.717	0.842	0.409	0.296	0.307	0.470
May 25, 2005	r	-0.361	-0.414	-0.530	**-0.709***	**-0.735***	**-0.674***
	P	0.427	0.356	0.221	**0.074**	**0.060**	**0.097**
June 10, 2005	r	-0.236	0.117	0.099	-0.112	-0.338	-0.528
	P	0.610	0.803	0.833	0.810	0.459	0.223
June 26, 2005	r	-0.243	-0.206	-0.182	-0.201	-0.243	-0.303
	P	0.599	0.658	0.696	0.666	0.600	0.508
July 12, 2005	r	-0.570	-0.644	-0.619	-0.544	-0.487	-0.445
	P	0.182	0.119	0.138	0.207	0.268	0.317
July 28, 2005	r	-0.077	-0.053	-0.214	-0.057	-0.330	**-.766** **
	P	0.870	0.911	0.645	0.903	0.470	**0.045**
Mean for Year	r			**-0.685***			
	P			**0.089**			
Mean, Wet Season	r			-0.593			
	P			0.160			
Mean, Dry Season	r			-0.572			
	P			0.180			
Seasonality Index	r			0.529			
	P			0.222			

Topographic		
Elevation	r 0.321	P 0.482
Slope	r 0.333	P 0.466
Aspect ††	r^2 0.018	P 0.964

† Pearson's Correlation Coefficient (*r*); †† Quadratic regression (r^2)
* Significant at the 0.10 level (2-tailed); ** Significant at the 0.05 level (2-tailed); *** Significant at the 0.01 level (2-tailed).

Appendix I. Correlations by pathogen.

Table 5. Correlations of infectious bronchitis virus - Mass. strain (IBVM) prevalence with environmental variables (†).

Pathogen Prevalence	r	P
MG	**0.690****	**0.027**
NDV	0.408	0.242
MDV	**0.952*****	**0.000**
ILTV	**0.802*****	**0.005**
IBVM	---	
IBVC	**0.973*****	**0.000**
IBDV	0.211	0.559
ARV	**0.733****	**0.016**
AEV	0.462	0.179
AAVI	0.156	0.666

WORLDCLIM Temperature	r	P
Annual Mean Temp	0.247	0.593
Mean Temp, Driest Qtr	0.136	0.772
Mean Temp, Wettest Qtr	0.226	0.625
Temp Annual Range	-0.088	0.852
Min Temp, Coldest Month	0.222	0.633
Max Temp, Warmest Month	0.501	0.252
Temp Seasonality	-0.266	0.565
Mean Diurnal Temp Range	-0.393	0.384
Mean Temp, Coldest Qtr	0.245	0.597
Mean Temp, Warmest Qtr	0.290	0.528

WORLDCLIM Precipitation	r	P
Precip, Coldest Qtr	-0.120	0.798
Precip, Warmest Qtr	-0.102	0.827
Precip, Driest Qtr	-0.106	0.820
Precip, Wettest Qtr	0.512	0.24
Precip Seasonality	0.025	0.958
Precip, Driest Month	-0.078	0.867
Precip, Wettest Month	-0.119	0.799
Annual Precipitation	-0.11	0.815

MODIS Water Vapor	r	P
Mean, August 2004	0.068	0.884
Mean, September 2004	-0.098	0.834
Mean, October 2004	0.174	0.708
Mean , November 2004	-0.042	0.929
Mean, December 2004	0.091	0.847
Mean, January 2005	0.006	0.990
Mean, February 2005	0.270	0.559
Mean, March 2005	0.433	0.332
Mean, April 2005	0.077	0.870
Mean, May 2005	-0.014	0.977
Mean, June 2005	-0.079	0.866
Mean, July 2005	0.009	0.985
Mean, 12 Months	0.240	0.604
Mean, Min Month	-0.059	0.900
Mean, Max Month	0.077	0.870
Mean, Annual Range	0.096	0.837
Mean Seasonality	0.095	0.840
12-Month Mean, Std. Dev.	0.180	0.699

MODIS Land Surface Temp	r	P
Mean Day LST, 12 Months	-0.368	0.417
Mean Day LST, 6 Warmer Mos.	-0.545	0.206
Mean Day LST, 6 Cooler Mos.	**-0.807****	**0.028**
Mean Night LST, 12 Months	**0.699***	**0.081**
Mean Night LST, 6 Warmer Mos.	0.657	0.109
Mean Night LST, 6 Cooler Months	0.273	0.554
Diurnal Range, 12 Mos.	**-0.720***	**0.068**
Diurnal Range, Warm Mos.	**-0.777****	**0.040**
Diurnal Range, Cool Mos.	**-0.799****	**0.031**
Day LST Seasonality	0.636	0.125
Night LST Seasonality	0.103	0.826

Data Set Princ. Comp.	r	P
WORLDCLIM Temp PC1	0.660	0.107
WORLDCLIM Temp PC2	0.493	0.261
WORLDCLIM Precip PC1	0.299	0.515
WORLDCLIM Precip PC2	-0.448	0.313
Topographic Variables PC1	-0.708*	0.075
Topographic Variables PC2	-0.031	0.947
MODIS NDVI PC1	**-0.711***	**0.073**
MODIS NDVI PC2	**0.676***	**0.095**
MODIS NDVI PC3	-0.129	0.782
MODIS NDVI PC4	-0.527	0.224
MODIS LST PC1	-0.510	0.242
MODIS LST PC2	-0.528	0.224
MODIS Water Vapor PC1	0.618	0.139
MODIS Water Vapor PC2	**-.788****	**0.036**
MODIS Water Vapor PC3	-0.291	0.527
MODIS Water Vapor PC4	-0.460	0.299

All-Layers PCA Comp.	r	P
PC1	**0.730***	**0.063**
PC2	0.416	0.354
PC3	-0.451	0.310
PC4	-0.590	0.163
PC5	-0.047	0.921
PC6	0.455	0.305
PC7	**.857****	**0.014**
PC8	-0.564	0.188
PC9	-0.353	0.437
PC10	-0.252	0.586
PC11	0.206	0.658
PC12	0.026	0.955
PC13	-0.430	0.336
PC14	-0.439	0.324
PC15	-0.248	0.591
PC16	-0.092	0.844

NDVI (sq.km.)		0.063	0.56	1.56	5.06	10.56	22.56
August 13, 2004	r	**-0.689***	**-0.753***	**-.787****	**-.798****	**-.804****	**-.795****
	P	**0.087**	**0.051**	**0.036**	**0.032**	**0.029**	**0.033**
August 29, 2004	r	-0.086	0.057	0.045	-0.105	-0.423	-0.563
	P	0.855	0.903	0.923	0.823	0.344	0.188
September 14, 2004	r	0.281	-0.065	-0.149	-0.057	-0.107	-0.587
	P	0.542	0.891	0.751	0.904	0.819	0.166
September 30, 2004	r	-0.583	-0.476	-0.517	**-.811****	**-.877*****	**-.847****
	P	0.170	0.280	0.234	**0.027**	**0.010**	**0.016**
October 16, 2004	r	0.082	-0.614	**-0.670***	**-.807****	**-.849****	**-.875*****
	P	0.862	0.143	**0.099**	**0.028**	**0.016**	**0.010**
November 1, 2004	r	-0.642	**-0.713***	**-.770****	**-.788****	**-.816****	**-.833****
	P	0.120	**0.072**	**0.043**	**0.035**	**0.025**	**0.020**
November 17, 2004	r	-0.401	-0.590	**-.776****	**-.972*****	**-.973*****	**-.950*****
	P	0.373	0.163	**0.040**	**0.000**	**0.000**	**0.001**
December 3, 2004	r	0.423	0.722	0.625	0.561	0.547	0.441
	P	0.344	0.067	0.133	0.190	0.204	0.322
December 19, 2004	r	-0.441	-0.401	-0.461	**-0.701***	**-.768****	**-.770****
	P	0.322	0.373	0.298	**0.079**	**0.044**	**0.043**
January 1, 2005	r	0.039	0.048	-0.393	-0.446	-0.340	-0.071
	P	0.933	0.919	0.384	0.315	0.455	0.880
January 17, 2005	r	-0.613	-0.489	-0.437	-0.512	-0.620	**-.788****
	P	0.143	0.265	0.327	0.240	0.137	**0.035**
February 2, 2005	r	**.761****	0.615	0.559	0.662	**0.733***	**0.751***
	P	**0.047**	0.141	0.192	0.105	**0.061**	**0.052**
February 18, 2005	r	0.435	0.494	0.483	0.587	0.658	0.632
	P	0.329	0.260	0.272	0.166	0.108	0.128
March 6, 2005	r	**0.707***	**.922*****	**.858****	**.811****	**0.735***	0.528
	P	**0.076**	**0.003**	**0.013**	**0.027**	**0.060**	0.223
March 22, 2205	r	0.112	0.394	0.307	-0.261	-0.478	-0.432
	P	0.811	0.382	0.504	0.572	0.278	0.333
April 7, 2005	r	-0.203	-0.188	-0.256	-0.112	-0.002	-0.049
	P	0.663	0.686	0.579	0.810	0.997	0.917
April 23, 2005	r	0.044	0.274	0.282	0.144	0.228	0.065
	P	0.925	0.553	0.540	0.758	0.622	0.890
May 9, 2005	r	0.129	0.084	-0.351	-0.434	-0.421	-0.473
	P	0.783	0.857	0.440	0.331	0.347	0.283
May 25, 2005	r	-0.262	-0.266	-0.417	-0.569	-0.627	**-0.744***
	P	0.571	0.564	0.352	0.182	0.132	**0.055**
June 10, 2005	r	-0.193	0.144	-0.026	-0.270	-0.424	-0.596
	P	0.679	0.758	0.956	0.558	0.343	0.158
June 26, 2005	r	-0.632	-0.615	-0.582	-0.584	-0.615	-0.659
	P	0.128	0.142	0.170	0.169	0.142	0.107
July 12, 2005	r	**-.789****	**-.872****	**-.883*****	**-.825****	**-.786****	**-.771****
	P	**0.035**	**0.011**	**0.008**	**0.022**	**0.036**	**0.043**
July 28, 2005	r	-0.466	-0.320	-0.199	-0.075	-0.314	**-.796****
	P	0.291	0.484	0.669	0.874	0.493	**0.032**
Mean for Year	r			**-0.726***			
	P			**0.065**			
Mean, Wet Season	r			-0.047			
	P			0.920			
Mean, Dry Season	r			**-.802****			
	P			**0.030**			
Seasonality Index	r			**.841****			
	P			**0.018**			

Topographic	r	P
Elevation	0.268	0.561
Slope	0.034	0.942
Aspect ††	r^2 0.235	0.585

† Pearson's Correlation Coefficient (r); †† Quadratic regression (r^2)
* Significant at the 0.10 level (2-tailed); ** Significant at the 0.05 level (2-tailed); *** Significant at the 0.01 level (2-tailed).

Appendix I. Correlations by pathogen.

Table 6. Correlations of infectious bronchitis virus - Conn. strain (IBVC) prevalence with environmental variables (†).

Pathogen Prevalence		
MG	r	**0.644****
	P	**0.045**
NDV	r	0.391
	P	0.264
MDV	r	**0.935*****
	P	**0.000**
ILTV	r	**0.831*****
	P	**0.003**
IBVM	r	**0.973*****
	P	**0.000**
IBVC	r	---
	P	
IBDV	r	0.286
	P	0.423
ARV	r	**0.813*****
	P	**0.004**
AEV	r	0.414
	P	0.234
AAVI	r	0.272
	P	0.447

WORLDCLIM Temperature		
Annual Mean Temp	r	0.167
	P	0.721
Mean Temp, Driest Qtr	r	0.026
	P	0.956
Mean Temp, Wettest Qtr	r	0.152
	P	0.745
Temp Annual Range	r	-0.024
	P	0.959
Min Temp, Coldest Month	r	0.156
	P	0.739
Max Temp, Warmest Month	r	0.436
	P	0.328
Temp Seasonality	r	-0.196
	P	0.674
Mean Diurnal Temp Range	r	-0.322
	P	0.481
Mean Temp, Coldest Qtr	r	0.170
	P	0.716
Mean Temp, Warmest Qtr	r	0.205
	P	0.660

WORLDCLIM Precipitation		
Precip, Coldest Qtr	r	0.011
	P	0.981
Precip, Warmest Qtr	r	0.030
	P	0.949
Precip, Driest Qtr	r	0.017
	P	0.972
Precip, Wettest Qtr	r	0.580
	P	0.172
Precip Seasonality	r	-0.110
	P	0.814
Precip, Driest Month	r	0.049
	P	0.917
Precip, Wettest Month	r	0.015
	P	0.975
Annual Precipitation	r	0.019
	P	0.968

MODIS Water Vapor		
Mean, August 2004	r	0.015
	P	0.974
Mean, September 2004	r	-0.129
	P	0.783
Mean, October 2004	r	0.306
	P	0.505
Mean , November 2004	r	0.062
	P	0.895
Mean, December 2004	r	-0.047
	P	0.921
Mean, January 2005	r	-0.004
	P	0.993
Mean, February 2005	r	0.150
	P	0.748
Mean, March 2005	r	0.559
	P	0.192
Mean, April 2005	r	0.008
	P	0.986
Mean, May 2005	r	0.133
	P	0.776
Mean, June 2005	r	-0.122
	P	0.794
Mean, July 2005	r	0.158
	P	0.735
Mean, 12 Months	r	0.258
	P	0.577
Mean, Min Month	r	0.068
	P	0.885
Mean, Max Month	r	0.008
	P	0.986
Mean, Annual Range	r	-0.043
	P	0.928
Mean Seasonality	r	-0.047
	P	0.921
12-Month Mean, Std. Dev.	r	0.051
	P	0.913

MODIS Land Surface Temp		
Mean Day LST, 12 Months	r	-0.447
	P	0.314
Mean Day LST, 6 Warmer Mos.	r	-0.513
	P	0.239
Mean Day LST, 6 Cooler Mos.	r	**-0.739***
	P	0.058
Mean Night LST, 12 Months	r	**0.690***
	P	0.086
Mean Night LST, 6 Warmer Mos.	r	0.601
	P	0.154
Mean Night LST, 6 Cooler Months	r	0.340
	P	0.455
Diurnal Range, 12 Mos.	r	**-0.777****
	P	0.040
Diurnal Range, Warm Mos.	r	**-0.718***
	P	0.069
Diurnal Range, Cool Mos.	r	**-0.794****
	P	0.033
Day LST Seasonality	r	0.577
	P	0.175
Night LST Seasonality	r	0.024
	P	0.959

Data Set Princ. Comp.		
WORLDCLIM Temp PC1	r	0.513
	P	0.239
WORLDCLIM Temp PC2	r	0.327
	P	0.473
WORLDCLIM Precip PC1	r	0.116
	P	0.805
WORLDCLIM Precip PC2	r	-0.277
	P	0.548
Topographic Variables PC1	r	-0.563
	P	0.188
Topographic Variables PC2	r	-0.106
	P	0.822
MODIS NDVI PC1	r	**-0.696***
	P	**0.083**
MODIS NDVI PC2	r	0.611
	P	0.145
MODIS NDVI PC3	r	0.040
	P	0.932
MODIS NDVI PC4	r	-0.388
	P	0.390
MODIS LST PC1	r	-0.502
	P	0.251
MODIS LST PC2	r	-0.476
	P	0.280
MODIS Water Vapor PC1	r	0.426
	P	0.341
MODIS Water Vapor PC2	r	**-.766****
	P	**0.045**
MODIS Water Vapor PC3	r	-0.419
	P	0.349
MODIS Water Vapor PC4	r	-0.636
	P	0.125

All-Layers PCA Comp.		
PC1	r	**0.714***
	P	**0.072**
PC2	r	0.377
	P	0.405
PC3	r	-0.282
	P	0.541
PC4	r	-0.466
	P	0.292
PC5	r	0.041
	P	0.931
PC6	r	0.576
	P	0.176
PC7	r	**.811****
	P	**0.027**
PC8	r	-0.662
	P	0.106
PC9	r	-0.377
	P	0.404
PC10	r	-0.205
	P	0.659
PC11	r	0.242
	P	0.601
PC12	r	-0.078
	P	0.867
PC13	r	-0.426
	P	0.341
PC14	r	-0.478
	P	0.278
PC15	r	-0.219
	P	0.638
PC16	r	-0.100
	P	0.832

NDVI (sq.km.)		0.063	0.56	1.56	5.06	10.56	22.56
August 13, 2004	r	**-0.653***	**-0.713***	**-0.746***	**-.757****	**-.761****	**-0.743***
	P	**0.112**	**0.072**	**0.054**	**0.049**	**0.047**	**0.056**
August 29, 2004	r	-0.198	-0.093	-0.114	-0.235	-0.522	-0.626
	P	0.671	0.843	0.808	0.612	0.230	0.133
September 14, 2004	r	0.148	-0.199	-0.281	-0.196	-0.264	-0.687
	P	0.752	0.669	0.541	0.674	0.568	0.088
September 30, 2004	r	**-0.674***	-0.580	-0.623	**-.885*****	**-.912*****	**-.876*****
	P	**0.097**	0.172	0.135	**0.008**	**0.004**	**0.010**
October 16, 2004	r	-0.047	-0.611	-0.657	**-.787****	**-.828****	**-.853****
	P	0.921	0.145	0.109	**0.036**	**0.021**	**0.015**
November 1, 2004	r	-0.638	**-0.692***	**-0.732***	**-0.745***	**-.767****	**-.786****
	P	0.123	**0.085**	**0.062**	**0.055**	**0.044**	**0.036**
November 17, 2004	r	-0.256	-0.493	**-0.691***	**-.948*****	**-.930*****	**-.890*****
	P	0.580	0.261	**0.086**	**0.001**	**0.002**	**0.007**
December 3, 2004	r	0.373	0.589	0.473	0.404	0.388	0.288
	P	0.410	0.164	0.283	0.369	0.390	0.531
December 19, 2004	r	-0.300	-0.289	-0.307	-0.572	-0.642	**-0.689***
	P	0.513	0.529	0.503	0.180	0.120	**0.087**
January 1, 2005	r	0.064	-0.012	-0.416	-0.497	-0.409	-0.183
	P	0.892	0.979	0.353	0.257	0.362	0.695
January 17, 2005	r	**-0.707***	-0.582	-0.524	-0.608	**-0.737***	**-.876*****
	P	**0.076**	0.171	0.227	0.148	**0.059**	**0.010**
February 2, 2005	r	**0.724***	0.555	0.498	0.601	**0.696***	**.777****
	P	**0.066**	0.196	0.255	0.153	**0.082**	**0.040**
February 18, 2005	r	0.384	0.460	0.449	0.548	0.613	0.617
	P	0.396	0.298	0.312	0.203	0.143	0.140
March 6, 2005	r	**0.748***	**.887*****	**.843****	**.813****	**.787****	0.602
	P	**0.053**	**0.008**	**0.017**	**0.026**	**0.036**	0.153
March 22, 2205	r	0.002	0.290	0.142	-0.342	-0.472	-0.385
	P	0.997	0.529	0.762	0.453	0.285	0.393
April 7, 2005	r	-0.186	-0.221	-0.273	-0.157	-0.024	-0.063
	P	0.690	0.634	0.554	0.737	0.959	0.894
April 23, 2005	r	0.219	0.412	0.394	0.168	0.192	-0.007
	P	0.637	0.358	0.382	0.719	0.680	0.988
May 9, 2005	r	0.115	0.123	-0.269	-0.392	-0.388	-0.422
	P	0.807	0.794	0.560	0.385	0.390	0.346
May 25, 2005	r	-0.312	-0.331	-0.477	-0.649	**-0.718***	**-.799****
	P	0.496	0.469	0.279	0.115	**0.069**	**0.031**
June 10, 2005	r	-0.171	0.098	-0.074	-0.326	-0.521	**-0.682***
	P	0.713	0.834	0.875	0.475	0.230	**0.092**
June 26, 2005	r	-0.587	-0.574	-0.549	-0.553	-0.588	-0.639
	P	0.166	0.178	0.202	0.198	0.165	0.123
July 12, 2005	r	**-.776****	**-.835****	**-.812****	**-0.734***	**-0.690***	**-0.672***
	P	**0.040**	**0.019**	**0.027**	**0.060**	**0.086**	**0.098**
July 28, 2005	r	-0.342	-0.171	-0.086	0.059	-0.171	**-0.743***
	P	0.453	0.714	0.854	0.900	0.713	**0.055**
Mean for Year	r			**-0.724***			
	P			**0.066**			
Mean, Wet Season	r			-0.132			
	P			0.777			
Mean, Dry Season	r			**-.771****			
	P			**0.042**			
Seasonality Index	r			**.800****			
	P			**0.031**			

Topographic		
Elevation	r	-0.204
	P	0.660
Slope	r	-0.071
	P	0.880
Aspect ††	r^2	0.258
	P	0.551

† Pearson's Correlation Coefficient (*r*); †† Quadratic regression (r^2)
* Significant at the 0.10 level (2-tailed); ** Significant at the 0.05 level (2-tailed); *** Significant at the 0.01 level (2-tailed).

Appendix I. Correlations by pathogen.

Table 7. Correlations of infectious bursal disease virus (IBDV) prevalence with environmental variables (†).

Pathogen Prevalence	r	P
MG	0.143	0.694
NDV	**0.565***	**0.089**
MDV	0.245	0.495
ILTV	0.381	0.277
IBVM	0.211	0.559
IBVC	0.286	0.423
IBDV	---	
ARV	0.406	0.245
AEV	0.495	0.146
AAVI	**0.767*****	**0.010**

WORLDCLIM Temperature	r	P
Annual Mean Temp	-0.308	0.501
Mean Temp, Driest Qtr	-0.464	0.294
Mean Temp, Wettest Qtr	-0.327	0.474
Temp Annual Range	0.338	0.458
Min Temp, Coldest Month	-0.242	0.602
Max Temp, Warmest Month	0.007	0.988
Temp Seasonality	0.262	0.570
Mean Diurnal Temp Range	0.212	0.648
Mean Temp, Coldest Qtr	-0.295	0.520
Mean Temp, Warmest Qtr	-0.276	0.549

WORLDCLIM Precipitation	r	P
Precip, Coldest Qtr	**0.719***	**0.069**
Precip, Warmest Qtr	**0.704***	**0.078**
Precip, Driest Qtr	**0.736***	**0.059**
Precip, Wettest Qtr	0.030	0.948
Precip Seasonality	**-0.891*****	**0.007**
Precip, Driest Month	**0.822****	**0.023**
Precip, Wettest Month	0.624	0.134
Annual Precipitation	**0.713***	**0.072**

MODIS Water Vapor	r	P
Mean, August 2004	**-0.687***	0.088
Mean, September 2004	**-0.772****	0.042
Mean, October 2004	-0.122	0.794
Mean , November 2004	-0.124	0.790
Mean, December 2004	**-0.701***	0.079
Mean, January 2005	-0.605	0.150
Mean, February 2005	-0.246	0.594
Mean, March 2005	**0.814****	0.026
Mean, April 2005	-0.277	0.548
Mean, May 2005	-0.061	0.897
Mean, June 2005	**-.866****	0.012
Mean, July 2005	0.444	0.318
Mean, 12 Months	-0.453	0.307
Mean, Min Month	-0.091	0.846
Mean, Max Month	-0.277	0.548
Mean, Annual Range	-0.131	0.779
Mean Seasonality	-0.086	0.855
12-Month Mean, Std. Dev.	0.019	0.967

MODIS Land Surface Temp	r	P
Mean Day LST, 12 Months	-0.520	0.231
Mean Day LST, 6 Warmer Mos.	-0.568	0.183
Mean Day LST, 6 Cooler Mos.	0.018	0.969
Mean Night LST, 12 Months	0.240	0.604
Mean Night LST, 6 Warmer Mos.	-0.118	0.801
Mean Night LST, 6 Cooler Months	0.549	0.202
Diurnal Range, 12 Mos.	-0.556	0.195
Diurnal Range, Warm Mos.	-0.192	0.679
Diurnal Range, Cool Mos.	-0.365	0.421
Day LST Seasonality	-0.233	0.616
Night LST Seasonality	-0.491	0.264

Data Set Princ. Comp.	r	P
WORLDCLIM Temp PC1	-0.269	0.559
WORLDCLIM Temp PC2	-0.494	0.260
WORLDCLIM Precip PC1	**-.772****	**0.042**
WORLDCLIM Precip PC2	0.655	0.110
Topographic Variables PC1	0.347	0.445
Topographic Variables PC2	0.131	0.780
MODIS NDVI PC1	0.330	0.469
MODIS NDVI PC2	-0.429	0.336
MODIS NDVI PC3	0.537	0.214
MODIS NDVI PC4	0.380	0.400
MODIS LST PC1	-0.077	0.869
MODIS LST PC2	0.014	0.977
MODIS Water Vapor PC1	-0.384	0.395
MODIS Water Vapor PC2	0.270	0.559
MODIS Water Vapor PC3	**-.855****	**0.014**
MODIS Water Vapor PC4	-0.670	0.100

All-Layers PCA Comp.	r	P
PC1	-0.344	0.450
PC2	-0.285	0.536
PC3	0.583	0.169
PC4	0.370	0.414
PC5	-0.214	0.645
PC6	**0.684***	**0.090**
PC7	-0.025	0.957
PC8	-0.454	0.307
PC9	0.402	0.372
PC10	**0.738***	**0.058**
PC11	-0.117	0.802
PC12	-0.572	0.180
PC13	-0.122	0.795
PC14	**-0.731***	**0.062**
PC15	0.304	0.507
PC16	0.521	0.231

NDVI (sq.km.)		0.063	0.56	1.56	5.06	10.56	22.56
August 13, 2004	r	0.439	0.403	0.371	0.352	0.346	0.376
	P	0.324	0.370	0.413	0.438	0.447	0.405
August 29, 2004	r	-0.501	-0.447	-0.511	-0.406	-0.571	-0.464
	P	0.252	0.315	0.242	0.366	0.180	0.294
September 14, 2004	r	-0.601	**-0.749***	**-.836****	**-.880*****	**-.797****	-0.399
	P	0.154	**0.053**	**0.019**	**0.009**	**0.032**	0.376
September 30, 2004	r	0.009	0.025	0.053	-0.081	-0.030	0.017
	P	0.985	0.958	0.910	0.863	0.949	0.971
October 16, 2004	r	-0.309	0.008	0.025	0.093	0.153	0.175
	P	0.500	0.986	0.958	0.843	0.743	0.708
November 1, 2004	r	0.261	0.319	0.342	0.343	0.335	0.317
	P	0.572	0.485	0.453	0.451	0.462	0.489
November 17, 2004	r	**0.677***	0.507	0.353	-0.165	-0.331	-0.280
	P	**0.095**	0.246	0.437	0.723	0.469	0.543
December 3, 2004	r	-0.542	-0.398	-0.454	-0.641	-0.620	-0.592
	P	0.209	0.377	0.306	0.121	0.138	0.162
December 19, 2004	r	0.564	0.405	0.474	0.453	0.424	0.418
	P	0.187	0.368	0.283	0.307	0.344	0.350
January 1, 2005	r	-0.283	-0.317	**-0.681***	**-.824****	**-.825****	**-.786****
	P	0.538	0.489	**0.092**	**0.023**	**0.022**	**0.036**
January 17, 2005	r	-0.250	0.008	-0.034	-0.290	-0.364	-0.477
	P	0.588	0.986	0.943	0.529	0.423	0.279
February 2, 2005	r	-0.200	-0.279	-0.341	-0.254	-0.124	0.138
	P	0.667	0.544	0.454	0.583	0.792	0.768
February 18, 2005	r	-0.326	-0.290	-0.304	-0.300	-0.292	-0.226
	P	0.476	0.528	0.507	0.513	0.526	0.627
March 6, 2005	r	0.548	0.235	0.196	0.355	0.601	**.793****
	P	0.203	0.613	0.673	0.435	0.153	**0.033**
March 22, 2205	r	-0.384	-0.337	-0.442	-0.180	0.302	0.428
	P	0.394	0.459	0.320	0.700	0.511	0.339
April 7, 2005	r	-0.153	-0.144	-0.159	-0.118	0.113	0.382
	P	0.743	0.758	0.733	0.801	0.809	0.397
April 23, 2005	r	**.764****	**.866****	**.814****	0.637	0.582	0.514
	P	**0.046**	**0.012**	**0.026**	0.124	0.171	0.238
May 9, 2005	r	0.465	**0.715***	0.617	0.338	0.345	0.535
	P	0.293	**0.071**	0.140	0.458	0.448	0.216
May 25, 2005	r	0.195	0.146	0.089	-0.154	-0.214	-0.084
	P	0.675	0.755	0.850	0.741	0.644	0.859
June 10, 2005	r	0.648	0.695	0.669	0.413	0.092	-0.006
	P	0.116	0.083	0.100	0.357	0.844	0.989
June 26, 2005	r	0.369	0.364	0.355	0.351	0.334	0.303
	P	0.416	0.422	0.434	0.441	0.464	0.509
July 12, 2005	r	0.214	0.226	0.269	0.380	0.441	0.466
	P	0.646	0.627	0.560	0.400	0.323	0.292
July 28, 2005	r	0.082	0.399	0.582	**0.706***	0.603	0.227
	P	0.861	0.375	0.170	**0.076**	0.152	0.624
Mean for Year	r			0.300			
	P			0.514			
Mean, Wet Season	r			-0.001			
	P			0.998			
Mean, Dry Season	r			0.338			
	P			0.468			
Seasonality Index	r			-0.303			
	P			0.508			

Topographic		
Elevation	r 0.280	P 0.543
Slope	r -0.198	P 0.671
Aspect ††	r^2 0.461	P 0.291

† Pearson's Correlation Coefficient (*r*); †† Quadratic regression (r^2)
* Significant at the 0.10 level (2-tailed); ** Significant at the 0.05 level (2-tailed); *** Significant at the 0.01 level (2-tailed).

Appendix I. Correlations by pathogen.

Table 8. Correlations of avian reovirus (ARV) prevalence with environmental variables (†).

Pathogen Prevalence	r	P
MG	**0.763*** **	**0.010**
NDV	0.394	0.259
MDV	**0.794*** **	**0.006**
ILTV	**0.902*** **	**0.000**
IBVM	**0.733** **	**0.016**
IBVC	**0.813*** **	**0.004**
IBDV	0.406	0.245
ARV	---	
AEV	0.284	0.426
AAVI	**0.584***	**0.077**

WORLDCLIM Temperature	r	P
Annual Mean Temp	-0.213	0.647
Mean Temp, Driest Qtr	-0.374	0.408
Mean Temp, Wettest Qtr	-0.261	0.571
Temp Annual Range	0.270	0.559
Min Temp, Coldest Month	-0.211	0.650
Max Temp, Warmest Month	-0.052	0.911
Temp Seasonality	0.115	0.806
Mean Diurnal Temp Range	0.011	0.982
Mean Temp, Coldest Qtr	-0.207	0.657
Mean Temp, Warmest Qtr	-0.213	0.646

WORLDCLIM Precipitation	r	P
Precip, Coldest Qtr	0.250	0.589
Precip, Warmest Qtr	0.244	0.598
Precip, Driest Qtr	0.225	0.627
Precip, Wettest Qtr	**0.669***	**0.100**
Precip Seasonality	-0.320	0.484
Precip, Driest Month	0.248	0.591
Precip, Wettest Month	0.211	0.649
Annual Precipitation	0.233	0.616

MODIS Water Vapor	r	P
Mean, August 2004	0.028	0.953
Mean, September 2004	-0.239	0.606
Mean, October 2004	0.262	0.570
Mean , November 2004	0.107	0.819
Mean, December 2004	-0.042	0.928
Mean, January 2005	-0.199	0.669
Mean, February 2005	-0.137	0.770
Mean, March 2005	0.368	0.417
Mean, April 2005	-0.428	0.338
Mean, May 2005	0.118	0.801
Mean, June 2005	0.007	0.988
Mean, July 2005	0.225	0.628
Mean, 12 Months	-0.010	0.983
Mean, Min Month	-0.013	0.979
Mean, Max Month	-0.428	0.338
Mean, Annual Range	-0.295	0.521
Mean Seasonality	-0.232	0.617
12-Month Mean, Std. Dev.	-0.310	0.498

MODIS Land Surface Temp	r	P
Mean Day LST, 12 Months	-0.384	0.395
Mean Day LST, 6 Warmer Mos.	-0.237	0.609
Mean Day LST, 6 Cooler Mos.	-0.572	0.180
Mean Night LST, 12 Months	0.269	0.560
Mean Night LST, 6 Warmer Mos.	0.461	0.298
Mean Night LST, 6 Cooler Months	-0.007	0.988
Diurnal Range, 12 Mos.	-0.467	0.291
Diurnal Range, Warm Mos.	-0.473	0.284
Diurnal Range, Cool Mos.	-0.428	0.338
Day LST Seasonality	0.529	0.222
Night LST Seasonality	0.237	0.609

Data Set Princ. Comp.	r	P
WORLDCLIM Temp PC1	-0.077	0.870
WORLDCLIM Temp PC2	-0.125	0.789
WORLDCLIM Precip PC1	-0.176	0.707
WORLDCLIM Precip PC2	0.017	0.971
Topographic Variables PC1	-0.061	0.897
Topographic Variables PC2	-0.293	0.523
MODIS NDVI PC1	**-0.685***	**0.090**
MODIS NDVI PC2	0.260	0.574
MODIS NDVI PC3	0.501	0.252
MODIS NDVI PC4	0.086	0.855
MODIS LST PC1	-0.296	0.519
MODIS LST PC2	-0.206	0.658
MODIS Water Vapor PC1	-0.020	0.966
MODIS Water Vapor PC2	-0.578	0.174
MODIS Water Vapor PC3	-0.341	0.453
MODIS Water Vapor PC4	**-.768** **	**0.044**

All-Layers PCA Comp.	r	P
PC1	**0.672***	**0.098**
PC2	0.021	0.965
PC3	0.248	0.592
PC4	-0.018	0.969
PC5	0.286	0.534
PC6	0.438	0.326
PC7	0.505	0.248
PC8	-0.525	0.227
PC9	-0.388	0.390
PC10	-0.305	0.505
PC11	0.401	0.372
PC12	0.055	0.906
PC13	-0.232	0.616
PC14	-0.282	0.540
PC15	-0.325	0.476
PC16	-0.097	0.836

NDVI (sq.km.)		0.063	0.56	1.56	5.06	10.56	22.56
August 13, 2004	r	-0.573	-0.572	-0.579	-0.599	-0.603	-0.567
	P	0.179	0.179	0.173	0.156	0.151	0.185
August 29, 2004	r	-0.062	-0.304	-0.477	**-0.662***	**-.853** **	**-.904*** **
	P	0.895	0.508	0.279	**0.105**	**0.015**	**0.005**
September 14, 2004	r	-0.365	-0.621	-0.629	-0.524	-0.616	**-.893*** **
	P	0.421	0.136	0.130	0.228	0.140	**0.007**
September 30, 2004	r	**-.767** **	**-0.745***	**-.783** **	**-.871** **	**-.812** **	**-.807** **
	P	**0.044**	**0.055**	**0.037**	**0.011**	**0.027**	**0.028**
October 16, 2004	r	-0.097	-0.333	-0.412	-0.573	-0.623	-0.644
	P	0.837	0.465	0.359	0.179	0.135	0.118
November 1, 2004	r	-0.553	-0.566	-0.563	-0.562	-0.555	-0.558
	P	0.198	0.185	0.189	0.189	0.196	0.193
November 17, 2004	r	0.245	-0.003	-0.252	-0.662	-0.623	-0.578
	P	0.597	0.994	0.585	0.105	0.135	0.174
December 3, 2004	r	0.316	0.071	-0.073	-0.006	0.100	0.034
	P	0.490	0.880	0.876	0.990	0.831	0.943
December 19, 2004	r	0.017	0.115	0.188	-0.150	-0.278	-0.523
	P	0.971	0.806	0.687	0.747	0.546	0.229
January 1, 2005	r	0.439	0.274	-0.096	-0.205	-0.143	-0.041
	P	0.324	0.552	0.838	0.660	0.760	0.930
January 17, 2005	r	-0.373	-0.304	-0.177	-0.246	-0.515	**-.791** **
	P	0.409	0.508	0.704	0.596	0.237	**0.034**
February 2, 2005	r	0.553	0.372	0.311	0.436	0.598	**.784** **
	P	0.197	0.412	0.498	0.328	0.156	**0.037**
February 18, 2005	r	0.234	0.353	0.366	0.456	0.522	0.576
	P	0.613	0.437	0.419	0.304	0.229	0.176
March 6, 2005	r	**0.697***	**0.706***	**.788** **	**.819** **	**.860** **	**0.709***
	P	**0.082**	**0.077**	**0.035**	**0.024**	**0.013**	**0.074**
March 22, 2205	r	-0.378	-0.025	-0.341	**-.779** **	-0.633	-0.547
	P	0.403	0.958	0.454	**0.039**	0.127	0.204
April 7, 2005	r	-0.508	-0.600	-0.631	-0.611	-0.515	-0.483
	P	0.244	0.154	0.129	0.145	0.236	0.272
April 23, 2005	r	0.360	0.398	0.275	-0.146	-0.170	-0.322
	P	0.428	0.376	0.551	0.755	0.716	0.481
May 9, 2005	r	-0.277	-0.163	-0.398	-0.608	-0.615	-0.493
	P	0.548	0.726	0.377	0.147	0.142	0.261
May 25, 2005	r	-0.660	**-0.705***	**-.790** **	**-.922*** **	**-.941*** **	**-.873** **
	P	0.107	**0.077**	**0.035**	**0.003**	**0.002**	**0.010**
June 10, 2005	r	-0.219	-0.030	-0.092	-0.406	-0.654	**-.774** **
	P	0.637	0.948	0.845	0.366	0.111	**0.041**
June 26, 2005	r	-0.450	-0.429	-0.430	-0.452	-0.487	-0.535
	P	0.311	0.337	0.336	0.308	0.268	0.216
July 12, 2005	r	-0.532	-0.593	-0.540	-0.465	-0.429	-0.411
	P	0.219	0.160	0.211	0.294	0.336	0.360
July 28, 2005	r	-0.173	-0.078	-0.260	-0.040	-0.147	-0.629
	P	0.711	0.868	0.574	0.933	0.753	0.130
Mean for Year	r			**-0.686***			
	P			**0.089**			
Mean, Wet Season	r			-0.488			
	P			0.267			
Mean, Dry Season	r			-0.608			
	P			0.148			
Seasonality Index	r			0.568			
	P			0.184			

Topographic	r	P
Elevation	0.089	0.850
Slope	0.125	0.790
Aspect ††	r^2 0.230	0.593

† Pearson's Correlation Coefficient (*r*); †† Quadratic regression (r^2)
* Significant at the 0.10 level (2-tailed); ** Significant at the 0.05 level (2-tailed); *** Significant at the 0.01 level (2-tailed).

Appendix I. Correlations by pathogen.

Table 9. Correlations of avian encephalomyelitis virus (AEV) prevalence with environmental variables (†).

Pathogen Prevalence	r	P
MG	0.514	0.128
NDV	**0.830***	**0.003**
MDV	0.448	0.194
ILTV	0.538	0.109
IBVM	0.462	0.179
IBVC	0.414	0.234
IBDV	0.495	0.146
ARV	0.284	0.426
AEV	---	
AAVI	0.037	0.918

WORLDCLIM Temperature	r	P
Annual Mean Temp	-0.416	0.354
Mean Temp, Driest Qtr	-0.450	0.311
Mean Temp, Wettest Qtr	-0.414	0.356
Temp Annual Range	0.536	0.215
Min Temp, Coldest Month	-0.403	0.370
Max Temp, Warmest Month	-0.054	0.909
Temp Seasonality	0.450	0.311
Mean Diurnal Temp Range	0.375	0.407
Mean Temp, Coldest Qtr	-0.418	0.351
Mean Temp, Warmest Qtr	-0.359	0.429

WORLDCLIM Precipitation	r	P
Precip, Coldest Qtr	**0.674***	**0.097**
Precip, Warmest Qtr	**0.677***	**0.095**
Precip, Driest Qtr	**0.712***	**0.072**
Precip, Wettest Qtr	-0.261	0.572
Precip Seasonality	**-0.699***	**0.081**
Precip, Driest Month	**0.724***	**0.066**
Precip, Wettest Month	0.632	0.127
Annual Precipitation	**0.690***	**0.087**

MODIS Water Vapor	r	P
Mean, August 2004	**-.827****	0.022
Mean, September 2004	**-0.707***	0.076
Mean, October 2004	-0.339	0.457
Mean, November 2004	0.045	0.924
Mean, December 2004	-0.554	0.197
Mean, January 2005	**-0.808****	0.028
Mean, February 2005	-0.355	0.435
Mean, March 2005	0.522	0.230
Mean, April 2005	-0.397	0.378
Mean, May 2005	-0.150	0.748
Mean, June 2005	**-.756****	0.049
Mean, July 2005	0.469	0.288
Mean, 12 Months	-0.635	0.126
Mean, Min Month	-0.131	0.779
Mean, Max Month	-0.397	0.378
Mean, Annual Range	-0.188	0.687
Mean Seasonality	-0.134	0.775
12-Month Mean, Std. Dev.	-0.002	0.996

MODIS Land Surface Temp	r	P
Mean Day LST, 12 Months	**-0.753***	0.051
Mean Day LST, 6 Warmer Mos.	-0.656	0.110
Mean Day LST, 6 Cooler Mos.	-0.453	0.307
Mean Night LST, 12 Months	0.057	0.903
Mean Night LST, 6 Warmer Mos.	-0.319	0.485
Mean Night LST, 6 Cooler Months	0.460	0.299
Diurnal Range, 12 Mos.	-0.625	0.133
Diurnal Range, Warm Mos.	-0.081	0.863
Diurnal Range, Cool Mos.	-0.660	0.107
Day LST Seasonality	0.220	0.635
Night LST Seasonality	-0.525	0.226

Data Set Princ. Comp.	r	P
WORLDCLIM Temp PC1	0.257	0.578
WORLDCLIM Temp PC2	0.196	0.674
WORLDCLIM Precip PC1	-0.363	0.423
WORLDCLIM Precip PC2	0.273	0.553
Topographic Variables PC1	-0.223	0.631
Topographic Variables PC2	**0.679***	**0.093**
MODIS NDVI PC1	0.270	0.559
MODIS NDVI PC2	-0.060	0.899
MODIS NDVI PC3	-0.158	0.734
MODIS NDVI PC4	0.237	0.608
MODIS LST PC1	0.195	0.675
MODIS LST PC2	0.187	0.688
MODIS Water Vapor PC1	0.103	0.826
MODIS Water Vapor PC2	0.234	0.613
MODIS Water Vapor PC3	-0.598	0.156
MODIS Water Vapor PC4	-0.213	0.647

All-Layers PCA Comp.	r	P
PC1	-0.245	0.596
PC2	0.114	0.807
PC3	-0.003	0.996
PC4	0.261	0.572
PC5	-0.111	0.812
PC6	0.456	0.304
PC7	-0.015	0.975
PC8	-0.583	0.169
PC9	**0.704***	**0.077**
PC10	0.530	0.221
PC11	-0.597	0.157
PC12	-0.638	0.123
PC13	0.160	0.732
PC14	**-.873****	**0.010**
PC15	0.039	0.934
PC16	0.235	0.612

NDVI (sq.km.)		0.063	0.56	1.56	5.06	10.56	22.56
August 13, 2004	r	0.251	0.202	0.162	0.159	0.170	0.182
	P	0.587	0.664	0.729	0.734	0.715	0.696
August 29, 2004	r	-0.304	-0.302	-0.375	-0.319	-0.452	-0.325
	P	0.507	0.510	0.407	0.486	0.309	0.477
September 14, 2004	r	-0.094	-0.237	-0.314	-0.374	-0.146	-0.025
	P	0.842	0.608	0.493	0.408	0.755	0.957
September 30, 2004	r	0.434	0.496	0.461	0.022	-0.086	0.034
	P	0.330	0.257	0.298	0.963	0.854	0.942
October 16, 2004	r	-0.096	-0.437	-0.417	-0.272	-0.145	-0.061
	P	0.838	0.328	0.352	0.554	0.756	0.897
November 1, 2004	r	0.370	0.349	0.289	0.260	0.213	0.183
	P	0.414	0.443	0.530	0.573	0.647	0.694
November 17, 2004	r	0.207	0.229	0.102	-0.247	-0.487	-0.551
	P	0.656	0.622	0.827	0.593	0.268	0.200
December 3, 2004	r	-0.107	0.017	-0.031	-0.227	-0.139	-0.052
	P	0.820	0.972	0.948	0.625	0.766	0.912
December 19, 2004	r	0.398	0.369	0.220	0.211	0.153	0.214
	P	0.377	0.415	0.635	0.650	0.743	0.645
January 1, 2005	r	-0.157	0.005	-0.517	**-0.723***	**-0.722***	**-0.677***
	P	0.737	0.992	0.235	**0.066**	**0.067**	**0.095**
January 17, 2005	r	-0.171	0.020	0.029	-0.178	-0.261	-0.438
	P	0.714	0.967	0.952	0.702	0.572	0.325
February 2, 2005	r	-0.251	-0.358	-0.453	-0.368	-0.283	-0.161
	P	0.588	0.430	0.308	0.417	0.538	0.731
February 18, 2005	r	-0.528	-0.511	-0.529	-0.474	-0.415	-0.417
	P	0.224	0.241	0.222	0.282	0.354	0.353
March 6, 2005	r	0.154	0.181	0.060	0.211	0.344	0.593
	P	0.742	0.697	0.899	0.650	0.451	0.161
March 22, 2205	r	0.325	0.380	0.317	0.159	0.326	0.364
	P	0.477	0.400	0.488	0.733	0.475	0.423
April 7, 2005	r	-0.035	0.068	0.006	0.087	0.235	0.464
	P	0.941	0.885	0.990	0.852	0.612	0.294
April 23, 2005	r	0.446	0.537	0.556	0.551	0.585	0.564
	P	0.316	0.214	0.195	0.200	0.167	0.187
May 9, 2005	r	0.290	0.488	0.368	0.301	0.397	0.514
	P	0.528	0.266	0.417	0.512	0.378	0.238
May 25, 2005	r	0.385	0.358	0.280	0.070	0.008	0.057
	P	0.394	0.430	0.543	0.882	0.987	0.904
June 10, 2005	r	0.611	**.817****	**0.670***	0.455	0.280	0.120
	P	0.145	**0.025**	**0.100**	0.306	0.543	0.797
June 26, 2005	r	0.457	0.456	0.477	0.471	0.446	0.398
	P	0.303	0.304	0.279	0.286	0.316	0.376
July 12, 2005	r	-0.095	-0.038	-0.027	0.073	0.153	0.180
	P	0.839	0.935	0.954	0.876	0.743	0.699
July 28, 2005	r	0.085	0.363	0.422	0.529	0.238	-0.067
	P	0.856	0.423	0.345	0.222	0.608	0.886
Mean for Year	r			0.185			
	P			0.691			
Mean, Wet Season	r			0.047			
	P			0.921			
Mean, Dry Season	r			0.193			
	P			0.679			
Seasonality Index	r			-0.135			
	P			0.772			

Topographic		Value	P
Elevation	r	0.465	0.293
Slope	r	-0.042	0.929
Aspect ††	r^2	0.193	0.651

† Pearson's Correlation Coefficient (r); †† Quadratic regression (r^2)
* Significant at the 0.10 level (2-tailed); ** Significant at the 0.05 level (2-tailed); *** Significant at the 0.01 level (2-tailed).

Appendix I. Correlations by pathogen.

Table 10. Correlations of avian adenovirus I (AAVI) prevalence with environmental variables†.

Pathogen Prevalence		r	P
MG		0.153	0.673
NDV		0.390	0.265
MDV		0.189	0.601
ILTV		0.305	0.392
IBVM		0.156	0.666
IBVC		0.272	0.447
IBDV		**0.767*** **	**0.010**
ARV		**0.584***	**0.077**
AEV		0.037	0.918
AAVI		---	

WORLDCLIM Temperature	r	P
Annual Mean Temp	-0.061	0.897
Mean Temp, Driest Qtr	-0.241	0.602
Mean Temp, Wettest Qtr	-0.103	0.826
Temp Annual Range	-0.001	0.998
Min Temp, Coldest Month	0.003	0.995
Max Temp, Warmest Month	0.006	0.990
Temp Seasonality	-0.046	0.921
Mean Diurnal Temp Range	-0.066	0.889
Mean Temp, Coldest Qtr	-0.041	0.930
Mean Temp, Warmest Qtr	-0.094	0.841

WORLDCLIM Precipitation	r	P
Precip, Coldest Qtr	0.395	0.379
Precip, Warmest Qtr	0.375	0.408
Precip, Driest Qtr	0.373	0.410
Precip, Wettest Qtr	0.604	0.151
Precip Seasonality	-0.567	0.184
Precip, Driest Month	0.454	0.307
Precip, Wettest Month	0.343	0.452
Annual Precipitation	0.369	0.415

MODIS Water Vapor	r	P
Mean, August 2004	-0.216	0.641
Mean, September 2004	-0.490	0.265
Mean, October 2004	0.079	0.866
Mean , November 2004	-0.127	0.786
Mean, December 2004	-0.461	0.297
Mean, January 2005	-0.194	0.677
Mean, February 2005	-0.091	0.847
Mean, March 2005	0.519	0.232
Mean, April 2005	-0.232	0.617
Mean, May 2005	0.076	0.871
Mean, June 2005	-0.352	0.439
Mean, July 2005	0.212	0.648
Mean, 12 Months	-0.140	0.765
Mean, Min Month	-0.047	0.920
Mean, Max Month	-0.232	0.617
Mean, Annual Range	-0.130	0.780
Mean Seasonality	-0.082	0.861
12-Month Mean, Std. Dev.	-0.120	0.798

MODIS Land Surface Temp	r	P
Mean Day LST, 12 Months	-0.157	0.737
Mean Day LST, 6 Warmer Mos.	-0.266	0.564
Mean Day LST, 6 Cooler Mos.	0.233	0.615
Mean Night LST, 12 Months	0.221	0.634
Mean Night LST, 6 Warmer Mos.	0.146	0.755
Mean Night LST, 6 Cooler Months	0.291	0.527
Diurnal Range, 12 Mos.	-0.260	0.574
Diurnal Range, Warm Mos.	-0.245	0.597
Diurnal Range, Cool Mos.	-0.024	0.959
Day LST Seasonality	-0.326	0.476
Night LST Seasonality	-0.163	0.727

Data Set Princ. Comp.	r	P
WORLDCLIM Temp PC1	-0.603	0.152
WORLDCLIM Temp PC2	**-.816****	**0.025**
WORLDCLIM Precip PC1	-0.702	0.079
WORLDCLIM Precip PC2	0.638	0.123
Topographic Variables PC1	0.630	0.129
Topographic Variables PC2	-0.615	0.142
MODIS NDVI PC1	-0.094	0.841
MODIS NDVI PC2	-0.471	0.286
MODIS NDVI PC3	**0.746***	**0.054**
MODIS NDVI PC4	0.376	0.406
MODIS LST PC1	-0.023	0.961
MODIS LST PC2	0.093	0.843
MODIS Water Vapor PC1	-0.628	0.131
MODIS Water Vapor PC2	-0.103	0.826
MODIS Water Vapor PC3	-0.621	0.137
MODIS Water Vapor PC4	**-.856****	**0.014**

All-Layers PCA Comp.	r	P
PC1	0.034	0.942
PC2	-0.587	0.166
PC3	**0.710***	**0.074**
PC4	0.333	0.465
PC5	0.192	0.679
PC6	0.609	0.147
PC7	0.154	0.742
PC8	-0.203	0.663
PC9	-0.303	0.508
PC10	0.268	0.561
PC11	0.565	0.186
PC12	-0.168	0.719
PC13	-0.006	0.990
PC14	-0.263	0.569
PC15	0.387	0.391
PC16	0.458	0.301

NDVI (sq.km.)		0.063	0.56	1.56	5.06	10.56	22.56
August 13, 2004	r	0.067	0.101	0.112	0.090	0.070	0.101
	P	0.887	0.830	0.810	0.849	0.881	0.829
August 29, 2004	r	-0.501	-0.584	-0.574	-0.522	-0.554	-0.577
	P	0.252	0.169	0.178	0.229	0.197	0.175
September 14, 2004	r	-0.616	**-0.733***	**-.777****	**-0.730***	**-.895*** **	**-.771****
	P	0.141	**0.061**	**0.040**	**0.062**	**0.006**	**0.043**
September 30, 2004	r	-0.559	-0.612	-0.551	-0.319	-0.182	-0.284
	P	0.192	0.144	0.200	0.486	0.696	0.537
October 16, 2004	r	-0.554	0.317	0.318	0.208	0.136	0.064
	P	0.197	0.488	0.488	0.655	0.772	0.891
November 1, 2004	r	-0.269	-0.147	-0.040	-0.005	0.040	0.050
	P	0.560	0.753	0.933	0.991	0.932	0.916
November 17, 2004	r	0.658	0.487	0.367	-0.023	-0.081	-0.001
	P	0.108	0.267	0.417	0.962	0.864	0.998
December 3, 2004	r	-0.459	-0.526	-0.567	-0.609	-0.650	-0.742
	P	0.301	0.225	0.184	0.147	0.114	0.056
December 19, 2004	r	0.485	0.396	0.559	0.354	0.325	0.168
	P	0.270	0.380	0.192	0.436	0.477	0.719
January 1, 2005	r	0.176	-0.037	-0.130	-0.292	-0.330	-0.360
	P	0.706	0.938	0.781	0.525	0.470	0.428
January 17, 2005	r	-0.201	-0.083	-0.052	-0.186	-0.362	-0.458
	P	0.666	0.859	0.912	0.690	0.425	0.302
February 2, 2005	r	0.187	0.150	0.116	0.140	0.249	0.509
	P	0.687	0.748	0.804	0.764	0.590	0.243
February 18, 2005	r	0.178	0.245	0.247	0.207	0.166	0.298
	P	0.703	0.596	0.593	0.656	0.722	0.516
March 6, 2005	r	0.531	0.194	0.286	0.308	0.507	0.674
	P	0.220	0.678	0.535	0.502	0.245	0.097
March 22, 2005	r	**-.848****	**-0.720***	**-.872****	-0.454	0.024	0.105
	P	**0.016**	**0.068**	**0.010**	0.306	0.959	0.822
April 7, 2005	r	-0.129	-0.219	-0.212	-0.264	-0.171	-0.073
	P	0.782	0.637	0.648	0.567	0.714	0.877
April 23, 2005	r	**0.724***	**0.713***	0.607	0.269	0.132	0.006
	P	**0.066**	**0.072**	0.149	0.560	0.777	0.989
May 9, 2005	r	0.015	0.238	0.227	-0.143	-0.172	-0.015
	P	0.975	0.607	0.624	0.760	0.712	0.975
May 25, 2005	r	-0.461	-0.493	-0.490	-0.585	-0.603	-0.477
	P	0.298	0.261	0.264	0.167	0.152	0.279
June 10, 2005	r	0.309	0.143	0.103	-0.226	-0.496	-0.474
	P	0.500	0.759	0.827	0.626	0.257	0.282
June 26, 2005	r	-0.120	-0.137	-0.178	-0.192	-0.198	-0.208
	P	0.797	0.770	0.702	0.680	0.671	0.655
July 12, 2005	r	0.132	0.136	0.214	0.288	0.297	0.287
	P	0.778	0.771	0.645	0.530	0.517	0.533
July 28, 2005	r	-0.066	0.191	0.194	0.390	0.551	0.212
	P	0.888	0.681	0.677	0.388	0.200	0.647
Mean for Year	r			0.041			
	P			0.930			
Mean, Wet Season	r			-0.048			
	P			0.919			
Mean, Dry Season	r			0.063			
	P			0.893			
Seasonality Index	r			-0.065			
	P			0.889			

Topographic			P
Elevation	r	-0.074	0.875
Slope	r	-0.308	0.502
Aspect ††	r^2	0.633	0.134

† Pearson's Correlation Coefficient (*r*); †† Quadratic regression (r^2)
* Significant at the 0.10 level (2-tailed); ** Significant at the 0.05 level (2-tailed); *** Significant at the 0.01 level (2-tailed).

Appendix II. Eigen matrix and eigenvalues from the all-layers PCA.

Table 1. All-Layers PCA eigen matrix (component loadings). The variance in each component is based on the loading values listed below it; # is the key to input variables.

#	PC1	#	PC2	#	PC3	#	PC4	#	PC5	#	PC6	#	PC7	#	PC8
8	0.25989	8	0.94233	9	0.95362	10	0.96581	5	0.34990	1	0.03993	16	0.40330	16	0.80837
10	0.06367	7	0.27197	10	0.20443	13	0.06962	15	0.08661	8	0.00248	13	0.20729	14	0.33317
9	0.06058	9	0.13846	5	0.05236	14	0.02890	16	0.07809	12	0.00121	6	0.11235	3	0.15384
13	0.04240	10	0.13417	7	0.02045	7	0.02293	10	0.05348	11	-0.00083	3	0.09313	4	0.07979
3	0.00288	16	0.02020	4	0.00382	3	0.00963	8	0.01782	14	-0.00316	5	0.02811	1	0.02140
1	0.00095	3	0.01209	12	0.00017	16	0.00776	4	0.00460	2	-0.00431	9	0.02221	9	0.01411
6	0.00037	14	0.00706	11	-0.00014	1	0.00335	12	0.00151	7	-0.00511	4	0.01963	11	0.00119
4	0.00011	6	0.00495	2	-0.00018	4	0.00213	11	-8.83E-05	10	-0.00740	7	0.01954	12	0.00056
12	-1.14E-05	1	0.00109	6	-0.00459	11	0.00034	2	-0.00072	4	-0.00749	10	0.00837	2	-0.00973
2	-2.50E-05	11	0.00049	14	-0.00574	12	2.91E-05	6	-0.00479	9	-0.02122	12	-0.00114	7	-0.01662
15	-0.00016	4	0.00029	1	-0.00625	2	-6.40E-05	1	-0.04143	3	-0.13631	11	-0.00286	10	-0.01669
11	-0.00023	2	4.04E-05	15	-0.00733	6	-0.00380	7	-0.04146	13	-0.19307	1	-0.00341	8	-0.01705
16	-0.00546	12	-0.00031	16	-0.01478	15	-0.01241	3	-0.12004	6	-0.21068	2	-0.00585	15	-0.06145
5	-0.01246	15	-0.00637	3	-0.02890	5	-0.02735	9	-0.13812	16	-0.21385	8	-0.01248	13	-0.08426
14	-0.01582	5	-0.00719	13	-0.11675	8	-0.11202	14	-0.20284	5	-0.27718	15	-0.19156	5	-0.12958
7	-0.96046	13	-0.01230	8	-0.17555	9	-0.21765	13	-0.88469	15	-0.88033	14	-0.85677	6	-0.41981

#	PC9	#	PC10	#	PC11	#	PC12	#	PC13	#	PC14	#	PC15	#	PC16
6	0.86541	5	0.80927	3	0.87820	3	0.18227	11	0.96552	1	0.49989	1	0.85835	11	0.25688
14	0.28179	13	0.31019	5	0.32071	5	0.08011	12	0.25764	5	0.04943	2	0.50234	1	0.02419
16	0.26465	14	0.18001	4	0.19478	16	0.03745	15	0.00421	12	0.03526	5	0.09911	5	0.00760
3	0.14612	16	0.11014	11	0.02756	2	0.02730	16	0.00331	15	0.01163	11	0.02213	16	0.00379
11	0.00878	4	0.02650	14	0.01966	14	0.01975	13	0.00280	6	0.00908	4	0.01705	13	0.00282
4	0.00618	8	0.01184	10	8.49E-05	9	0.00386	9	0.00023	3	0.00376	12	0.01216	14	0.00098
9	0.00089	12	0.01145	9	-0.00108	12	0.00237	7	-5.01E-05	10	0.00018	6	0.00942	10	-6.64E-05
2	-0.00092	7	0.00046	2	-0.00300	10	0.00184	8	-0.00010	9	0.00016	16	0.00416	8	-0.00014
12	-0.00132	11	-0.00434	7	-0.00303	7	-0.00170	10	-0.00026	8	-6.64E-06	15	0.00265	7	-0.00015
1	-0.00220	10	-0.00768	8	-0.00408	8	-0.00278	6	-0.00391	7	-0.00017	13	0.00030	9	-0.00021
10	-0.00634	2	-0.01278	12	-0.01013	13	-0.00350	14	-0.00541	14	-0.00079	9	0.00019	15	-0.00085
8	-0.01313	9	-0.01288	13	-0.02771	1	-0.00399	5	-0.00771	13	-0.00321	10	-4.03E-05	6	-0.00171
7	-0.01349	6	-0.03347	1	-0.03116	11	-0.00678	4	-0.01119	16	-0.00861	8	-0.00019	4	-0.00771
5	-0.05378	1	-0.08776	6	-0.11820	15	-0.04211	1	-0.01559	11	-0.01939	7	-0.00049	3	-0.01888
13	-0.11189	15	-0.29531	15	-0.15270	6	-0.04947	2	-0.02045	4	-0.02250	14	-0.00123	2	-0.03072
15	-0.25364	3	-0.32697	16	-0.21830	4	-0.97647	3	-0.02141	2	-0.86327	3	-0.00557	12	-0.96539

= INPUT LAYER
1 = WorldClim Temperature PC1
2 = WorldClim Temperature PC2
3 = WorldClim Precipitation PC1
4 = WorldClim Precipitation PC2
5 = Topographic Variables PC1
6 = Topographic Variables PC2
7 = NDVI PC1
8 = NDVI PC2
9 = NDVI PC3
10 = NDVI PC4
11 = Land Surface Temperature PC1
12 = Land Surface Temperature PC2
13 = Water Vapor PC1
14 = Water Vapor PC2
15 = Water Vapor PC3
16 = Water Vapor PC4

Table 2. Eigen values representing the proportion of variation in input layers described by output components.

PC	Variance	Prop.
1	23792429.23	0.50022
2	14952370.84	0.31436
3	5058773.43	0.10636
4	3624866.56	0.07621
5	74727.40	0.00157
6	26070.68	0.00055
7	18419.53	0.00039
8	8429.07	0.00018
9	4785.82	0.00010
10	2121.27	4.46E-05
11	890.46	1.872E-05
12	225.13	4.733E-06
13	15.30	3.217E-07
14	8.66	1.82E-07
15	3.73	7.838E-08
16	1.03	2.159E-08
Total	47564138.12	1.00000

CHAPTER 2: Ecological correlates of microfilarial prevalence and intensity in flightless cormorants (*Phalacocorax harrisi*) and Galápagos penguins (*Spheniscus mendiculus*) with modeling of prevalence distribution.

ABSTRACT:

This study assesses the ecological factors associated with variability in prevalence and intensity of microfilarid infections in wild populations of endangered flightless cormorants and Galápagos penguins. Prevalence and intensity values were investigated for correlation with a large number of environmental variables, as modeled from weather station data and as measured by satellite-borne sensors, including data on temperature, precipitation, atmospheric water vapor, soil moisture, vegetation density and topographic variables. Predictions were made based on the expected effects of climatic and landscape variables on sustained populations of arthropod vectors required for transmission of microfilarids. In general, findings were consistent with predictions with respect to infection prevalence in both cormorants and penguins, exhibiting positive correlations with temperature, precipitation and vegetation density variables, and negative correlations with measures of environmental variablility. Correlates of infection intensity were more counter-intuitive, possibly indicating a greater impact of ecological variables on the hosts themselves, as opposed to the arthropod vector community. Resulting correlates were used to derive predictive distributions of prevalence and intensity values in cormorants and penguins throughout the archipelago, though these models remain unvalidated. Ability to utilize environmental variables to predict risk of disease transmission by arthropod vectors may be useful in control measures should novel pathogens be introduced to the ecosystem.

INTRODUCTION:

Emerging infectious diseases of wildlife pose substantial threat to the conservation of global biodiversity (Daszak et al. 2000), and there is evidence for the involvement of pathogens in population declines (Van Riper III et al. 1986, Cooper 1989, Atkinson et al. 1995, Daszak et al. 2003). In recognition of the potential influence of endemic and introduced pathogens on the ecology of Galápagos avifauna, the Saint Louis Zoo and the University of Missouri–Saint Louis, in cooperation with the Galápagos National Park Service and the Charles Darwin Research Station, implemented an avian disease surveillance program in 2001, with the objective of identifying and monitoring for pathogens that pose risk for native bird populations (Miller et al. 2002; Parker et al. 2006), including establishing baseline health parameters for many Galápagos bird species (Padilla et al. 2003, 2004, 2006; Travis et al. 2005).

As part of these efforts, Merkel et al. (in review) assessed the prevalence and intensity of infections of microfilarids, the first-stage larval form of filarioid nematode worms, in multiple colonies of two ecologically similar species of coastal seabird, the flightless cormorant (or "Galápagos cormorant"; Pelecaniformes: *Phalacrocorax harrisi*) and the Galápagos penguin (Sphenisciformes: *Spheniscus mendiculus*). Both species are endemic to the Galápagos (Figure 1) and are of conservation concern, listed as endangered due small population sizes, narrow ranges, and severe population fluctuations which primarily result from marine perturbations (El Niño events) that may be becoming more extreme (IUCN 2006). They are also under pressure from natural and anthropogenic forces such as fishing, ecotourism, oil spills, and volcanic activity (CBSG 2005). Merkel et al. (in review) examined blood smears from 380 flightless cormorants and 298 Galápagos penguins, constituting 22% and 19%, respectively, of the total populations of these two species. Among the findings was a notable heterogeneity in the levels of prevalence and intensity of microfilarid infections among geographic locations (Figure 2). The purpose of this study is to investigate the climatic and landscape factors that may influence the spatial distribution of microfilarid infection in these two species, potentially providing means of identifying areas of higher likelihood of infection by other arthropod-borne pathogens as well.

Natural History and Pathogenicity of Filarioid Nematodes

Filarioid nematodes are highly-specialized parasites of tissues & tissue spaces of non-fish vertebrates, which have evolved to utilize blood-feeding arthropods as intermediate hosts & vectors (Anderson 2001, Klei & Rajan 2002). These long, thin, tissue-dwelling worms (of the order Onchocercidae, with 80 genera) comprise a minute portion of the phylum Nematoda (Bain 2002). They are believed to have originated 150 million years ago, with crocodilians as the first known definitive host and being vectored by mosquitoes; however, the main expansion of the lineage occurred with the diversification of birds and mammals (Bain 2002), and they have since adapted to a wider range of intermediate hosts/vectors.

The order exhibits the adaptation of mobile embryos, “microfilariae,” which migrate in circulating fluids (lymph or blood) to places favorable for ingestion by hematophagous arthropod vectors, such as the peripheral blood or skin (Bain 2002). Upon ingestion, the arthropod serves as an intermediate host where the larvae undergo further development, migrating through the gut wall, into muscle tissues, and eventually into the mouthparts of the vector. At subsequent feedings, the 3rd-stage larvae leave the mouthparts and invade the puncture wound left by the arthropod; alternatively, infective larvae may enter the host through hair follicles, dermal abrasions, or through the salivary secretions of vectors that remain attached, such as ticks. Within the definitive host, filarids undergo two more molts. Adult filarid worms migrate to specific sites within the host, where they produce microfilariae which migrate to the peripheral blood or skin where they are available to blood-feeding vectors, continuing the cycle of transmission (Anderson 2001, Bain 2002).

Filarial nematodes are important human pathogens (Klei & Rajan 2002). *Wucheria bancrofti* and *Brugia malayi* cause disfiguring and debilitating lymphatic filariases ("elephantiasis"), and *Onchocera volvulus* is the agent of onchoceriasis, or "river blindness." Filarial infections of humans are also associated with chronic conditions such as recurrent fevers, hydrocele, chronic skin disease, chyluria and eosinophilia (Klei & Rajan 2002). Of 120 million humans infected, 1/3 have clinically overt disease (Kazura 1999); however, the majority of filarial infections do not exhibit overt clinical signs (Kazura 2002).

Filarioid nematodes primarily parasitize birds and mammals, which do not differ greatly in biochemical pathways, making host-switching possible (Bain 2002). While birds and mammals typically have different filarial genera, cross-infections between them have occurred (Bain 2002). If vectors have broad feeding preferences, infective larvae can be transmitted to a variety of vertebrate hosts other than those to which they are adapted; however, these events are usually not infective – the larval filariae may not invade or may perish shortly thereafter, being encapsulated and destroyed by host defenses (Anderson 2001). Filarid infestation is documented in nearly all bird orders (Cooper 1973, Ashford et al. 1976, Dharma et al. 1985, Bartlett & Anderson 1986, Echols et al. 2000, Borkent 2005).

The pathogenicity of filarial infections in wildlife is not well known. Infestations of a particular organism may be silent in some hosts, while pathogenic in others (Anderson 2001). Consequences of infection are typically mechanical in nature, resulting from the travel or accumulation of larval and adult filariae through or within host tissues and circulatory systems of the blood or lymph, including: skin irritations; tissue necrosis; eye irritation and blindness; cardio-pulmonary inflammation and degeneration; occlusion of the lymphatic system; neurological damage; and interference with hepatic and renal functions (Echols et al. 2000, Anderson 2001). Problems may also be associated with the host's immune responses such as allergic reactions and increased white blood cell count (Echols et al. 2000, Anderson 2001). Within birds in particular, filariae have been found in the abdominal wall, air sacs, brain, heart, lungs, crop, subcutaneous tissue, and joints of infected birds, depending on the parasite and host species (Echols et al. 2000). Best-known among filarial infections of wildlife are those caused by *Dirofilaria immitis*, or "heartworm". Infections are common among domestic dogs, and there is evidence that prevalence in wildlife is increasing (Sacks 1998). Even in the absence of clinical signs of disease, there is growing evidence that parasites may affect a great variety of host fitness components such as egg laying rates, reproductive success, parental condition and survivorship (Earle et al. 1993, Korpimaki et al. 1995, Merino et al. 2000, Sacks & Blejwas 2000, Anderson 2001, Votypka et al. 2003, Remple 2004).

Ancestrally, the progenitor of the Onchocercidae was likely vectored by a mosquito ~150mya (Bain 2002); today, microfilariae are primarily transmitted by mosquitoes (Diptera: Culicidae; genera *Aedes, Anopheles, Culex,* & *Mansonia;* Bartholomay & Christensen 2002), ceratopogonid midges (Diptera: Ceratopogonidae; Borkent 2005), and simuliid black flies (Diptera: Simuliidae; Adler 2005). While filarial infestation of Galápagos avifauna may be the result of natural ecological relationships with native vector populations, the introduction of alien vector species to the Galápagos may be cause for concern (Snell et al. 2002, Wikelski et al. 2004); ceratopogonid midge, simuliid black fly, and mosquito species have been documented as being introduced to the Galápagos Islands (Causton et al. 2006). The mosquito *Culex* *quinquefasciatus,* a known vector of human lymphatic filariasis (Eldridge 2005), is among the potential vectors that has been introduced (Whiteman et al. 2005).

Best-studied among the filarial diseases is lymphatic filariasis of humans, caused by *Wucheria bancrofti* & *Brugia malayi*. The spatial distribution of disease prevalence appears to be bioclimatically structured, and within a given geographic area distribution is highly focal, with local transmission conditions accounting in part for this heterogeneity (Kazura 1999). Transmission is dependent upon the availability of susceptible arthropod hosts (Bartholomay & Christensen 2002), and heterogeneity of infection patterns at local and global levels is due in large part to peculiarities of the ecological relationships between the intermediate and definitive hosts (Kazura 1999). Proportions of individuals in a population infected are remarkably variable in different endemic areas, and proximity of human dwellings to vector breeding sites increases risk of contact with mosquitoes bearing infective larvae (Kazura 1999).

Similarly, the results of Merkel et al. (in review) included findings of a notable heterogeneity of microfilarid prevalence and intensity among sampling sites of flightless cormorants and Galápagos penguins. The purpose of this study is to explore possible ecological correlates of spatial patterns of prevalence and intensity. This analysis will consider a broad suite of ecological variables which may explain a portion of the variance observed in microfilarid infections in colonies of these two species, including climatic factors (describing temperature and precipitation variables) and topographic variables (elevation, slope, and aspect). In addition, remote sensing data is increasingly being recognized as an important source of information about landscape-level biogeophysical properties of the earth's surface and atmosphere. Remote sensing, herein referring to the interpretation of multi-spectral imagery of the Earth obtained by satellite sensors, has been particularly useful in identifying climatic and habitat conditions conducive to the breeding of arthropod vectors of disease. See Hay et al. (2000a), Beck et al. (2000), and Correia et al. (2004) for reviews of applications of remote sensing in parasitology and spatial epidemiology. Remotely-sensed data utilized in this study include land surface temperature, total precipitable water vapor, vegetation density, and soil moisture values. See Appendix I for a description of the characteristics of the satellite sensors from which many of these measures were obtained.

The climatic and landscape factors represented by the variables considered in this study may have direct or indirect impacts on the definitive hosts, intermediate hosts, or the pathogens themselves (Curran et al. 2000). This inquiry is a first attempt to identify relationships between ecological factors and microfilarid prevalence, and the findings may be used to formulate testable hypotheses to further elucidate the causation behind the correlations observed.

METHODS:

Ecological correlates of microfilarial infection measures were sought within data sets based on weather station records and remote sensing data from satellite-borne sensors. Remotely-sensed data used in this study fall loosely into two categories: 1) data with only moderate spatial resolution but with high temporal resolution (from the MODIS sensor); and 2) data with low temporal resolution but high spatial and spectral resolution (from the Landsat 7 ETM+ and ASTER sensors). See Appendix I for a summary of the resolution characteristics of these satellite data sources.

Table 1 summarizes the data sets used in this study, the analytical procedures applied to them, and our *a priori* predictions of the possible effects of these variables on infection measures via influence on arthropod vectors.

Principal Components of Ecological Factors – There is an inherently large amount of covariance among most of the ecological factors considered here. To reduce redundancy among the data layers used in this study, they were submitted to a principal components analysis (PCA), with resulting data layers that are non-correlated and independent. Each of the major data groupings (WorldClim temperature & precipitation; MODIS land surface temperature, water vapor & NDVI; and SRTM topographic variables) was subjected to a PCA, with the resulting layers representing the majority of the variation being assessed for correlation with disease data (Appendix III). These resulting layers were also submitted to another PCA to diminish redundancy among data sets (hereafter referred to as the "all-layers PCA"), with the resulting principal components also being assessed for correlation with disease prevalence. The first four components of the all-layers PCA, describing 99.8% of the variation in the input variables, were considered in the correlative analyses.

Microfilarid Infection Measures – Merkel et al. (in review) collected blood from the 380 cormorants and 298 penguins sampled in this study during four sampling periods (8/8-8/13/03, 3/10-3/16/04, 8/6-8/11/04, and 2/13-2/19/05). Presence of microfilariae was assessed by examining blood smears at 100X for 5 minutes. DNA sequence data from the mitochondrial cytochrome c oxidase subunit I gene confirmed that the microfialriae infecting the flightless cormorants and Galápagos penguins are of the same species, though taxonomic identification was not possible.

Prevalence values describe the proportion of individuals at each sampling site positive for infection. Intensity values are the average number, by sampling site, of filarids seen in 25 100X fields for infected individuals only. Where birds were re-sampled in the course of the study, only the results of the first testing were used to avoid pseudo-replication. Only sites with five or more sampled individuals are included in the analyses. See Tables 2-5 for a listing of site locations, prevalence and intensity values, and sample sizes.

In this study, environmental variable values were calculated over multiple geographic extents, to identify the scale at which these variables may affect transmission dynamics. Each sampling site is represented by a single geographic location based on GPS points. Independent GPS points are not available for each individual sample; typically, a single GPS point was taken per sampling site, and multiple birds captured and sampled around that point. Where there were multiple GPS points for a site name, coordinates were averaged for a single epicenter of analysis. Around each point, buffer zones for analysis were rendered using ArcGIS 9.1, describing polygons of contiguous landscape within radii of 1, 2, 3, 4, 6, and 8 kilometers around the respective points (see Figures 3 – 6); ERDAS Imagine 9.0 was then used to calculate the values of the environmental factors within these polygons.

As the radii increase, areas of overlap between sites become considerable; to increase independence of data, infection and environmental values at sample collection sites within close geographic proximity were averaged together, resulting in a smaller number of sites with greatly-reduced geographic overlapping. Correlative analyses were then conducted on both data sets: 1) the sites assessed individually; and, 2) the results obtained by merging the proximal localities (hereafter referred to as the "merged" results). Where analyses of the results indicate correlations at wider radii, these results were confirmed or negated by assessing the significance of the merged results. In general, the merged results tended to support the relationships indicated by the analysis of individually-assessed sites; in some cases, the merged results were statistically significant when the individual results were not. Where the larger geographic areas encompassed sites with too few samples to be included individually, the test results at these sites were included in the merged analysis.

To further assure independence of data, site-specific measures of prevalence and intensity were assessed for spatial autocorrelation using Moran's I in ArcGIS 9.1. Resulting low values of I (prevalence in cormorants, 0.13; intensity in cormorants, 0.15; prevalence in penguins, -0.03; intensity in penguins, 0.06) indicate that prevalence and intensity values were neither clustered nor dispersed, so adjustments were not made for spatial autocorrelation.

SPSS was used to calculate Pearson's correlation coefficients (r) for all comparisons. Where directionality of correlative relationships could not be logically predicted *a priori*, 2-tailed tests were used; when predictions could be made about the relationship between an environmental factor and microfilarial prevalence, 1-tailed tests were employed (see last column of Table 1 for predictions). In general, unless stated otherwise, predictions about directionality of correlations were guided by the assumptions that measures of warmth, moisture and vegetation (conducive to arthropod vector populations) would be positively correlated with infection measures, and that indices of variability (seasonality, standard deviations of means, etc., which may be detrimental to sustained vector populations) would be negatively correlated.

Each comparison of an infection value (prevalence or intensity) for each species (cormorant or penguin) with an environmental variable, at each of the analysis extents previously mentioned, is considered here as an independent hypothesis. This approach is dictated by the relatively small number of sites for which these values could be calculated (n = 6-14); a strong multivariate approach would require more sites, which may be logistically impossible given the fact that the sampling reported here covers the majority of the nesting sites of these extremely geographically restricted species. The environmental factors assessed here are also highly correlated with each other, further impeding multivariate approaches. Corrections of P-values for multiple comparisons (i.e. Bonferroni adjustments) were not conducted, as they may not be appropriate when each comparison is viewed as an independent hypothesis (Perneger 1998). It is possible that some of the observed correlations may be serendipitous, given the large number of tests, and it is felt that the best approach is to merely describe how the analyses were conducted, particularly given the exploratory nature of the study. Trends noted herein may suggest future hypotheses for more rigorous statistical verification.

Eleven of the resulting significant correlates of prevalence in cormorant populations (see Results) were used to create a single model predicting distribution of prevalence values throughout the islands of Fernandina and Isabela, comprising the majority of the range of this species (see variables identified by * in Table 6). These variables were subjectively chosen to be representative of the different data sources and reflecting both positive and negative correlations. Equations derived from regressions of observed levels of prevalence against environmental variables were applied to data layers, resulting in layers with predicted levels of prevalence across both islands. The resulting eleven predictive models were averaged for a single "model agreement" data layer describing predicted distribution of prevalence. The final model agreement layer was produced by several methods, in order to find the best fit to observed prevalence: 1) a simple mean derived from the eleven regressed environmental layers; 2) a mean weighted by the correlation coefficients (r) of the individual environmental layers, with the logic that layers with stronger correlations should carry more weight in the resulting model; and 3) a mean weighted by the r^2 values of the regressions of the individual layers, giving even further weight to the more highly-correlated layers.

The resulting predicted values for the sampled sites were compared to the observed levels of prevalence to determine the amount of variation in prevalence data described by the model, and to select the final model agreement weighting scheme with the best fit.

A similar approach was taken to modeling prevalence and intensity in both species across the majority of the Galápagos archipelago. All significantly correlated factors were regressed into predictive data layers, with mean predicted prevalence and intensity obtained by the r^2-weighted method mentioned above. To reduce possible over-weighting of correlated variables, all predictive layers were also subjected to a principal components analysis, with a similar model-agreement approach being applied to the components which were significantly correlated with the various infection measures. Modeling functions were performed using ERDAS Imagine 9.0.

RESULTS:

Correlation coefficients for all comparisons are included in Appendix II. Significant correlations ($p < 0.05$, unless otherwise noted) are presented in Tables 6-9, along with indications of predictions of directionality in relationships and whether or not the results were consistent with predictions.

Microfilarid prevalence in flightless cormorants – Positive correlations with WorldClim mean temperatures appear to be consistent with the role of heat in the development of arthropod vectors (Gullan & Cranston 2005), though these correlations are only observed when considering the larger geographic extent surrounding the sampled sites; these results are supported by similar relationships with MODIS-derived land surface temperature measurements, particularly in the daytime. Negative correlation with temperature annual range at the broader geographic extents is in keeping with predictions about the influence of climatic stability on vector communities; this seems to be contradicted by the positive correlation with temperature seasonality at the 1- and 2-kilometer radii, but the relationship does become negative, as we would have predicted, at the larger geographic scales, though it does not reach statistical significance (r = -0.416, p = 0.070 at 6kmr). A role for temperature stability in influencing prevalence values is also supported by the negative relationship between prevalence and MODIS-derived nighttime temperature seasonality at all spatial extents.

Diurnal temperature range results from WorldClim values (negative relationships at larger extents) and from MODIS data (positive relationships at larger extents) are contradictory, as are potential interpretations of the influence of diurnal temperature range: diurnal temperature stability may be conducive to development of pathogens or vectors, while greater temperature fluctuations may indicate moister soils favorable to arthropod breeding (Thompson et al. 1996). However, WorldClim data describes ambient temperature, while MODIS measures surface temperature; daily fluctuations of ambient temperatures may indicate relative climatic instability, with a negative influence on vector communities and hence prevalence, while fluctuating land surface temperatures may be more indicative of surface moisture conditions lending to increased vector breeding habitat. This interpretation of these results is consistent with our *a priori* expectations.

Precipitation levels from the WorldClim data were positively correlated with prevalence at the smaller spatial scales, which is in keeping with *a priori* expectations based on the role of fresh water in the development of many arthropod vectors. A negative relationship with precipitation seasonality at these same scales seems to indicate that seasonal extremes in rainfall may be detrimental to microfilarid transmission, possibly signifying that a more stable rainfall regime is conducive to sustaining arthropod vector populations.

While measures of NDVI – predicted to be the strongest correlates of arthropod vector breeding habitat – were not consistently correlated with prevalence, there were positive correlations with NDVI measurements in the dry season and the driest quarter, perhaps reflecting the importance of stable, sustained vegetative density, supported by a negative relationship with NDVI seasonality (though the statistical strength of this relationship did not meet our threshold; $r = -0.434$, $p = 0.061$). A positive correlation with the tasseled cap greenness index derived from the Landsat image may also lend support to a role for vegetation in explaining variation in prevalence.

Positive correlation between prevalence and the proportion of land surface within larger geographic extent suggests that larger amounts of land surface may provide habitat for vectors effecting transmission, while sites primarily surrounded by water may be relatively poorer in vector abundance leading to reduced prevalence levels.

The observed correlations are largely consistent with expectations for factors which would be conducive to sustained arthropod vector communities, thereby influencing variation in prevalence among sampling sites.

Correlations with results of principal components analyses were generally consistent with these results. PC1 of WORLCLIM temperature variables is primarily derived from maximum temperature of the warmest month, and annual and seasonal mean temperatures. PC1 of WorldClim precipitation variables is largely derived from annual precipitation and precipitation in the warmest, wettest quarter. PC1 of MODIS land surface temperature variables draws on annual and seasonal mean temperatures, primarily daytime temperatures, followed by nighttime temperatures. PC2 of MODIS NDVI data is predominantly loaded by variation in the NDVI measures from the dry season and driest quarter. Elevation is the chief loading factor of PC1 of the topographic variables. In the all-layers PCA, correlation with PC2 results from high loading by PC1 of the topographic data (elevation).

Mean microfilarid intensity in flightless cormorants – Conversely to relationships with prevalence, mean intensity appears to be positively influenced by cooler temperatures, and positively associated with temperature instability, as indicated by positive correlations with the standard deviations of multiple MODIS land surface temperature measurements throughout the year and particularly in the cooler periods. A positive relationship with temperature instability is further evidenced by positive correlations with: MODIS daytime land surface temperature seasonality; land surface temperature heterogeneity during the wet season as measured by ASTER thermal infrared images; and standard deviations of diurnal temperature range means from throughout the year and the cooler periods.

However, strong positive associations with nearly all mean NDVI measures at all temporal and spatial resolutions, as well as positive correlations with tasseled cap greenness indices, reflect that there may indeed be a connection between intensity and surrounding habitat suitable for vector communities.

Mean intensity was also positively correlated with annual and wet period measures of total precipitable water vapor; perhaps the amount of water vapor in the air is correlated with aforementioned temperature instability.

Some PCA results were also correlated with infection intensity in cormorants. PC1 of WorldClim temperature variables (primarily maximum temperature of the warmest month and annual and seasonal means) was negatively correlated with intensity. The factor weighted most heavily in deriving PC2 of the water vapor data was the mean of the driest quarter, though this variable itself was not correlated in the individual analyses. PC1 of MODIS NDVI primarily describes the variation contained in the means of the wet periods, followed by annual and dry period means.

It is possible that environmental instability may be prejudicial to sustained vector communities, and thereby prevalence, but may bolster microfilarid intensity in hosts that *are* infected, perhaps by necessity for a host to invest more of its metabolic budget in coping with environmental stress at the expense of suppressing intensity of blood parasite infections. However, differences may also be a statistical artefact resulting from the much smaller sample of individuals included in calculating mean intensity values by location, as only infected individuals are included in these means.

Microfilarid prevalence in Galápagos penguins – While there were no correlations of prevalence in penguins with WorldClim data, there were positive correlations with MODIS-derived land surface temperature variables, including the annual mean and the means for all seasons. Seasonality of nighttime temperatures was negatively correlated with prevalence, suggesting some role of temperature stability in influencing prevalence. Correlations of MODIS land surface diurnal temperature range means with prevalence indicate a possible connection between surface moisture conditions, vectors, and prevalence, though this was not supported by results of tasseled cap wetness or modeled soil surface moisture comparisons. The only principal component associated with prevalence in penguins was PC1 of the MODIS land surface temperature data, which is primarily influenced by daytime mean temperatures, followed by nighttime means. While no other factors considered here were significantly linked with microfilarid prevalence in Galápagos penguins, the observed correlations are consistent with similar associations between climatic factors and prevalence of infection in flightless cormorants.

Microfilarid intensity in Galápagos penguins – The only correlate of microfilard intensity in Galápagos penguins was mean NDVI in the driest quarter; this correlation is in agreement with predictions regarding proximity to possible arthropod vector habitat, and is consistent with similar correlations of microfilarid intensity in cormorants. There was an indication of correlation with standard deviation of the driest quarter mean precipitable water vapor at the 4-km scale, but the merged results did not support these results with sufficient statistical strength.

The modeling of cormorant microfilaria prevalence based on the 11 selected correlations resulted in a distribution of prevalence values which was more closely correlated with observed prevalence levels than any of the individual input variables. The three weighting schemes of these models each provided a progressively better fit to the observed data (though the improvement was not significant), with the r^2-weighted mean providing the best fit ($r = 0.741$, $p = 0.001$). See Figure 7 for the resulting prevalence distribution model.

As the r^2-weighted method provided a better fit to the observed data, this method was used in the subsequent archipelago-wide modeling approaches. Figures 8-15 describe the predicted prevalence and intensity values in both species resulting from the all-correlates and principal components modeling approaches (see Methods). Tables 10-13 describe the fit of the observed prevalence levels to: a) the model derived by the r^2-weighted mean of all predictive layers based on correlated ecological variables; b) each of the components resulting from the principal components analysis conducted on the input predictive layers; and c) the predictive model derived by applying the r^2-weighted mean to significantly correlated principal components. See Tables 14-17 for the weightings of the factors contributing to the derivation of principal component layers.

DISCUSSION:

The ecological factors assessed here may impact transmission dynamics by their influences on the host, intermediate hosts, and/or the pathogens themselves; suggestions are made as to possible explanations for the statistical relationships, but these are largely speculative and further work is necessary to illuminate any true cause-effect relationships.

Many of the relationships observed are only significant at the larger geographic extents, while other relationships are only significant at the smaller scales. This may reflect that different processes are indeed affected at different spatial scales. It is conceivable that conditions further inland may be important in the development of arthropod vector communities, or that these larger extents may vary in presence of some reservoir species whose distribution is influenced by the factors being considered. Likewise, conditions more proximal to the hosts may affect their behavior, overall health status, or exposure to other vector species.

In general, factors correlated with prevalence and intensity of microfilarid infections in Galápagos penguins were consistent with respective factors influencing infection measures in flightless cormorant populations. More correlations were noted with infection measures in flightless cormorants than in Galápagos penguins; this may be due to the larger number of cormorant nesting sites sampled, increasing the ability to statistically support relationships with cormorant infection measures while failing to do so with penguin values. However, as reported by Merkel et al. (in review) overall prevalence and intensity levels are higher within cormorant populations, suggesting that cormorants may be a more definitive host, with infections in penguins being relatively more aberrant; if this is indeed the case, it may not be surprising that relationships between infection and ecological variables are less distinct.

The modeling exercises based upon observed correlations with ecological variables may prove useful in describing the distribution of observed prevalence values. While they may have some predictive value, the only validations conducted in this study are assessments of correlations with the observed prevalence data that were used to develop the model. True validation of the predictive value of the model will require more sampling at previously unsampled locations.

Visual assessments of the models derived by different methods (i.e. the all-correlates vs. principal components methods) reflect apparent differences in the predicted distribution of infection measures. However, it should be noted that these models were based on coastal values for nesting sites of coastal birds, so inland differences in predicted distribution are largely irrelevant. It is also possible that the more involved modeling methods, such as those based upon correlations with principal components, may over-fit the model to the observed data and diminish the true predictive ability of the models. Evaluation of relative strengths of these methods would require collection of validating data and is beyond the scope of this study.

It should also be noted that these predictions extend beyond the ranges of these species (refer to Figure 1). However, if one can cautiously accept the logic that geographic variation in prevalence or intensity of this arthropod-borne parasite results from variation in density or stability of arthropod vector communities, these models may be of interest to those studying other arthropod-borne pathogens in Galápagos seabirds, students of vector ecology, or protected area managers planning emergency control programs should an arthropod-borne pathogen be introduced to the ecosystem. While every pathogen-vector-host system will have varying characteristics, similar models based on prevalence of other pathogens in other taxa may begin to develop a more complete picture of the spatial distribution of risk of transmission by arthropod vector.

Acceptance of such relationships between environmental descriptors and pathogen prevalence also requires acceptance that transmission dynamics are at some sort of equilibrium, and there is some reason to believe that they may not be. Across the four sampling periods within two successive years, Merkel et al. (in review), demonstrated that microfilarid prevalence values in cormorant populations were increasing, while those in penguin populations were decreasing. However, the chronic nature of filarid infections should dampen short-term variability in prevalence values, making correlations with longer-term measures of environmental variability more plausible – supported by Merkel et al.'s findings of very limited seasonality in prevalence. Shorter-term dynamics, stochastic events, peculiarities of the unidentified vector species, and variation in host species factors such as population density may be the sources of some of the variability not explained by the environmental variables. The high temporal resolution of data sets provided by the MODIS sensor, in particular, may be very useful in the study of disease systems with shorter-term variability.

It should also be considered that the observed distribution of infection measures may not actually be influenced by the correlated ecological variables identified here, but rather that the distributions of infection measures and ecological variation may both be driven by some other factor not assessed here, such as wind speed and direction. Wind dynamics may have an important impact on the ability of flying vectors to disperse and feed; however, these data are not available on a meaningful scale.

The “ecological factor→vector→pathogen” conceptual model (Curran et al. 2000) would greatly benefit from the sampling of putative vector abundances at these and other sites. More direct evidence of correlations between ecological factors and vector abundance, and between vector abundance and infection measures, would strengthen the definitive link in this chain of assumptions.

CONCLUSION:

The findings in this paper support the utility of climate and vegetation indices in identifying the spatial distribution of factors affecting variability in pathogen transmission dynamics. Once correlations such as these are identified and validated, they may be used as predictors for modeling of expected prevalence and intensity levels at other locations.

The most logical connection between environmental factors and microfilarid prevalence is through the obligate arthropod vectors; the correlations observed here are largely consistent with descriptions of what we may consider to be suitable conditions for sustained arthropod vector populations. The most important first step in clarifying these relationships is identifying the single or multiple species that are actually vectoring the microfilarids. Understanding of the natural history of the particular species will be important in identifying the true causes of variation in prevalence and intensity of microfilarid infections.

Given the potential fitness consequences of filarial infestation, whether drastic or subtle, knowledge of the factors contributing to transmission, prevalence, and intensity of infection may prove valuable in the management of populations of these two endangered species. An assessment of ecological correlates of infection may also improve our understanding of the ecology of the vectors and the parasites themselves, as well as the spatial distribution of other arthropod-borne pathogens. With respect to the threat of introduction of potentially devastating exotic pathogens, ability to detect vector habitat may help in response planning, such as guiding spatially and/or temporally precise application of potentially harmful pesticides and minimizing their overuse.

Uses of climate modeling and remotely-sensed data on the earth's dynamic processes, such as presented here, may help to further our understanding of the interplay between ecological factors and the respective natural histories of pathogens, vectors and hosts, with implications for the transmission dynamics of emerging infectious diseases of humans and wildlife. Predictive use of these data may be particularly important in the face of changing climate and land use patterns, and as introductions of non-native organisms continue.

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Table 1. Summary of data sets assessed for correlations with microfilarid infection measures.

Data Set	Data Description	Analysis Procedures	Anticipated Effect on Vectors or Infection
WorldClim Interpolated Climate Surfaces[24]	Climate data describing precipitation and atmospheric temperature (mm and C°) at 30 arc-second resolution (approx. 1km²); interpolated by applying an adaptive-spline algorithm to a minimum of 30 years of weather records (1960-1990) from over 3000 weather stations.	Mean measures of 18 bioclimatic variables describing annual and seasonal temperature and precipitation means, maxima and minima, as well as measures of climatic variability such as temperature ranges and seasonality were assessed for correlation.	Temperature and precipitation measures expected to be positively correlated due to the role of heat in development and water in certain life cycle stages of some potential vectors; measures of variability (ranges and seasonality) expected to be negatively correlated. These data are frequently used in ecological niche modelling applications.
Total Precipitable Water Vapor[25] (TPWV)	The MODIS sensors aboard the Aqua and Terra satellites provide daily quantification of the amount of water vapor in the atmospheric column, in centimeters, derived from a near-infrared algorithm at 1-km spatial resolution[7].	Variables were derived from daily measurements over the three-year period preceding the last sampling effort (Mar '02-Feb'05). Means calculated for wet and dry seasons (Dec-May & Jun-Nov) and wettest and driest quarters (Feb-Apr & Aug-Oct). Seasonality measures are differences between means for wet and dry seasons and wettest and driest quarters.	Contributing factor to humidity, which might affect arthropod vector population growth, longevity, mobility and vector competence[1,2,3,4] as well as behaviors such as rate of attack and resting[5,6]; areas of lower humidity less likely to have persistent pools of water necessary for life cycles of some potential vectors. However, TPWV is not to be considered an absolute proxy for relative humidity, which has a temperature component not available. Correlations with mean TPWV values are expected to be positive, and with variability measures expected to be negative.
Land Surface Temperature (LST)	Derived from thermal infrared emissions measured by MODIS, Landsat and ASTER sensors. MODIS provides 8-day composites of daytime and nighttime LST at 1-km resolution, accurate to one Kelvin[7]. LST from Landsat ETM+ and ASTER imagery are at 60m and 90m resolution.	Mean daytime and nighttime LST, and their standard deviations, calculated for the three-year period including and preceding sampling, warm and cool seasons (Dec-May & Jun-Nov), and warmest and coolest quarters (Feb-Apr & Aug-Oct). Differences between seasonal means assessed as measures of seasonality. Mean LST based on higher-resolution imagery calculated for cloud-free pixels; standard deviation of means was considered as a measure of LST heterogeneity, which at this resolution may indicate patchy moisture.	LST expected to be positively correlated with vector abundance due to the role of heat in development. Measures of variability (standard deviations of means, measures of seasonality) expected to be negatively correlated, with the exception of high-resolution LST heterogeneity, which may be indicative of surface moisture and therefore positively correlated with vector abundance.
Diurnal Temperature Range (DTR)	Derived from differences between MODIS daytime and nightime LST measures (see above)	Measurements from the three years preceding and including the sampling periods used to calculate annual mean, means for the warm and cool seasons (Dec-May & Jun-Nov), and for the warmest and coolest quarters (Feb-Apr & Aug-Oct). Standard deviations of means assessed for same periods, as well as differences between seasonal means as measures of LST DTR seasonality.	DTR increases with increasing surface moisture and standing water, and may therefore be predicted to be positively correlated with infection measures. Thompson et al. (1996) demonstrated a positive correlation between diurnal temperature range and Bancroftian filariasis infections in humans.
Normalized Difference Vegetation Index[26] (NDVI)	Normalized ratio of the reflectance values of the red (R) and near-infrared (NIR) bands of a remotely captured image (NDVI=(NIR-R)/(NIR+R)). High values of NDVI result from high absorption of red and high reflectance of near-infrared characteristic of vegetation, describing regions of denser vegetation.	MODIS NDVI values are generated by the data provider every 16 days; derivation of NDVI from the Landsat and ASTER imagery in this study was conducted by applying the NDVI equation using ERDAS Imagine 9.0. Correlative analyses were conducted on MODIS NDVI datasets for the three-year period including and preceding sampling. Means and standard deviations were derived for the entire period, periods of high and low vegetative density (Jan-Jun & Jul-Dec), and quarters of highest and lowest density (Feb-Apr & Oct-Dec), along with seasonal differences as indices of seasonality. NDVI was calculated from cloud-free portions of the Landsat and ASTER image mosaics (30m & 15m resolutions). Difference between NDVI in the dry- and wet-season ASTER scenes was calculated as a measure of vegetation seasonality.	The most important applications of remote sensing to epidemiology have used NDVI as a proxy for arthropod vector habitat, with the logic that areas of denser vegetation are likely to provide more suitable habitat, and that levels of moisture sufficient to support denser vegetation are more likely to provide the moisture necessary for breeding (i.e., mosquitoes[8]). NDVI has been positively correlated with human and non-human animal diseases such as: trypanosomiasis through its tsetse fly vector[9]; sin nombre virus infections in deer mice[10]; urinary schistosomiasis via snails[11]; tick-borne encephalitis and Lyme's disease[12,13]; and mosquito-vectored malaria, filariasis, rift valley fever, eastern equine encephalitis and leishmaniasis[14,15,16,17,18]. Correlations of NDVI with microfilarial infection measures are expected to be positive.
Tasseled Cap Transform[27] (TCT)	Method for reducing multispectral satellite imagery into few bands with meaningful physical scene characteristics[19]: 1) SBI, or Soil Brightness Index; 2) GVI, or Greenness Vegetative Index; and 3) wetness, or relative soil moisture.	TCT coefficients were applied to Landsat 7 ETM+ reflectance values[20] and ASTER radiance values[21]. Six visible and infrared bands of Landsat 7 ETM+ images, and nine of ASTER images, are reduced to three 30m resolution principal component layers which describe the majority of the variation in images. Mean brightness, greenness and wetness values were calculated for all cloud-free pixels within the regions of interest.	While there is no clear rationale for a relationship between the brightness index and vector abundance or filarid prevalence, correlations with greenness and wetness indices are expected to be positive. Dister et al. (1997) found tick abundance to be positively correlated with greenness and wetness values derived by a TCT of Landsat TM images.
Modeled Soil Surface Moisture[22] (MSSM)	Technique for modeling the moisture content of soils, utilizing land surface temperature (derived from thermal infrared radiance) and NDVI (calculated from the red and near infrared bands of an image as above).	MSSM was generated using a feature-space classification in ERDAS Imagine 9.0, constructing a 2-D scatter plot with temperature on the x-axis and NDVI on the y-axis. The plot results in a triangular distribution of points, with points along the right edge referred to as the "warm dry edge" and those on the left edge representing the "cold wet edge". Gradations between these edges reflect decreasing soil moisture from left to right. Regions are mapped out on the feature space by manually drawing polygons around them. The exact placement of polygon delineations is somewhat arbitrary, but consistent with decreasing levels of soil moisture[22]. All pixels were assigned to five soil moisture categories. The classification was applied to the wet season ASTER scene, resulting in an image with each 90m pixel classified with a value from 1 to 5, with mean MSSM values calculated for areas of analysis.	A variation of this procedure was used by Crombie et al. (1999) to correlate modeled soil moisture with human filarial infections in the Nile delta. The Galápagos coastline is naturally quite different from most applications of these methods, being mostly lava and poor in soils; however, the relationship between surface temperature and vegetation may be similarly indicative of surface moisture, and worthy of assessment for this preliminary investigation. If correlations of modeled soil surface moisture are observed, we expect them to be positive.
Topographic Factors	Elevation, slope and aspect are based on a 90m-resolution digital elevation model produced by the 2000 Shuttle Radar Topography Mission (SRTM). Proportion of land surface describes the amount of land within the radius of analysis, based on GIS shapefiles.	The digital elevation model was converted to slope and aspect in ERDAS Imagine 9.0. Proportion of land surface was calculated by dividing the area of contiguous land surface by the total area within respective analysis extents.	Elevation is expected to be negatively correlated with vector abundance[6,23]. Slope and aspect may affect transmission by influence on surface moisture or exposure to sun or winds. As arthropod vectors require land surface for resting and reproduction, colonies of birds on small islands or points, with little surrounding land surface, may experience less contact with vectors than those within bays, predicting a positive correlation between proportion of land surface and infection measures.

1=Gullan & Cranston 2005; 2=Black & Moore 2005; 3=Higgs & Beaty 2005; 4=Black & Severson 2005; 5=Borkent 2005; 6=Hay et al. 2000a; 7=King et al. 2004; 8=Curran et al. 2000; 9=Rogers 2000; 10=Boone et al. 2000; 11=Brooker et al. 2001; 12=Kitron & Kazmierczak 1997; 13=Randolph 2001; 14=Hay et al. 2000b; 15=Crombie et al. 1999; 16=Anyamba et al. 1999; 17=Moncaya et al. 2000; 18=Thompson et al. 2002; 19=Crist & Cicone 1984; 20=Huang et al. 2002; 21=Yarbrough et al. 2005; 22=Gillies & Carlson 1995; 23=VanRiper III et al. 1986; 24=Hijmans et al. 2005; 25=Gao & Kaufman 2003; 26=Tucker 1979; 27=Kauth & Thomas 1976

Table 2. Prevalence and intensity values for microfilariae in flightless cormorants by site for the individual analyses. **ID** = Site code used in figures.

Site	ID	Lat	Lon	Prev	N	Intensity	N
Cabo Douglas	CDO	-0.30397	-91.65189	0.046	65	5.00	3
Carlos Valle	CV	-0.26090	-91.45938	0.362	47	2.82	17
Punta Moreno	PMO	-0.71767	-91.33820	0.778	45	29.20	35
Cabo Hammond	CH	-0.46912	-91.61080	0.114	44	4.20	5
Canones Sur	CS	-0.32987	-91.33652	0.828	29	10.67	24
Playa Perros	PPE	-0.78742	-91.42853	0.769	26	23.60	20
Punta Espinosa	PE	-0.26373	-91.44476	0.480	25	15.67	12
El Muneco	EM	0.00757	-91.57812	0.273	22	26.17	6
Elizabeth Norte	EN	-0.58828	-91.09607	0.810	21	23.65	17
Priscilla Sur	PS	-0.37073	-91.38187	0.727	11	5.63	8
Colonia Escondida	CE	-0.26208	-91.46876	0.500	10	3.60	5
Punta Mangle	PMA	-0.45528	-91.38832	0.500	10	34.20	5
Punta Espinosa Sur	PES	-0.27300	-91.43776	0.750	8	7.17	6
Caleta Derek	CDE	-0.63467	-91.08794	0.571	7	5.00	4

Table 3. Prevalence and intensity values for microfilariae in flightless cormorants by site for the merged analyses. **ID** = Site code used in figures.

Site	ID	Lat	Lon	Prev	N	Intensity	N
Cabo Douglas	CDO	-0.30397	-91.65189	0.046	65	5.00	3
Punta Moreno	PMO	-0.71767	-91.33820	0.778	45	29.20	35
Cabo Hammond	CH	-0.46912	-91.61080	0.114	44	4.20	5
Canones Sur	CS	-0.32987	-91.33652	0.828	29	10.67	24
Playa Perros	PPE	-0.78742	-91.42853	0.769	26	23.60	20
El Muneco	EM	0.00757	-91.57812	0.273	22	26.17	6
Elizabeth Norte	EN	-0.58828	-91.09607	0.810	21	23.65	17
Caleta Derek	CDE	-0.63467	-91.08794	0.571	7	5.00	4
C1 (Colonia Escondida, Carlos Valle, Punta Espinosa, Punta Espinosa Sur)	C1	-0.26493	-91.45267	0.444	90	7.43	40
C2 (Cactus, Copiano, Priscilla Sur)	C2	-0.34948	-91.38451	0.733	15	5.27	11
C3 (Garzas, Punta Mangle)	C3	-0.44007	-91.38977	0.570	14	26.90	8

Table 4. Prevalence and intensity values for microfilariae in Galapagos Penguins by site for the individual analyses. **ID** = Site code used in figures.

Site	ID	Lat	Lon	Prev	N	Intensity	N
Cabo Douglas	CDO	-0.30397	-91.65189	0.000	5		
Caleta Derek	CDE	-0.63467	-91.08794	0.333	9	8.33	3
Caleta Iguana	CI	-0.97461	-91.44577	0.137	51	8.00	7
El Muneco	EM	0.00757	-91.57812	0.088	57	9.40	5
Las Marielas	LM	-0.59603	-91.09070	0.095	63	7.83	6
Playa Perros	PPE	-0.78742	-91.42853	0.364	11	25.75	4
Puerto Pajo	PPA	-0.75595	-91.37601	0.158	19	39.00	3
Puerto Villamil	PV	-0.96787	-90.96082	0.000	7		
Punta Espinosa	PE	-0.26373	-91.44476	0.333	24	5.38	8
Punta Moreno	PMO	-0.71767	-91.33820	0.053	38	2.00	2

Table 5. Prevalence and intensity values for microfilariae in Galapagos penguins by site for the merged analyses. **ID** = Site code used in figures.

Site	ID	Lat	Lon	Prev	N	Intensity	N
Cabo Douglas	CDO	-0.30397	-91.65189	0.000	5		
Caleta Iguana	CI	-0.97461	-91.44577	0.137	51	8.00	7
El Muneco	EM	0.00757	-91.57812	0.088	57	9.40	5
Puerto Villamil	PV	-0.96787	-90.96082	0.000	7		
Punta Espinosa	PE	-0.26373	-91.44476	0.333	24	5.38	8
P1 (Piedras Blancas, Copiano)	P1	-0.35606	-91.38415	0.500	6	4.33	3
P2 (Las Marielas, Caleta Derek)	P2	-0.61535	-91.08932	0.125	72	8.00	9
P3 (Punta Moreno, Puerto Pajo, Playa Perros)	P3	-0.75368	-91.38092	0.130	68	24.90	9

Table 6. Statistically significant correlates of microfilarid prevalence in flightless cormorants ($p \leq 0.05$).

Data Source	Variable	Range	Kmr	*r*	p	n	Tail	Pred	Cons?
WORLDCLIM Temp.	Annual Mean Temperature *	6 - 8	8	0.580	0.015 (1)	14	1	+	Y
	Mean Temperature, Driest Quarter	6 - 8	8	0.519	0.029 (1)	14	1	+	Y
	Mean Temperature, Wettest Quarter	6 - 8	8	0.592	0.013 (1)	14	1	+	Y
	Mean Temperature, Coldest Quarter	8	8	0.556	0.019 (1)	14	1	+	Y
	Mean Temperature, Warmest Quarter	6 - 8	8	0.591	0.013 (1)	14	1	+	Y
	Minimum Temperature, Coldest Month	6 - 8	8	0.575	0.016 (1)	14	1	+	Y
	Temperature Annual Range *	6 - 8	8	-0.620	0.009 (1)	14	1	-	Y
	Mean Diurnal Temperature Range	1 - 8	8	-0.664	0.005 (1)	14	1	-	Y
	Temperature Seasonality	1 - 2	1	0.515	0.031	14	1	-	N
WORLDCLIM Precip.	Annual Precipitation	1 - 4	1	0.512	0.031	14	1	+	Y
	Precipitation, Warmest Quarter *	1 - 8	1	0.566	0.017	14	1	+	Y
	Precipitation, Wettest Quarter	1 - 6	1	0.566	0.017	14	1	+	Y
	Precipitation, Wettest Month	1 - 2	1	0.493	0.037	14	1	+	Y
	Precipitation Seasonality *	1 - 6	1	-0.497	0.035	14	1	-	Y
MODIS Day LST	Annual Mean *	6 - 8	8	0.555	0.020 (1)	14	1	+	Y
	Warm Season Mean	4 - 8	8	0.591	0.013 (1)	14	1	+	Y
	Cool Season Mean	6 - 8	8	0.530	0.026 (1)	14	1	+	Y
	Warmest Quarter Mean	4 - 8	8	0.653	0.011 (1)	14	1	+	Y
	Coolest Quarter Mean	6 - 8	8	0.530	0.026 (1)	14	1	+	Y
	Standard Deviation of the Coolest Quarter Mean	4	4	0.525	0.027 (1)	14	1	-	N
MODIS Night LST	Annual Mean	8	8	0.485	0.039 (1)	14	1	+	
	Standard Deviation of Annual Mean	1	1	-0.491	0.037	14	1	-	Y
	Warm Season Mean	8	8	0.468	0.046 (1)	14	1	+	Y
	Cool Season Mean	6 - 8	8	0.506	0.032 (1)	14	1	+	Y
	Standard Deviation of Cool Season Mean	1, 6 - 8	1	-0.522	0.028 (1)	14	1	-	Y
	Coolest Quarter Mean	1, 8	8	0.480	0.041 (1)	14	1	+	Y
	Seasonality (Warm Mean - Cool Mean) *	1 - 8	3	-0.677	0.004 (1)	14	1	-	Y
	Seasonality (Warmest Qtr Mean - Coolest Qtr Mean)	8	8	-0.482	0.040 (1)	14	1	-	Y
MODIS LSDTR	Annual Mean *	8	8	0.495	0.036 (1)	14	1	+	Y
	Warm Season Mean	6 - 8	8	0.543	0.022 (1)	14	1	+	Y
	Warmest Quarter Mean	6 - 8	8	0.627	0.008 (1)	14	1	+	Y
Landsat Temp	*No Significant Correlations Observed*					14			
ASTER Temp	*No Significant Correlations Observed*					12-14			
MODIS Water Vapor	*No Significant Correlations Observed*					14			
MODIS NDVI	Dry Season Mean *	1	1	0.463	0.048	14	1	+	Y
	Standard Deviation of Dry Season Mean	1	1	0.539	0.023	14	1	-	N
	Driest Quarter Mean	1	1	0.468	0.046	14	1	+	Y
	Standard Deviation of Driest Quarter Mean	1	1	0.573	0.016	14	1	-	N
	Seasonality (Wet Season - Dry Season) *	1	1	-0.434	0.061	14	1	-	Y
Landsat NDVI	*No Significant Correlations Observed*					14	1		
ASTER NDVI	*No Significant Correlations Observed*					12-14	1		
Topographic	Mean Elevation *	6 - 8	8	-0.621	0.009 (1)	14	1	-	Y
	Mean Slope	8	8	-0.464	0.047 (2)	14	1	-	Y
	Proportion of Land Surface *	4 - 8	6	0.579	0.015 (1)	14	1	+	Y
Tasseled Cap Indices	Landsat Greenness Index	1 - 6	2	0.607	0.011 (1)	14	1	+	Y
	ASTER Wet Season Wetness Index	1	1	-0.474	0.043	14	1	-	N
Modeled Soil Moisture	*No Significant Correlations Observed*					14	1		
Principal Components	PC1 of WORLDCLIM Temperature Variables	6 - 8	8	0.579	0.015 (1)	14	1	+	Y
	PC1 of WORLDCLIM Precipitation Variables	1 - 4	1	0.525	0.027	14	1	+	Y
	PC1 of MODIS Land Surface Temperature Variables	4 - 8	8	0.579	0.015 (1)	14	1	+	Y
	PC2 of MODIS NDVI Variables	1 - 3	1	0.674	0.004	14	1	+	Y
	PC1 of Topographic Variables	4 - 8	8	-0.537	0.024	14	1	-	Y
	PC2 of All-Layers PCA	2 - 8	8	-0.640	0.014 (1)	14	2	--	--

Range = range of geographic extents (kilometers radius) over which relationship is statistically significant (≤ 0.05); **Kmr** = radius, in kilometers, of the extent of the most significant correlation; ***r*** = Pearson's correlation coefficient for most significant correlation; **(1)** = Correlations at broader extents supported by results of analyses merging geographically proximate sites; **(2)** = Results of merged analysis not significant; **(3)** = Results of merged analysis more significant that individual analysis; **n** = number of site-to-variable comparisons possible with data sets; **Tail** = 1-tailed or 2-tailed test; **Pred** = Predicted directionality of the correlation; **Cons?** = whether or not results are consistent with predictions; * = Variables used in prevalence distribution model.

Table 7. Statistically significant correlates of microfilarid infection intensity in flightless cormorants (p≤ 0.05) .

Data Source	Variable	Range	Kmr	*r*	p	n	Tail	Pred	Cons?
WORLDCLIM Temp.	Annual Mean Temperature	1	1	-0.582	0.015	14	1	+	N
	Mean Temperature, Coldest Quarter	1-2	1	-0.600	0.012	14	1	+	N
	Minimum Temperature, Coldest Month	1	1	-0.577	0.015	14	1	+	N
	Temperature Annual Range	1	1	0.542	0.023	14	1	-	N
WORLDCLIM Precip.	*No Significant Correlations Observed*					14	1		
MODIS Day LST	Standard Deviation of Annual Mean	6-8	6	0.727	0.002 (1)	14	1	-	N
	Standard Deviation of Cool Season Mean	6-8	6	0.697	0.003 (1)	14	1	-	N
	Seasonality (Warmest Qtr Mean - Coolest Qtr Mean)	4 - 8	6	0.542	0.023 (1)	14	1	-	N
MODIS Night LST	Standard Deviation of Warmest Quarter Mean	6	6	0.459	0.049 (2)	14	1	-	N
MODIS LSDTR	Standard Deviation of Annual Mean	6	6	0.620	0.009 (2)	14	1	-	N
	Standard Deviation of Warm Season Mean	3	3	-0.530	0.026 (3)	14	1	-	Y
	Standard Deviation of Cool Season Mean	6 - 8	6	0.740	0.001 (1)	14	1	-	N
	Standard Deviation of Coolest Season Mean	6 - 8	6	0.702	0.003 (1)	14	1	-	N
Landsat Temp	*No Significant Correlations Observed*					14	1		
ASTER Temp	Dry Season Surface Temperature Heterogeneity	1	1	0.517	0.043	12-14	1	+	Y
	Wet Season Surface Temperature Heterogeneity	1 - 2	1	0.692	0.003	14	1	+	Y
MODIS Water Vapor	Annual Mean	1	1	0.511	0.031	14	1	+	Y
	Wet Season Mean	1	1	0.497	0.035	14	1	+	Y
	Wettest Quarter Mean	1	1	0.517	0.029	14	1	+	Y
MODIS NDVI	Annual Mean	1 - 4	1	0.668	0.004	14	1	+	Y
	Wet Season Mean	1 - 4	1	0.685	0.003	14	1	+	Y
	Dry Season Mean	1 - 4	1	0.631	0.008	14	1	+	Y
	Wettest Quarter Mean	1 - 6	1	0.606	0.011	14	1	+	Y
	Driest Quarter Mean	1, 4 - 6	1	0.600	0.012	14	1	+	Y
	Seasonality (Wettest Season - Driest Season)	3	3	0.458	0.050	14	1	-	N
Landsat NDVI	Mean NDVI	1	1	0.595	0.012	14	1	+	Y
ASTER NDVI	Dry Season Mean NDVI	1	1	0.618	0.009	12-14	1	+	Y
	Wet Season NDVI	1 - 3	1	0.660	0.005	14	1	+	Y
Topographic	*No Significant Correlations Observed*					14	1		
Tasseled Cap Indices	ASTER Dry Season Greenness Index	1 - 4	1	0.549	0.032	12-14	1	+	Y
	ASTER Wet Season Brightness Index	1 - 3	2	0.570	0.017	14	2	--	--
	ASTER Wet Season Greenness Inex	1 - 4	1	0.601	0.011	14	1	+	Y
	ASTER Wet Season Tasseled Cap Wetness Index	1	1	-0.469	0.045	14	1	+	N
Modeled Soil Moisture	*No Significant Correlations Observed*					14	1		
Principal Components	PC1 of WORLDCLIM Temperature Variables	1	1	-0.525	0.027	14	1	+	N
	PC2 of MODIS Total Precipitable Water Vapor	1 - 2	1	-0.483	0.040	14	1	+	N
	PC1 of MODIS NDVI Variables	1,3-6	1	0.585	0.014	14	1	+	Y

Range = range of geographic extents (kilometers radius) over which relationship is statistically gignificant (≤0.05); **Kmr** = radius, in kilometers, of the extent of the most significant correlation; *r* = Pearson's correlation coefficient for most significant correlation; **(1)** = Correlations at broader extents supported by results of analyses merging geographically proximate sites; **(2)** = Results of merged analysis not significant; **(3)** = Results of merged analysis more significant that individual analysis; **n** = number of site-to-variable comparisons possible with data sets; **Tail** = 1-tailed or 2-tailed test; **Pred** = Predicted directionality of the correlation; **Cons?** = whether or not results are consistent with predictions.

Table 8. Statistically significant correlates of microfilarid infection prevalence in Galapagos penguins (p≤ 0.05).

Data Source	Variable	Range	Kmr	*r*	p	n	Tail	Pred	Cons?
WORLDCLIM Temp.	*No Significant Correlations Observed*					10			
WORLDCLIM Precip.	*No Significant Correlations Observed*					10			
MODIS Day LST	Annual Mean	3 - 8	4	0.582	0.039 (1)	10	1	+	Y
	Warm Season Mean	4 - 8	8	0.561	0.046 (1)	10	1	+	Y
	Standard Deviation of Warm Season Mean	3	3	0.562	0.045	10	1	-	N
	Cool Season Mean	2 - 8	4	0.593	0.036 (1)	10	1	+	Y
	Warmest Quarter Mean	8	8	0.566	0.044 (1)	10	1	+	Y
	Standard Deviation of Warmest Quarter Mean	2 - 4	3	0.603	0.032	10	1	-	N
	Coolest Quarter Mean	2 - 8	4	0.607	0.031 (1)	10	1	+	Y
	Seasonality (Warmest Qtr Mean - Coolest Qtr Mean)	3	3	-0.533	0.049 (2)	10	1	-	Y
MODIS Night LST	Annual Mean	2 - 3	2	0.574	0.041	10	1	+	Y
	Standard Deviation of Annual Mean	1 - 4	1	-0.598	0.034	10	1	-	Y
	Cool Season Mean	1 - 8	2	0.615	0.029 (2)	10	1	+	Y
	Coolest Quarter mean	1 - 8	2	0.636	0.024 (2)	10	1	+	Y
	Seasonality (Warm Mean - Cool Mean)	1 - 6	3	-0.579	0.040 (2)	10	1	-	Y
	Seasonality (Warmest Qtr Mean - Coolest Qtr Mean)	3, 6	3	-0.562	0.045 (2)	10	1	-	Y
MODIS LSDTR	Annual Mean	4	4	0.553	0.049 (3)	10	1	+	Y
	Warm Season Mean	4, 8	4	0.554	0.048 (3)	10	1	+	Y
	Warmest Quarter Mean	6 - 8	8	0.568	0.043 (3)	10	1	+	Y
	Coolest Quarter Mean	4	4	0.564	0.045 (3)	10	1	+	Y
Landsat Temp	*No Significant Correlations Observed*					10			
ASTER Temp	*No Significant Correlations Observed*					8-10			
MODIS Water Vapor	*No Significant Correlations Observed*					10			
MODIS NDVI	*No Significant Correlations Observed*					10			
Landsat NDVI	*No Significant Correlations Observed*					10			
ASTER NDVI	*No Significant Correlations Observed*					8-10			
Topographic	Proportion of Land Surface	8	8	0.562	0.045 (2)	10	1	+	Y
Tasseled Cap Indices	*No Significant Correlations Observed*					8-10			
Modeled Soil Moisture	*No Significant Correlations Observed*					10			
Principal Components	PC1 of MODIS Land Surface Temperature Variables	3-8	4	0.577	0.040 (1)	10	1	+	Y

Range = range of geographic extents (kilometers radius) over which relationship is statistically gignificant (≤0.05); **Kmr** = radius, in kilometers, of the extent of the most significant correlation; ***r*** = Pearson's correlation coefficient for most significant correlation; **(1)** = Correlations at broader extents supported by results of analyses merging geographically proximate sites; **(2)** = Results of merged analysis not significant; **(3)** = Results of merged analysis more significant that individual analysis; **n** = number of site-to-variable comparisons possible with data sets; **Tail** = 1-tailed or 2-tailed test; **Pred** = Predicted directionality of the correlation; **Cons?** = whether or not results are consistent with predictions.

Table 9. Statistically significant correlates of microfilarid infection intensity in Galapagos penguins (p≤ 0.05).

Data Source	Variable	Range	Kmr	*r*	p	n	Tail	Pred	Cons?
WORLDCLIM Temp.	*No Significant Correlations Observed*					8			
WORLDCLIM Precip.	*No Significant Correlations Observed*					8			
MODIS Day LST	*No Significant Correlations Observed*					8			
MODIS Night LST	*No Significant Correlations Observed*					8			
MODIS LSDTR	*No Significant Correlations Observed*					8			
Landsat Temp	*No Significant Correlations Observed*					8			
ASTER Temp	*No Significant Correlations Observed*					6-8			
MODIS Water Vapor	Standard Deviation of Driest Quarter Mean	4	4	0.636	0.045 (2)	8	1	-	N
MODIS NDVI	Driest Quarter Mean	1	1	-0.635	0.045	8	1	+	N
Landsat NDVI	*No Significant Correlations Observed*					8			
ASTER NDVI	*No Significant Correlations Observed*					8			
Topographic	*No Significant Correlations Observed*					8			
Tasseled Cap Indices	*No Significant Correlations Observed*					6-8			
Modeled Soil Moisture	*No Significant Correlations Observed*					8			
Principal Components	*No Significant Correlations Observed*					8			

Range = range of geographic extents (kilometers radius) over which relationship is statistically gignificant (≤0.05); **Kmr** = radius, in kilometers, of the extent of the most significant correlation; ***r*** = Pearson's correlation coefficient for most significant correlation; **(1)** = Correlations at broader extents supported by results of analyses merging geographically proximate sites; **(2)** = Results of merged analysis not significant; **(3)** = Results of merged analysis more significant that individual analysis; **n** = number of site-to-variable comparisons possible with data sets; **Tail** = 1-tailed or 2-tailed test; **Pred** = Predicted directionality of the correlation; **Cons?** = whether or not results are consistent with predictions.

Table 10. Correlations between prevalence of filarids in cormorant populations and a) predictive model based on all correlated variables; b) components of the PCA based on all correlated variables (see Table 13 for component weightings); c) predictive model based on correlated principal components.

a)

	MODEL
r	**0.679**
P	**0.004**

b)

	PC01	PC02	PC03	PC04	PC05	PC06	PC07	**PC08**	PC09	PC10
r	**0.691**	-0.207	-0.439	0.372	0.295	-0.260	0.327	**-0.797**	-0.355	0.091
P	**0.006**	0.479	0.117	0.191	0.307	0.370	0.254	**0.001**	0.213	0.757

	PC11	PC12	PC13	PC14	PC15	PC16	PC17	PC18	PC19	PC20
r	0.250	0.445	0.125	-0.203	0.148	-0.311	-0.288	-0.044	0.057	-0.180
P	0.389	0.111	0.671	0.487	0.614	0.280	0.318	0.882	0.846	0.538

	PC21	PC22	PC23	PC24	PC25	PC26	PC27	PC28	PC29	PC30
r	0.016	0.484	0.117	0.471	0.263	0.044	0.289	0.168	0.072	-0.089
P	0.956	0.080	0.689	0.089	0.364	0.881	0.316	0.567	0.807	0.762

	PC31	PC32	PC33	**PC34**	PC35	PC36	PC37	PC38	PC39
r	-0.076	-0.145	0.017	**0.651**	-0.021	0.067	-0.101	-0.096	-0.058
P	0.796	0.620	0.953	**0.012**	0.944	0.819	0.732	0.744	0.844

c)

	MODEL
r	**0.790**
P	**0.000**

Table 11. Correlations between intensity of filarid infections in cormorant populations and a) predictive model based on all correlated variables; b) components of the PCA based on all correlated variables (see Table 14 for component weightings); c) predictive model based on correlated principal components.

a)

	MODEL
r	**0.864**
P	**0.000**

b)

	PC1	**PC2**	PC3	PC4	PC5	**PC6**	PC7	PC8	PC9	**PC10**
r	**0.841**	**0.528**	-0.013	-0.295	0.432	**0.695**	0.436	-0.349	-0.171	**0.499**
P	**0.000**	**0.052**	0.965	0.305	0.123	**0.006**	0.120	0.221	0.558	**0.069**

	PC11	PC12	PC13	PC14	PC15	PC16	PC17	PC18	PC19	PC20
r	**0.638**	-0.325	-0.059	-0.167	0.191	0.281	0.271	-0.233	0.323	0.150
P	**0.014**	0.256	0.841	0.568	0.512	0.330	0.348	0.423	0.260	0.608

	PC21
r	-0.165
P	0.574

c)

	MODEL
r	**0.871**
P	**0.000**

Table 12. Correlations between prevalence of filarids in penguin populations and a) predictive model based on all correlated variables; b) components of the PCA based on all correlated variables (see Table 15 for component weightings); c) predictive model based on correlated principal components.

a)

	MODEL
r	**0.554**
P	**0.048**

b)

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
r	0.516	-0.398	-0.199	0.545	0.527	-0.357	0.163	-0.255	0.014	0.334
P	0.127	0.255	0.581	0.103	0.117	0.311	0.653	0.478	0.969	0.346

	PC11	PC12	PC13	PC14	PC15	PC16	**PC17**	PC18	PC19
r	-0.488	0.105	-0.135	0.297	0.133	0.128	**0.805**	-0.430	0.324
P	0.153	0.773	0.711	0.405	0.713	0.724	**0.005**	0.215	0.360

c)

	MODEL
r	**0.874**
P	**0.000**

Table 13. Correlations between intensity of filarid infections in penguin populations and a) predictive model based on all correlated variables; b) components of the PCA based on all correlated variables (see Table 16 for component weightings); c) predictive model based on correlated principal components.

a)

	MODEL
r	**0.634**
P	**0.025**

b)

	PC1	PC2
r	**0.650**	0.081
P	**0.042**	0.824

c)

	MODEL
r	**0.681**
P	**0.011**

Table 14. Loading values for significantly correlated components derived from ecological correlates of filarid prevalence in flightless cormorant colonies. The ten highest values are in boldface.

Data Set	Variable	PC01	PC08	PC34
WORLDCLIM Temp.	Annual Mean Temperature	0.070	**-0.186**	-0.095
	Mean Temperature, Driest Quarter	0.105	-0.090	-0.016
	Mean Temperature, Wettest Quarter	0.060	**-0.212**	0.019
	Mean Temperature, Coldest Quarter	0.067	**-0.195**	-0.024
	Mean Temperature, Warmest Quarter	0.073	-0.167	0.074
	Minimum Temperature, Coldest Month	0.071	**-0.176**	0.045
	Temperature Annual Range	0.099	0.094	-0.028
	Mean Diurnal Temperature Range	0.120	0.150	0.048
	Temperature Seasonality	**0.259**	0.072	0.009
WORLDCLIM Precip.	Annual Precipitation	**0.255**	-0.085	0.076
	Precipitation, Warmest Quarter	**0.256**	-0.095	-0.049
	Precipitation, Wettest Quarter	**0.258**	-0.093	0.068
	Precipitation, Wettest Month	**0.244**	-0.102	-0.069
	Precipitation Seasonality	**0.249**	-0.089	0.015
MODIS Day LST	Annual Mean	0.147	0.026	**-0.250**
	Warm Season Mean	0.149	0.082	-0.018
	Cool Season Mean	0.145	0.003	**-0.178**
	Warmest Quarter Mean	0.156	0.125	**0.100**
	Coolest Quarter Mean	0.140	-0.001	**0.309**
	Standard Deviation of the Coolest Quarter Mean	0.150	**-0.316**	0.012
MODIS Night LST	Annual Mean	0.096	**0.320**	**0.260**
	Standard Deviation of Annual Mean	0.142	-0.113	0.011
	Warm Season Mean	0.116	**0.341**	**-0.199**
	Cool Season Mean	0.080	**0.278**	**0.305**
	Standard Deviation of Cool Season Mean	0.133	-0.167	-0.007
	Coolest Quarter Mean	0.084	**0.279**	**-0.345**
	Seasonality (Warm Mean - Cool Mean)	0.042	**-0.272**	-0.008
	Seasonality (Warmest Qtr Mean - Coolest Qtr Mean)	0.079	-0.115	-0.014
MODIS LSDTR	Annual Mean	0.164	-0.077	0.043
	Warm Season Mean	0.161	-0.034	**0.149**
	Warmest Quarter Mean	0.167	-0.011	**-0.148**
MODIS NDVI	Dry Season Mean	**0.200**	0.076	0.058
	Standard Deviation of Dry Season Mean	0.185	0.114	0.043
	Driest Quarter Mean	**0.190**	0.089	-0.066
	Standard Deviation of Driest Quarter Mean	**0.189**	0.126	-0.008
	Seasonality (Wet Season - Dry Season)	0.079	0.133	0.036
Topographic	Mean Elevation	0.087	-0.149	-0.020
	Mean Slope	0.145	0.066	-0.023
	Proportion of Land Surface	**0.285**	0.119	-0.061

Table 15. Loading values for significantly correlated components derived from ecological correlates of filarid intensity in flightless cormorant colonies. The ten highest values are in boldface.

Data Set	Variable	PC01	PC02	PC06	PC10	PC11
WORLDCLIM Temp.	Annual Mean Temperature	**0.280**	**-0.181**	0.025	0.001	0.114
	Mean Temperature, Coldest Quarter	**0.292**	**-0.183**	-0.020	0.029	**0.196**
	Minimum Temperature, Coldest Month	**0.285**	**-0.196**	0.006	0.053	**0.179**
	Temperature Annual Range	**0.245**	**-0.188**	0.054	**0.138**	-0.084
MODIS Day LST	Standard Deviation of Annual Mean	**0.311**	-0.039	**-0.221**	**-0.510**	**-0.562**
	Standard Deviation of Cool Season Mean	0.115	**0.430**	-0.017	**0.348**	**-0.211**
	Seasonality (Warmest Qtr Mean - Coolest Qtr Mean)	0.175	0.074	**0.478**	**0.135**	**-0.208**
MODIS Night LST	Standard Deviation of Warmest Quarter Mean	0.104	-0.015	**-0.140**	0.102	**0.490**
MODIS LSDTR	Standard Deviation of Annual Mean	0.125	**0.368**	**-0.159**	0.099	-0.106
	Standard Deviation of Warm Season Mean	0.179	**-0.320**	**0.227**	**0.256**	-0.021
	Standard Deviation of Cool Season Mean	0.122	**0.434**	0.075	**0.240**	**0.183**
	Standard Deviation of Coolest Season Mean	0.162	**0.377**	**0.580**	**-0.526**	**0.244**
MODIS Water Vapor	Annual Mean	**0.246**	0.166	**-0.269**	-0.025	0.121
	Wet Season Mean	**0.235**	0.160	**-0.233**	0.003	0.041
	Wettest Quarter Mean	0.221	**0.176**	**-0.334**	0.002	0.049
MODIS NDVI	Annual Mean	0.231	-0.062	0.039	0.019	0.063
	Wet Season Mean	**0.245**	-0.042	0.078	0.084	-0.025
	Dry Season Mean	0.192	-0.066	-0.048	**-0.176**	0.133
	Wettest Quarter Mean	**0.236**	-0.051	0.089	0.096	-0.056
	Driest Quarter Mean	0.171	-0.045	-0.087	**-0.230**	**0.136**
	Seasonality (Wettest Season - Driest Season)	**0.235**	-0.024	**0.131**	**0.238**	**-0.314**

Table 16. Loading values for significantly correlated components derived from ecological correlates of filarid prevalence in Galapagos penguin colonies. The ten highest values are in boldface.

Data Set	Variable	PC17
MODIS Day LST	Annual Mean	**0.679**
	Warm Season Mean	**-0.311**
	Standard Deviation of Warm Season Mean	-0.005
	Cool Season Mean	**-0.176**
	Warmest Quarter Mean	0.100
	Standard Deviation of Warmest Quarter Mean	0.002
	Coolest Quarter Mean	**-0.212**
	Seasonality (Warmest Qtr Mean - Coolest Qtr Mean)	0.052
MODIS Night LST	Annual Mean	**-0.108**
	Standard Deviation of Annual Mean	0.002
	Cool Season Mean	**0.140**
	Coolest Quarter mean	-0.047
	Seasonality (Warm Mean - Cool Mean)	-0.046
	Seasonality (Warmest Qtr Mean - Coolest Qtr Mean)	0.036
MODIS LSDTR	Annual Mean	**-0.502**
	Warm Season Mean	**0.129**
	Warmest Quarter Mean	**0.129**
	Coolest Quarter Mean	**0.177**
Topographic	Proportion of Land Surface	-0.020

Table 17. Loading values for significantly correlated components derived from ecological correlates of filarid intensity in Galapagos penguin colonies. The highest value is in boldface.

Data Set	Variable	PC01
MODIS Water Vapor	Standard Deviation of Driest Quarter Mean	**0.872**
MODIS NDVI	Driest Quarter Mean	0.490

FIGURES:

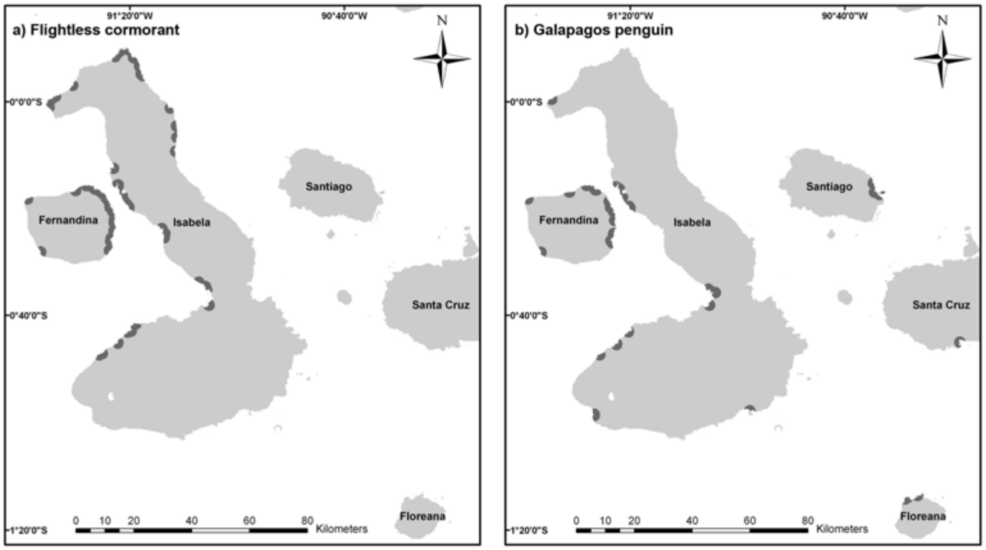

Figure 1. Geographic distributions of flightless cormorants and Galapagos penguins based on GPS points from all known breeding colonies (data provided by H. Vargas). Two-kilometer buffers are drawn around each point for ease of visualization.

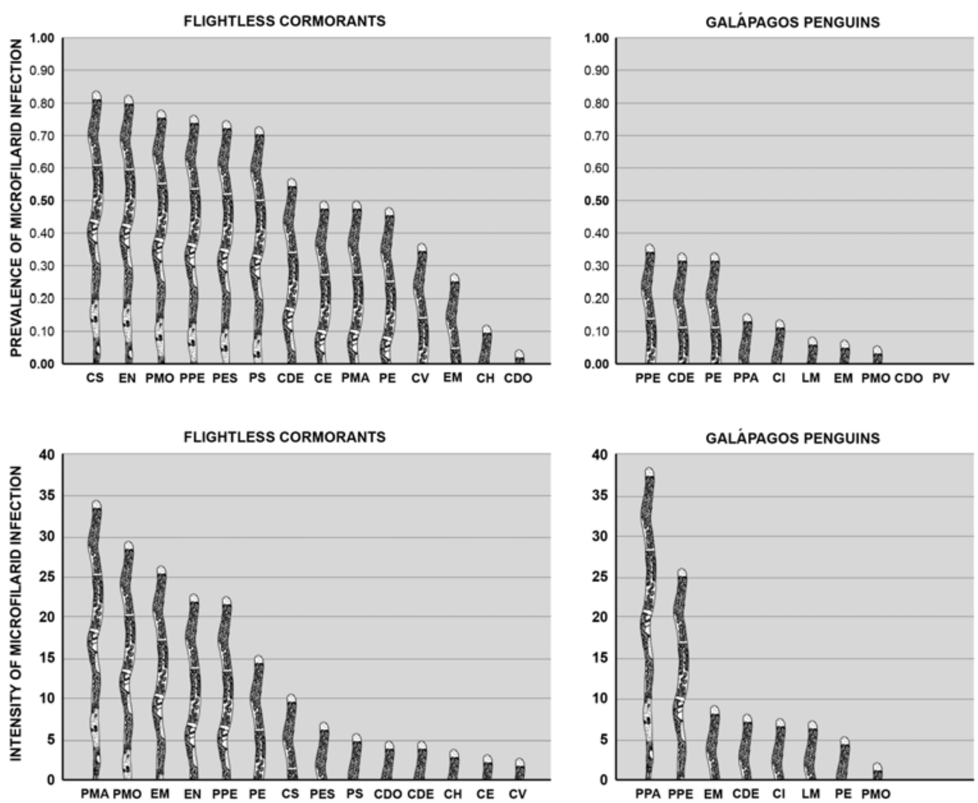

Figure 2. Prevalence and intensity values for microfilarid infections in flightless cormorants and Galapagos penguins. See Tables 1 & 2 for keys to site names.

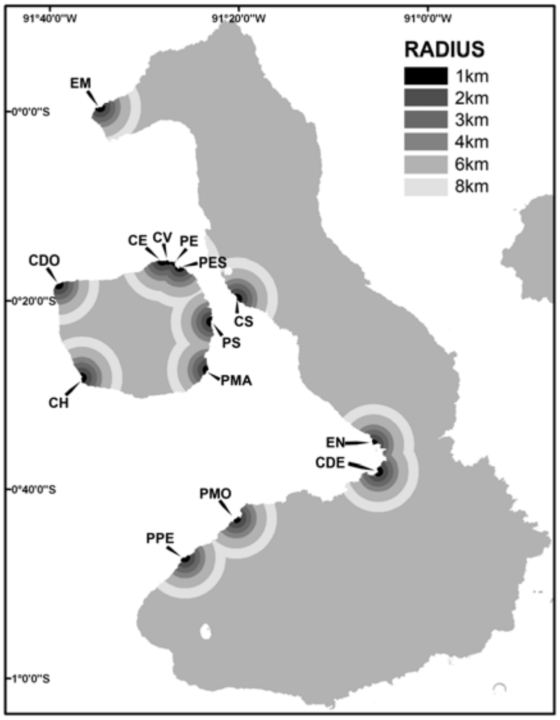

Figure 3. Flightless cormorant sites where 5 or more birds were sampled. See Table 1 for site names, coordinates and sample sizes.

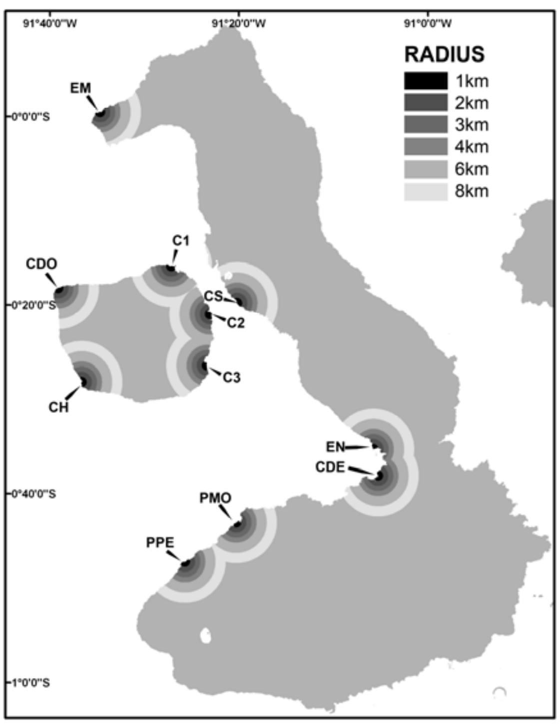

Figure 4. Flightless cormorant sites merged based on geographic proximity. See Table 2 for site names, coordinates and sample sizes.

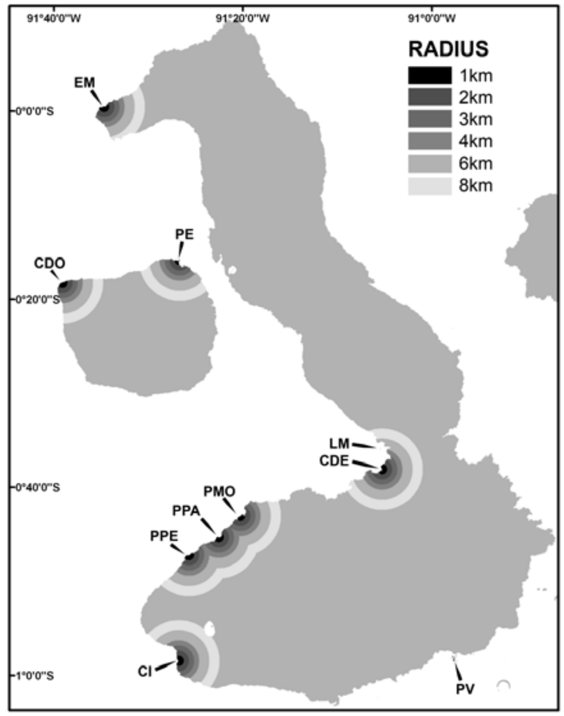

Figure 5. Galapagos penguin sites where 5 or more birds were sampled. See Table 3 for site names, coordinates and sample sizes.

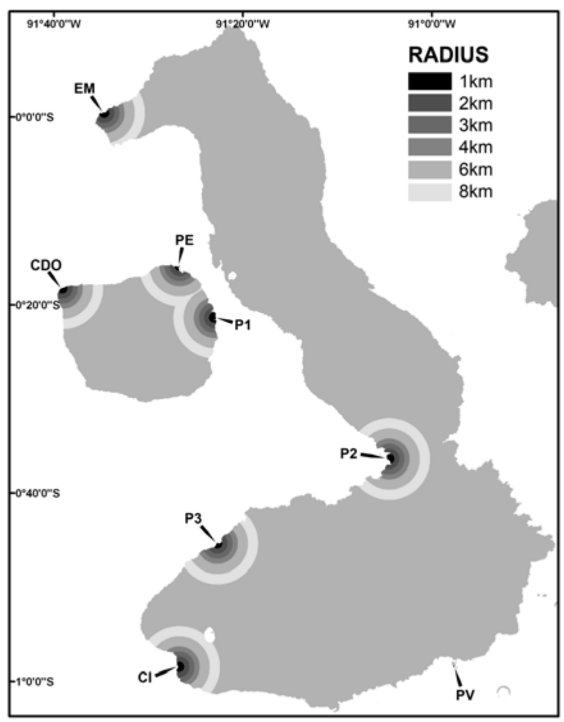

Figure 6. Galapagos penguin sites merged based on geographic proximity. See Table 4 for site names, coordinates and sample sizes.

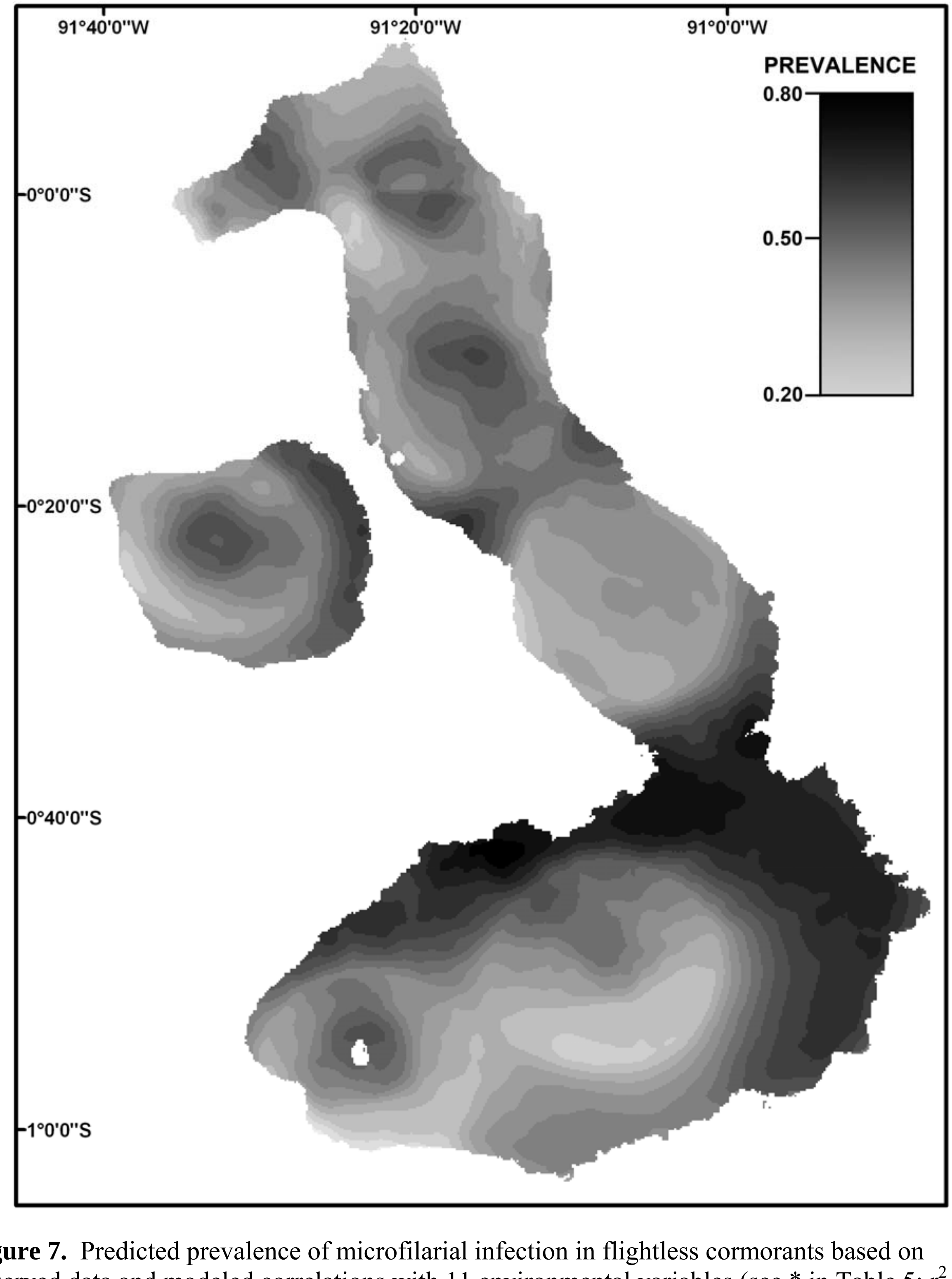

Figure 7. Predicted prevalence of microfilarial infection in flightless cormorants based on observed data and modeled correlations with 11 environmental variables (see * in Table 5; r^2-0.596, p=0.001).

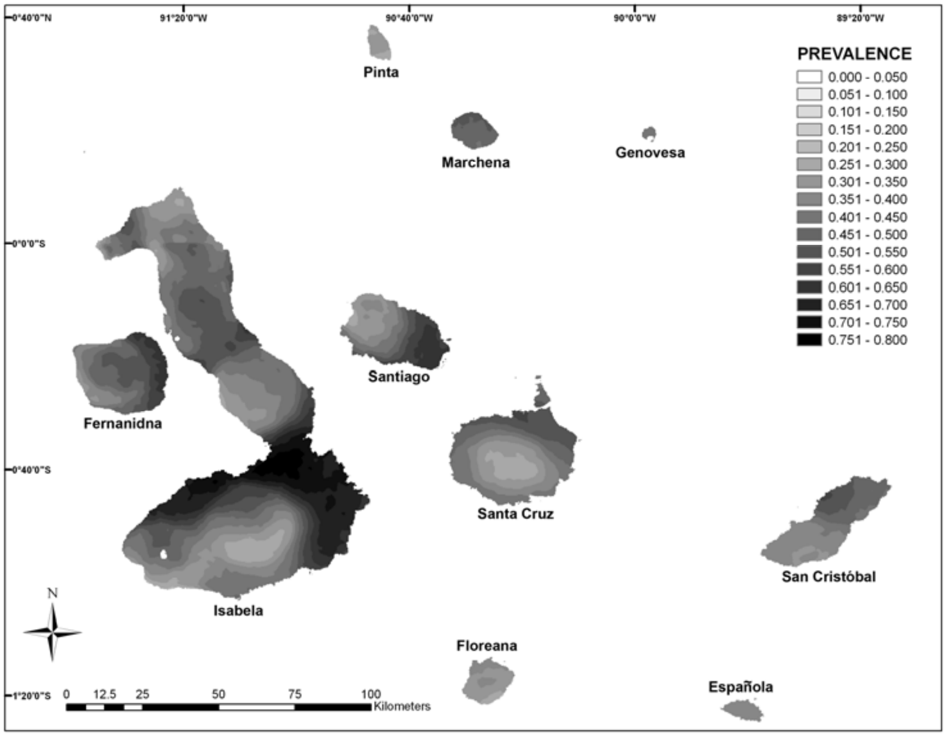

Figure 8. Cormorant filarid infection prevalence as modeled by a weighted mean of all correlated variables (see Table 5).

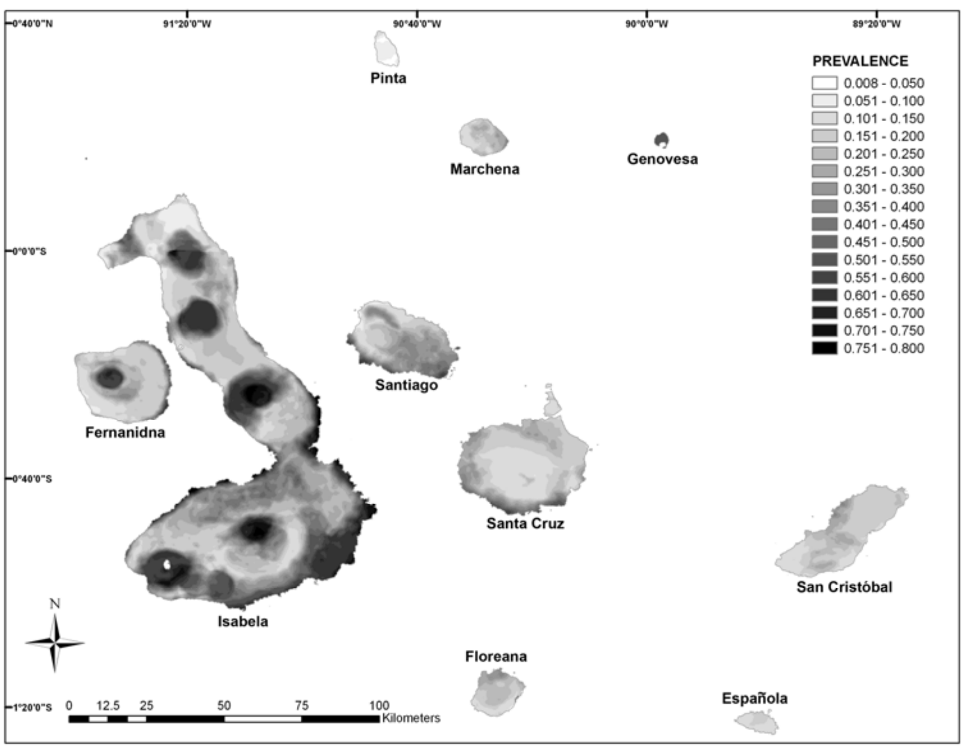

Figure 9. Cormorant filarid infection prevalence as modeled by a weighted mean of correlated PCA layers (see Table 9).

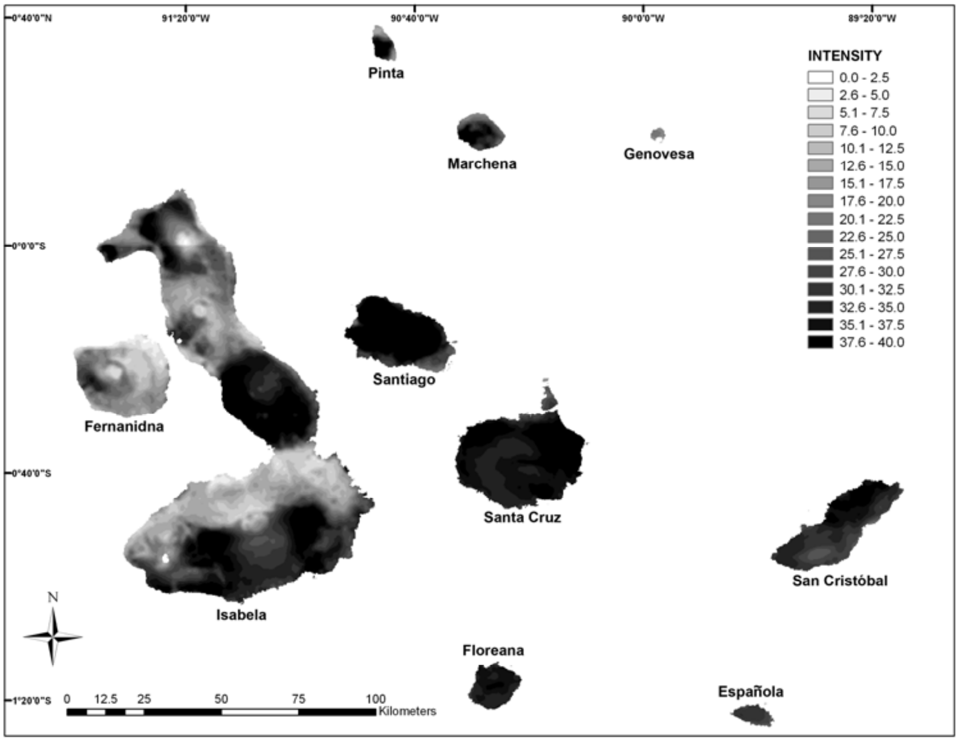

Figure 10. Cormorant filarid infection intensity as modeled by a weighted mean of all correlated variables (see Table 6).

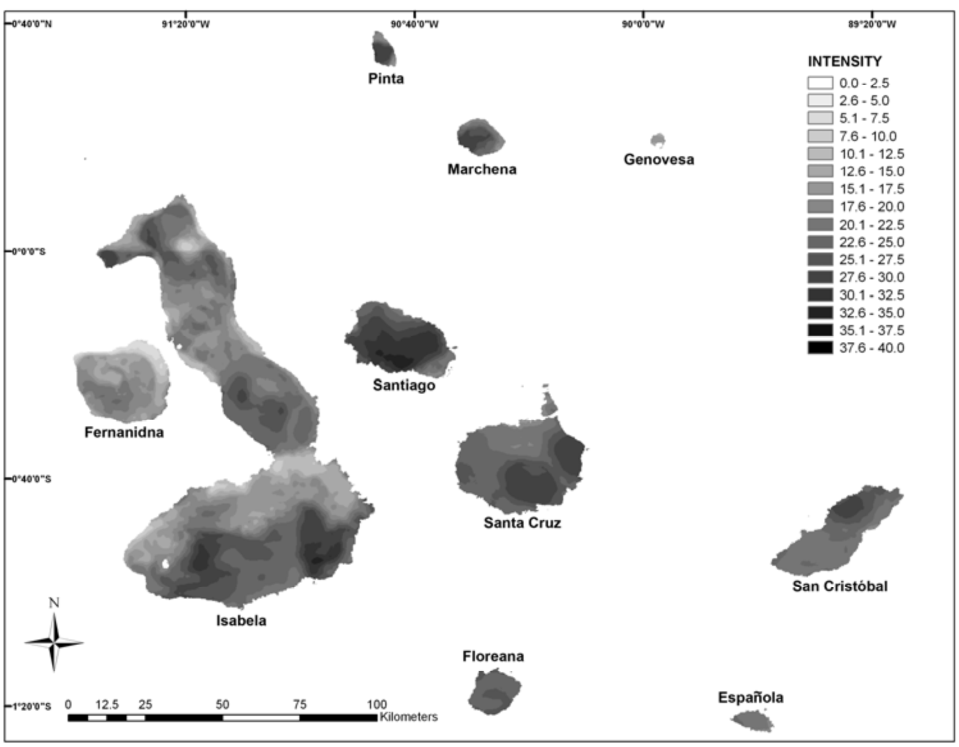

Figure 11. Cormorant filarid infection intensity as modeled by a weighted mean of correlated PCA layers (see Table 10).

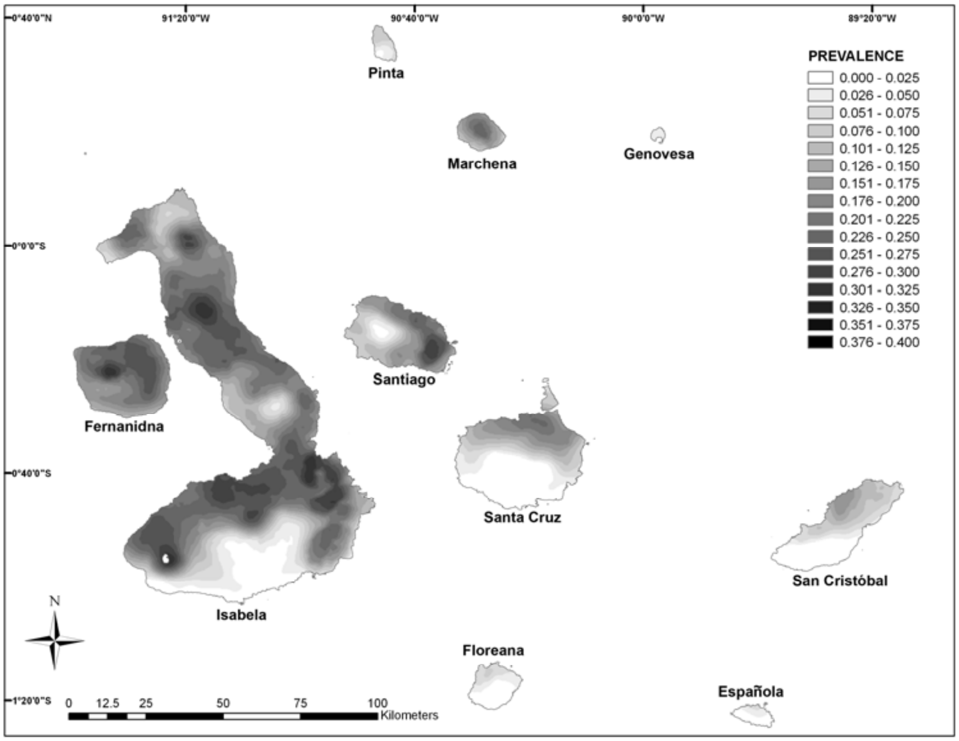

Figure 12. Penguin filarid infection prevalence as modeled by a weighted mean of all correlated variables (see Table 7).

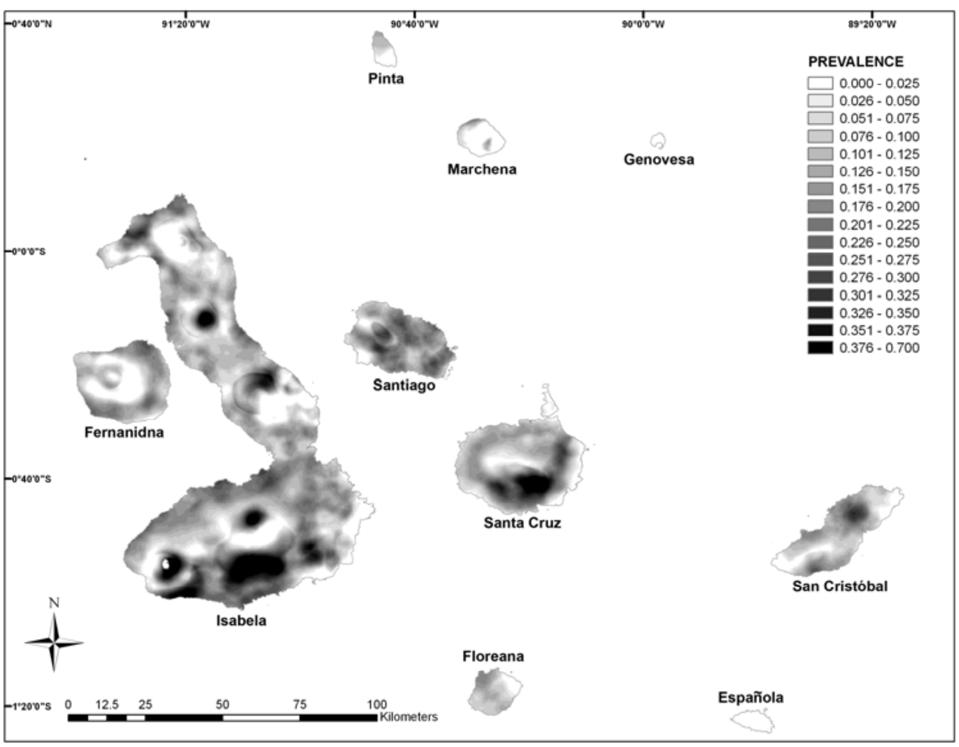

Figure 13. Penguin filarid infection prevalence as modeled by PC 17 of the PCA conducted on all significant correlates (see Table 11).

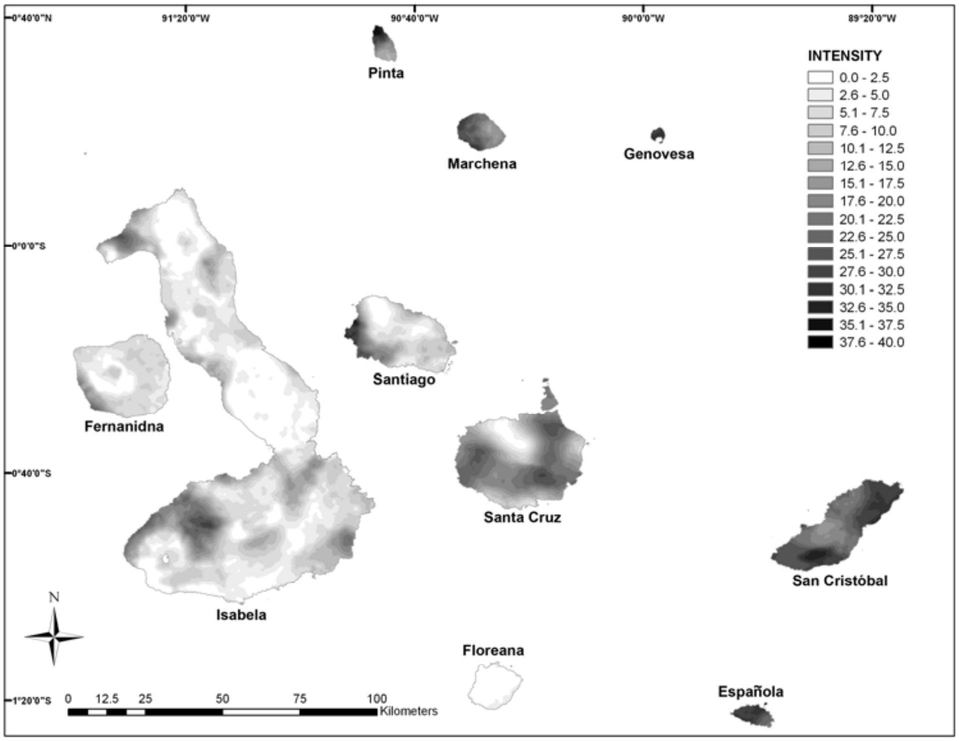

Figure 14. Penguin filarid infection intensity as modeled by a weighted mean of all correlated variables (see Table 8).

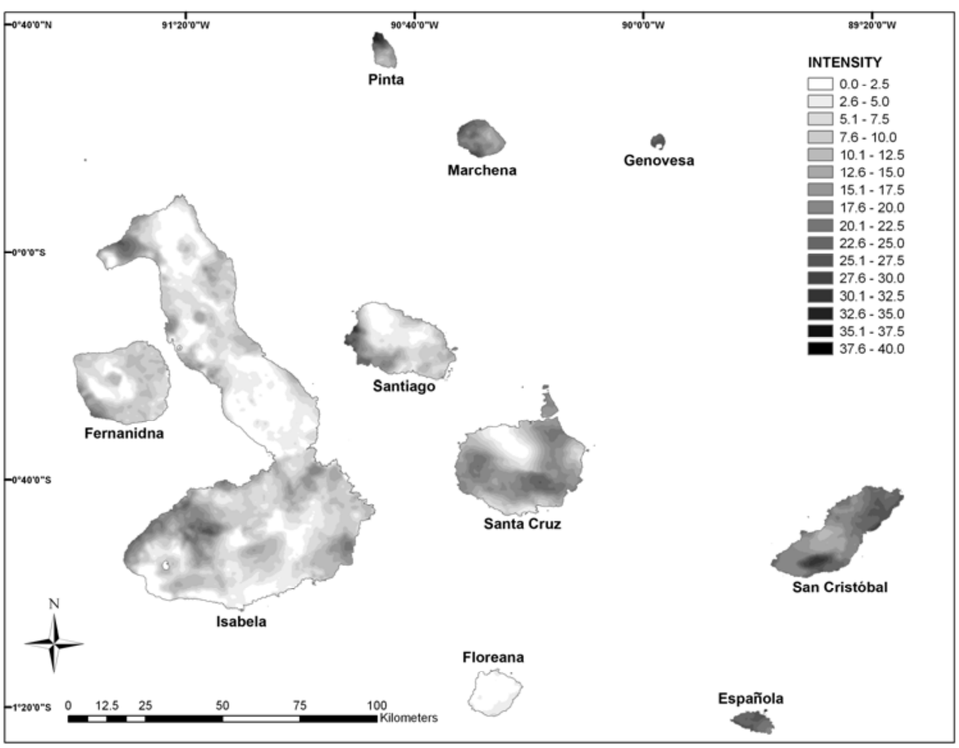

Figure 15. Penguin filarid infection intensity as modeled by PC 01 of the PCA conducted on all significant correlates (see Table 12).

APPENDICES:

Appendix I. Satellite Data Sources

MODIS – The Moderate Resolution Imaging Spectroradiometer (MODIS) is a NASA Earth Observing System (EOS) instrument flown aboard EOS' Terra and Aqua satellites. It is a multidisciplinary instrument, yielding data on atmospheric, oceanic and land surface features. Its spatial resolution varies from 250m to 1km, measuring the electromagnetic spectrum at 36 spectral bands, and viewing the entire Earth's surface every 1 to 2 days. Launched aboard Terra in December of 1999 and aboard Aqua in May of 2002, the MODIS sensors are making major contributions to the understanding of the global Earth system (King et al. 2004). MODIS data used in this study include day and night land surface temperatures, total precipitable water vapor, and a vegetation density index (NDVI).

Landsat – NASA's Landsat Program has been collecting images of the Earth's surface since 1972. Its current sensor, the Landsat 7 Enhanced Thematic Mapper (ETM+) returns 6 visible and infrared spectral bands with spatial resolution of 30 meters, a thermal infrared band with 60m resolution, and a panchromatic band at 15m. For this study, two scenes from the USGS Global Land Cover Facility Orthorectified ETM+ collection, taken on 16 March 2001 (wet season), were obtained, composited (or "mosaicked"), and converted to reflectance values . These are the most cloud-free images available free of charge; however, while the coastlines are relatively cloud-free, inland areas do contain significant cloud coverage, reducing the ability to accurately record values over larger spatial scales. The resulting mosaic was used to assess: vegetative distribution and density through the use of NDVI (see below) at 30m resolution; brightness, greenness and wetness indices as derived by the Tasseled Cap Transform (see below) at 30m resolution; and land surface temperature and temperature heterogeneity at 90m resolution.

ASTER – Further high-resolution images were obtained by the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) sensor aboard the EOS' Terra satellite. This sensor has high spatial and spectral resolution with four visible and near-infrared bands at 15m resolution, six shortwave infrared bands at 30m resolution, and five thermal infrared bands at 90m. As with Landsat and other high-spatial, low-temporal resolution imagers, cloud contamination of images, particularly over persistently cloudy regions such as the Galapagos Archipelago, places serious limitations on image availability. For this study, images were acquired from the EOS Land Processes Distributed Active Archive Center (LP DAAC) and composited for a wet season mosaic and a dry season mosaic. Due to high cloud cover, it was necessary to use images from multiple dates, and in the case of the dry season mosaic, across multiple years (the dry-season mosaic was constructed with images from 9/15/01 and 10/30/05, and the wet-season mosaic used scenes from 5/16/03 and 6/10/03). In both cases, however, the majority of sites analyzed fell within image areas captured on the same dates (9/15/01 for the dry season and 5/16/03 for the wet season). These seasonal mosaics were used to calculate intra-annual variations in some landscape measures (NDVI, surface temperature) but cannot account for inter-annual variation. Analyses were further complicated by the absence of short-wave and thermal infrared information for the scenes from 10/30/2005, eliminating the possibility of conducting seasonal comparisons of some parameters. These ASTER images were used to assess: dry season and wet season land surface temperature, and temperature seasonality and heterogeneity (90m); dry season and wet season vegetation indices, and vegetation seasonality

(15m); brightness, greenness and wetness indices derived by the Tasseled Cap Transform for the wet season only (30m); and modeled soil surface moisture at 90m resolution (see below).

Despite problems of cloud cover and image availability, the spatial and spectral resolution of these Landsat and ASTER images allowed us to assess some of the same factors at higher spatial resolution, and conduct other analyses not possible with the coarser MODIS data.

***SRTM* –** Topographic factors were derived from a global 90-meter resolution digital elevation model (DEM) constructed from remotely-sensed data produced by the Shuttle Radar Topography Mission (SRTM) during an 11-day mission in February of 2000.

Appendix II. Correlations of environmental variables with microfilarid infection measures.

Table 1a. Correlations of microfilarid infection prevalence in flightless cormorants with WorldClim variables

Analysis Extent (Radius)	n	t	1km r	1km p	2km r	2km p	3km r	3km p	4km r	4km p	6km r	6km p	8km r	8km p
WorldClim Temperature Variables														
Annual Mean Temperature	14	1	0.014	0.482	0.181	0.267	0.233	0.211	0.347	0.112	.466(*)	0.047	.580(*)	0.015
Merged (n=11, 1-tailed)											.553(*)	0.039	.665(*)	0.013
Mean Temperature of the Driest Quarter	14	1	0.269	0.176	0.309	0.141	0.387	0.086	0.447	0.055	.500(*)	0.034	.519(*)	0.029
Merged (n=11, 1-tailed)											.523(*)	0.049	.544(*)	0.042
Mean Temperature of the Wettest Quarter	14	1	0.167	0.284	0.243	0.201	0.272	0.174	0.358	0.104	.462(*)	0.048	.592(*)	0.013
Merged (n=11, 1-tailed)											.542(*)	0.042	.675(*)	0.011
Mean Temperature of the Coldest Quarter	14	1	-0.181	0.268	0.099	0.368	0.190	0.258	0.316	0.135	0.452	0.053	.556(*)	0.019
Merged (n=11, 1-tailed)											.549(*)	0.040	.644(*)	0.016
Mean Temperature of the Warmest Quarter	14	1	0.167	0.284	0.243	0.201	0.272	0.174	0.358	0.104	.462(*)	0.048	.591(*)	0.013
Merged (n=11, 1-tailed)											.542(*)	0.042	.674(*)	0.011
Minimum Temperature of the Coldest Month	14	1	-0.050	0.433	0.160	0.293	0.242	0.203	0.363	0.101	.484(*)	0.040	.575(*)	0.016
Merged (n=11, 1-tailed)											.580(*)	0.031	.661(*)	0.013
Maximum Temperature of the Warmest Month	14	1	-0.256	0.188	-0.034	0.454	0.058	0.422	0.121	0.340	0.281	0.166	0.405	0.075
Temperature Annual Range	14	1	-0.124	0.336	-0.246	0.198	-0.308	0.142	-0.445	0.055	-.550(*)	0.021	-.620(**)	0.009
Merged (n=11, 1-tailed)											-.633(*)	0.018	-.694(**)	0.009
Mean Diurnal Temperature Range	14	1	-.476(*)	0.043	-.473(*)	0.044	-.467(*)	0.046	-.538(*)	0.024	-.587(*)	0.014	-.664(**)	0.005
Merged (n=11, 1-tailed)									-.581(*)	0.030	-.646(*)	0.016	-.718(**)	0.006
Temperature Seasonality	14	1	.515(*)	0.030	.511(*)	0.031	0.085	0.386	-0.210	0.235	-0.416	0.070	-0.380	0.090
WorldClim Precipitation Variables														
Annual Precipitation	14	1	.512(*)	0.031	.499(*)	0.035	.480(*)	0.041	.462(*)	0.048	0.441	0.057	0.393	0.082
Precipitation in the Coldest Quarter	14	1	0.286	0.161	0.266	0.179	0.225	0.220	0.186	0.262	0.192	0.255	0.086	0.384
Precipitation in the Warmest Quarter	14	1	.566(*)	0.017	.557(*)	0.019	.542(*)	0.023	.522(*)	0.028	.499(*)	0.035	.459(*)	0.050
Merged	11	1	.627(*)	0.020	.617(*)	0.021	.603(*)	0.025	.582(*)	0.030	.558(*)	0.037	0.512	0.054
Precipitation in the Driest Quarter	14	1	0.261	0.184	0.250	0.194	0.217	0.228	0.198	0.249	0.181	0.267	0.021	0.472
Precipitation in the Wettest Quarter	14	1	.566(*)	0.017	.557(*)	0.019	.542(*)	0.023	.522(*)	0.028	.498(*)	0.035	0.449	0.054
Merged	11	1	.627(*)	0.020	.617(*)	0.021	.603(*)	0.025	.581(*)	0.030	.557(*)	0.038	0.502	0.058
Precipitation in the Driest Month	14	1	0.235	0.209	0.189	0.259	0.190	0.257	0.204	0.242	0.168	0.283	-0.095	0.373
Precipitation in the Wettest Month	14	1	.492(*)	0.037	.472(*)	0.044	0.447	0.055	0.422	0.066	0.392	0.083	0.359	0.104
Precipitation Seasonality	14	1	-.497(*)	0.035	-.505(*)	0.033	-.488(*)	0.038	-.479(*)	0.041	-.465(*)	0.047	-0.435	0.060
Merged	11	1	-.537(*)	0.044	-.538(*)	0.044	-0.519	0.051	-0.511	0.054	-0.499	0.059	-0.471	0.072

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Table 1b. Correlations of microfilarid infection prevalence in flightless cormorants with MODIS-derived land surface temperature variables.

Analysis Extent (Radius)	n	t	1km r	1km p	2km r	2km p	3km r	3km p	4km r	4km p	6km r	6km p	8km r	8km p
Daytime Land Surface Temperature Variables														
Annual Mean Daytime Land Surface Temperature	14	1	0.253	0.191	0.272	0.173	0.370	0.097	0.454	0.051	.513(*)	0.030	.555(*)	0.020
Merged (n=11, 1-tailed)											0.517	0.052	.584(*)	0.029
Standard Deviation of Annual Mean	14	1	0.234	0.211	0.125	0.335	0.250	0.195	0.399	0.079	0.223	0.222	-0.154	0.299
Warm Season Mean	14	1	0.262	0.183	0.299	0.149	0.407	0.074	.487(*)	0.039	.560(*)	0.019	.591(*)	0.013
Merged (n=11, 1-tailed)									0.487	0.064	.565(*)	0.035	.619(*)	0.021
Standard Deviation of the Warm Season Mean	14	1	0.206	0.240	0.070	0.407	0.102	0.364	0.264	0.181	0.011	0.485	-0.272	0.173
Cool Season Mean	14	1	0.257	0.187	0.265	0.180	0.351	0.109	0.437	0.059	.485(*)	0.039	.530(*)	0.026
Merged (n=11, 1-tailed)											0.487	0.064	.559(*)	0.037
Standard Deviation of the Cool Season Mean	14	1	0.246	0.198	0.162	0.290	0.265	0.180	0.342	0.116	0.212	0.233	-0.135	0.323
Warmest Quarter Mean	14	1	0.298	0.150	0.316	0.135	0.405	0.076	.527(*)	0.027	.650(**)	0.006	.653(**)	0.006
Merged (n=11, 1-tailed)									.534(*)	0.045	.657(*)	0.014	.678(*)	0.011
Standard Deviation of the Warmest Quarter Mean	14	1	0.242	0.202	0.196	0.251	0.276	0.170	0.296	0.152	0.155	0.298	-0.040	0.446
Coolest Quarter Mean	14	1	0.259	0.185	0.224	0.221	0.319	0.133	0.412	0.072	.488(*)	0.038	.530(*)	0.026
Merged (n=11, 1-tailed)											0.495	0.061	.566(*)	0.035
Standard Deviation of the Coolest Quarter Mean	14	1	0.257	0.188	0.215	0.230	0.415	0.070	.525(*)	0.027	0.322	0.131	-0.023	0.469
Merged (n=11, 1-tailed)									.658(*)	0.014				
Seasonality (Warm Mean - Cool Mean)	14	1	-0.027	0.464	0.191	0.257	0.283	0.164	0.321	0.131	0.442	0.057	0.422	0.067
Seasonality (Warmest Quarter - Coldest Quarter)	14	1	0.062	0.417	0.227	0.217	0.192	0.255	0.280	0.166	0.376	0.093	0.412	0.072
Nighttime Land Surface Temperature Variables														
Annual Mean Nighttime Land Surface Temperature	14	1	0.350	0.110	0.356	0.106	0.368	0.097	0.389	0.084	0.436	0.060	.485(*)	0.039
Merged (n=11, 1-tailed)													.544(*)	0.042
Standard Deviation of Annual Mean	14	1	-.491(*)	0.037	-0.450	0.053	-0.269	0.177	-0.194	0.253	-0.207	0.239	-0.266	0.179
Warm Season Mean	14	1	0.269	0.176	0.285	0.162	0.301	0.148	0.340	0.117	0.406	0.075	.468(*)	0.046
Merged (n=11, 1-tailed)													.522(*)	0.050
Standard Deviation of the Warm Season Mean	14	1	-0.309	0.141	-0.303	0.146	-0.036	0.452	0.066	0.412	0.101	0.366	0.026	0.465
Cool Season Mean	14	1	0.411	0.072	0.412	0.072	0.421	0.067	0.430	0.062	.464(*)	0.047	.506(*)	0.032
Merged (n=11, 1-tailed)											.526(*)	0.048	.567(*)	0.034
Standard Deviation of the Cool Season Mean	14	1	-.522(*)	0.028	-0.446	0.055	-0.435	0.060	-0.405	0.075	-.489(*)	0.038	-.497(*)	0.035
Merged (n=11, 1-tailed)											-0.516	0.052	-0.511	0.054
Warmest Quarter Mean	14	1	0.299	0.149	0.315	0.136	0.320	0.132	0.345	0.114	0.362	0.101	0.381	0.089
Standard Deviation of the Warmest Quarter Mean	14	1	-0.377	0.092	-0.389	0.084	-0.182	0.266	-0.044	0.441	0.110	0.355	0.075	0.399
Coolest Quarter Mean	14	1	.463(*)	0.048	0.452	0.053	0.446	0.055	0.437	0.059	0.448	0.054	.480(*)	0.041
Merged (n=11, 1-tailed)											.526(*)	0.048	.556(*)	0.038
Standard Deviation of the Coolest Quarter Mean	14	1	-0.369	0.097	-0.386	0.086	-0.378	0.091	-0.373	0.094	-0.420	0.068	-0.409	0.073
Seasonality (Warm Mean - Cool Mean)	14	1	-.635(**)	0.007	-.676(**)	0.004	-.677(**)	0.004	-.626(**)	0.008	-.586(*)	0.014	-.562(*)	0.018
Merged	14	1	-.654(*)	0.015	-.707(**)	0.007	-.754(**)	0.004	-.737(**)	0.005	-.669(*)	0.012	-.633(*)	0.018
Seasonality (Warmest Quarter - Coldest Quarter)	14	1	-0.335	0.121	-0.339	0.118	-0.426	0.064	-0.432	0.062	-0.454	0.051	-.482(*)	0.040
Merged (n=11, 1-tailed)													-0.503	0.057
Land Surface Diurnal Temperature Range Variables														
Annual Mean Land Surface Diurnal Temperature Range	14	1	0.157	0.296	0.163	0.288	0.266	0.179	0.367	0.098	0.433	0.061	.495(*)	0.036
Merged (n=11, 1-tailed)													0.512	0.054
Standard Deviation of Annual Mean	14	1	0.011	0.485	-0.145	0.310	-0.007	0.491	0.136	0.322	-0.065	0.412	-0.327	0.127
Warm Season Mean	14	1	0.182	0.267	0.210	0.236	0.331	0.124	0.409	0.073	.477(*)	0.042	.543(*)	0.022
Merged (n=11, 1-tailed)											0.480	0.068	.561(*)	0.036
Standard Deviation of the Warm Season Mean	14	1	-0.157	0.296	-0.431	0.062	-0.390	0.084	-0.310	0.140	-0.331	0.124	-0.408	0.074
Cool Season Mean	14	1	0.134	0.324	0.126	0.334	0.210	0.236	0.321	0.131	0.373	0.094	0.430	0.062
Standard Deviation of the Cool Season Mean	14	1	0.145	0.311	0.063	0.415	0.186	0.262	0.284	0.163	0.112	0.351	-0.213	0.233
Warmest Quarter Mean	14	1	0.190	0.257	0.198	0.249	0.290	0.157	0.400	0.078	.552(*)	0.020	.627(**)	0.008
Merged (n=11, 1-tailed)											.561(*)	0.036	.638(*)	0.017
Standard Deviation of the Warmest Quarter Mean	14	1	-0.030	0.460	-0.281	0.165	-0.222	0.223	-0.323	0.130	-0.417	0.069	-0.391	0.083
Coolest Quarter Mean	14	1	0.119	0.342	0.084	0.388	0.187	0.261	0.310	0.141	0.390	0.084	0.448	0.054
Standard Deviation of the Coolest Quarter Mean	14	1	0.145	0.310	0.064	0.414	0.181	0.268	0.308	0.142	0.050	0.433	-0.243	0.201
Seasonality (Warm Mean - Cool Mean)	14	1	0.214	0.231	0.304	0.145	0.386	0.087	0.356	0.106	0.392	0.083	0.430	0.062
Seasonality (Warmest Quarter - Coldest Quarter)	14	1	0.174	0.276	0.229	0.216	0.202	0.245	0.218	0.227	0.304	0.146	0.407	0.075

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Appendix II. Correlations of environmental variables with microfilarid infection measures.

Table 1c. Correlations of microfilarid infection prevalence in flightless cormorants with MODIS-derived total precipitable water vapor & NDVI variables.

Analysis Extent (Radius)			1km		2km		3km		4km		6km		8km	
	n	t	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p
Total Precipitable Water Vapor Variables														
Annual Mean Total Precipitable Water Vapor	14	1	0.059	0.421	0.024	0.467	0.002	0.497	0.059	0.421	0.028	0.462	0.004	0.495
Standard Deviation of Annual Mean	14	1	-0.213	0.232	-0.077	0.397	-0.022	0.470	0.001	0.499	0.072	0.403	0.091	0.379
Wet Season Mean	14	1	-0.037	0.450	-0.074	0.400	-0.095	0.373	-0.044	0.440	-0.074	0.400	-0.108	0.356
Standard Deviation of Wet Season Mean	14	1	-0.033	0.455	0.026	0.464	0.056	0.424	0.062	0.416	0.087	0.384	0.104	0.361
Dry Season Mean	14	1	0.191	0.257	0.176	0.273	0.164	0.288	0.218	0.227	0.182	0.267	0.166	0.286
Standard Deviation of Dry Season Mean	14	1	-0.043	0.443	0.172	0.278	0.209	0.236	0.188	0.260	0.196	0.251	0.195	0.252
Wettest Quarter Mean	14	1	0.106	0.360	0.083	0.389	0.072	0.403	0.121	0.340	0.097	0.371	0.058	0.421
Standard Deviation of Wettest Quarter Mean	14	1	-0.252	0.192	-0.320	0.132	-0.352	0.109	-0.379	0.091	-0.344	0.115	-0.323	0.130
Driest Quarter Mean	14	1	-0.184	0.264	-0.147	0.308	-0.132	0.326	-0.069	0.408	-0.072	0.404	-0.067	0.410
Standard Deviation of Driest Quarter Mean	14	1	-0.261	0.184	-0.214	0.232	-0.220	0.225	-0.203	0.243	-0.147	0.308	-0.125	0.335
Seasonality (Wet Mean - Dry Mean)	14	1	-0.216	0.229	-0.238	0.206	-0.244	0.201	-0.251	0.193	-0.298	0.151	-0.361	0.102
Seasonality (Wettest Mean - Driest Mean)	14	1	0.195	0.252	0.165	0.286	0.169	0.282	0.185	0.264	0.162	0.289	0.117	0.345
NDVI Variables														
MODIS Annual Mean NDVI	14	1	0.389	0.085	0.336	0.120	0.203	0.243	0.127	0.333	0.142	0.314	0.047	0.437
Standard Deviation of Annual Mean	14	1	0.407	0.074	0.184	0.265	0.146	0.309	0.057	0.423	0.202	0.244	0.249	0.195
Wet Season Mean	14	1	0.319	0.134	0.269	0.176	0.139	0.318	0.065	0.413	0.079	0.395	-0.012	0.484
Standard Deviation of Wet Season Mean	14	1	0.257	0.188	0.049	0.434	0.038	0.449	-0.033	0.456	0.097	0.370	0.111	0.353
Dry Season Mean	14	1	**.463(*)**	**0.048**	0.408	0.074	0.282	0.164	0.208	0.238	0.229	0.215	0.135	0.323
Standard Deviation of Dry Season Mean	14	1	**.539(*)**	**0.023**	0.322	0.131	0.261	0.183	0.178	0.271	0.273	0.172	0.325	0.129
Wettest Quarter Mean	14	1	0.284	0.163	0.249	0.195	0.142	0.314	0.078	0.395	0.104	0.361	0.013	0.482
Standard Deviation of Wettest Quarter Mean	14	1	0.120	0.341	-0.128	0.332	-0.176	0.274	-0.225	0.220	-0.153	0.300	-0.234	0.210
Driest Quarter Mean	14	1	**.468(*)**	**0.046**	0.427	0.064	0.330	0.125	0.255	0.190	0.325	0.128	0.280	0.166
Standard Deviation of Driest Quarter Mean	14	1	**.573(*)**	**0.016**	0.304	0.145	0.261	0.184	0.157	0.296	0.305	0.145	0.383	0.088
Seasonality (Wet Season - Dry Season)	14	1	-0.434	0.061	-0.360	0.103	-0.344	0.114	-0.326	0.128	-0.230	0.214	-0.259	0.186
Seasonality (Wettest Season - Driest Season)	14	1	-0.352	0.109	-0.242	0.202	-0.251	0.194	-0.215	0.231	-0.149	0.306	-0.208	0.238

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Table 1d. Correlations of microfilarid infection prevalence in flightless cormorants with variables based on higher-resolution satellite imagery.

Analysis Extent (Radius)			1km		2km		3km		4km		6km		8km	
	n	t	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p
Land Surface Temperature Variables (High-Resolution)														
Landsat Land Surface Temperature	14	1	-0.287	0.160	0.019	0.475	0.184	0.264	0.201	0.245	0.127	0.332	0.112	0.352
Landsat Land Surface Temperature Heterogeneity	14	1	-0.096	0.371	-0.102	0.364	-0.234	0.211	-0.197	0.250	-0.064	0.414	-0.080	0.392
ASTER Dry Season Land Surface Temperature	12	1	-0.143	0.329	0.191	0.276	0.334	0.144	0.391	0.104	0.377	0.113	0.228	0.238
ASTER Dry Season Land Surface Temperature Heterogeneity	12	1	0.069	0.415	0.005	0.494	-0.197	0.270	-0.216	0.250	-0.055	0.432	-0.046	0.444
ASTER Wet Season Land Surface Temperature	14	1	-0.364	0.100	-0.064	0.414	0.077	0.396	0.149	0.306	0.147	0.309	-0.025	0.466
ASTER Wet Season Land Surface Temperature Heterogeneity	14	1	-0.031	0.459	-0.138	0.319	-0.271	0.175	-0.286	0.161	-0.232	0.212	-0.281	0.165
ASTER Land Surface Temperature Seasonality	12	1	-0.368	0.120	-0.417	0.089	-0.390	0.105	-0.387	0.107	-0.279	0.190	-0.249	0.218
NDVI Variables (High-Resolution)														
Landsat Mean NDVI, 3/16/01	14	1	0.213	0.232	0.307	0.143	0.238	0.206	0.179	0.270	0.197	0.250	0.059	0.420
ASTER Mean NDVI, Dry Season Composite Image	14	1	0.325	0.129	0.380	0.090	0.307	0.143	0.271	0.175	0.302	0.147	0.188	0.260
ASTER Mean NDVI, Wet Season Composite Image	14	1	0.267	0.178	0.260	0.185	0.154	0.300	0.117	0.345	0.137	0.320	0.069	0.408
ASTER NDVI Seasonality (Wet Season - Dry Season)	14	1	-0.264	0.181	-0.268	0.177	-0.281	0.165	-0.251	0.193	-0.279	0.167	-0.217	0.228
Tasseled Cap Transformation Indices														
Landsat Tasseled Cap Brightness Index, 3/16/01	14	2	-0.310	0.281	-0.047	0.872	-0.070	0.811	-0.095	0.748	-0.054	0.855	-0.171	0.279
Landsat Tasseled Cap Greenness Index, 3/16/01	14	1	**.489(*)**	**0.038**	**.607(*)**	**0.011**	**.582(*)**	**0.014**	**.535(*)**	**0.024**	**.583(*)**	**0.014**	0.398	0.080
Merged	11	1	**.679(*)**	**0.011**	**.630(*)**	**0.019**	**.613(*)**	**0.022**	**.556(*)**	**0.038**	**.621(*)**	**0.021**	0.435	0.091
Landsat Tasseled Cap Wetness Index, 3/16/01	14	1	0.037	0.449	-0.104	0.362	-0.059	0.421	-0.029	0.460	-0.092	0.377	0.048	0.435
ASTER Dry Season Tasseled Cap Brightness Index	12	2	-0.240	0.452	-0.028	0.932	-0.165	0.608	-0.207	0.520	-0.153	0.635	-0.182	0.570
ASTER Dry Season Tasseled Cap Greenness Index	12	1	0.184	0.284	0.278	0.191	0.086	0.395	-0.028	0.465	0.049	0.440	-0.079	0.403
ASTER Dry Season Tasseled Cap Wetness Index	12	1	-0.260	0.208	-0.335	0.144	-0.429	0.082	-0.253	0.214	-0.202	0.264	0.032	0.461
ASTER Wet Season Tasseled Cap Brightness Index	14	2	-0.337	0.239	-0.042	0.887	-0.086	0.771	-0.101	0.732	-0.085	0.774	-0.170	0.562
ASTER Wet Season Tasseled Cap Greenness Index	14	1	0.265	0.180	0.262	0.183	0.150	0.304	0.112	0.351	0.128	0.332	0.045	0.439
ASTER Wet Season Tasseled Cap Wetness Index	14	1	**-.474(*)**	**0.043**	-0.399	0.079	-0.297	0.151	-0.247	0.197	-0.276	0.169	-0.160	0.292
Modeled Soil Surface Moisture Index (From ASTER Imagery)														
Modeled Soil Moisture Index	14	1	0.165	0.286	-0.153	0.301	-0.325	0.129	-0.397	0.080	-0.373	0.095	-0.050	0.432

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Table 1e. Correlations of microfilarid infection prevalence in flightless cormorants with topographic variables.

Analysis Extent (Radius)			1km		2km		3km		4km		6km		8km	
	n	t	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p
Topographic Variables														
Mean Elevation	14	1	-0.356	0.106	-0.389	0.084	-0.394	0.082	-0.432	0.061	**-.532(*)**	**0.025**	**-.621(**)**	**0.009**
Merged (n=11, 1-tailed)											**-.587(*)**	**0.029**	**-.686(**)**	**0.010**
Mean Slope	14	1	-0.336	0.120	-0.340	0.117	-0.355	0.106	-0.382	0.089	-0.390	0.084	**-.464(*)**	**0.047**
Merged (n=11, 1-tailed)													-0.504	0.057
Mean Aspect	14	1	-0.204	0.243	-0.273	0.172	-0.291	0.156	-0.304	0.146	-0.298	0.150	-0.274	0.172
Proportion of Contiguous Land Surface Within Radius	14	1	-0.064	0.413	0.111	0.352	0.354	0.107	**.507(*)**	**0.032**	**.579(*)**	**0.015**	**.569(*)**	**0.017**
Merged (n=11, 1-tailed)									0.494	0.061	**.584(*)**	**0.030**	**.592(*)**	**0.027**

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Appendix II. Correlations of environmental variables with microfilarid infection measures.

Table 1f. Correlations of microfilarid infection prevalence in flightless cormorants with principal components.

Analysis Extent (Radius)			1km		2km		3km		4km		6km		8km	
	n	t	r	p	r	p	r	p	r	p	r	p	r	p
Data Set Principal Components														
PC1 of WORLDCLIM Temperature Variables (99.8%)	14	1	0.089	0.381	0.229	0.216	0.281	0.165	0.382	0.089	.486(*)	0.039	.579(*)	0.015
									Merged (n=11, 1-tailed)		.567(*)	0.034	.655(*)	0.014
PC1 of WORLDCLIM Precipitation Variables (98.3%)	14	1	.525(*)	0.027	.513(*)	0.030	.494(*)	0.036	.476(*)	0.043	0.455	0.051	0.408	0.074
PC1 of MODIS Land Surface Temperature Variables (96.6%)	14	1	0.279	0.167	0.284	0.163	0.381	0.089	.471(*)	0.045	.547(*)	0.021	.579(*)	0.015
									Merged (n=11, 1-tailed)		.553(*)	0.039	.611(*)	0.023
PC1 of MODIS Total Precipitable Water Vapor Variables (64.2%)	14	1	-0.014	0.481	0.083	0.388	0.027	0.464	0.045	0.439	0.032	0.456	0.037	0.450
PC2 of MODIS Total Precipitable Water Vapor Variables (31.5%)	14	1	-0.043	0.442	-0.096	0.373	-0.049	0.434	-0.060	0.419	-0.038	0.449	0.001	0.498
PC1 of MODIS NDVI Variables (87.2%)	14	1	0.378	0.092	0.293	0.155	0.176	0.273	0.097	0.371	0.140	0.316	0.059	0.421
PC2 of MODIS NDVI Variables (6.7%)	14	1	.674(**)	0.004	.498(*)	0.035	.464(*)	0.047	0.390	0.084	0.306	0.144	0.337	0.120
PC1 of Topographic Variables (86.6%)	14	1	-0.305	0.144	-0.407	0.074	-0.429	0.063	-.471(*)	0.045	-.537(*)	0.024	-.596(*)	0.012
							Merged (n=11, 1-tailed)		-.526(*)	0.048	-.609(*)	0.023	-.679(*)	0.011
PC2 of Topographic Variables (13.4%)	14	1	-0.200	0.246	-0.263	0.182	-0.243	0.202	-0.227	0.218	-0.179	0.270	-0.127	0.333
All-Layers PCA Components														
PC1 (88.5%)	14	1	0.270	0.175	0.384	0.088	0.354	0.107	0.317	0.134	0.234	0.211	0.187	0.261
PC2 (7.9%)	14	1	-0.308	0.142	-.492(*)	0.037	-.526(*)	0.027	-.545(*)	0.022	-.604(*)	0.011	-.640(**)	0.007
			Merged (n=11, 1-tailed)		-.525(*)	0.049	-.557(*)	0.038	-.575(*)	0.032	-.631(*)	0.019	-.667(*)	0.012
PC3 (3.0%)	14	1	-0.374	0.094	-0.456	0.051	-.480(*)	0.041	-.510(*)	0.031	-.511(*)	0.031	-.494(*)	0.036
			Merged (n=11, 1-tailed)		-.525(*)	0.049	-.530(*)	0.047	-.548(*)	0.040	-.563(*)	0.036	-.560(*)	0.037
PC4 (0.4%)	14	1	0.068	0.409	0.151	0.303	0.183	0.265	0.209	0.236	0.234	0.210	0.231	0.214

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Table 2a. Correlations of microfilarid intensity in infected flightless cormorants with WorldClim variables.

Analysis Extent (Radius)			1km		2km		3km		4km		6km		8km	
	n	t	r	p	r	p	r	p	r	p	r	p	r	p
WorldClim Temperature Variables														
Annual Mean Temperature	14	1	-.582(*)	0.015	-0.440	0.058	-0.411	0.072	-0.362	0.102	-0.212	0.233	0.126	0.334
Mean Temperature of the Driest Quarter	14	1	-0.094	0.374	-0.134	0.324	-0.141	0.315	-0.123	0.338	-0.088	0.383	0.043	0.442
Mean Temperature of the Wettest Quarter	14	1	-0.412	0.072	-0.377	0.092	-0.360	0.103	-0.337	0.119	-0.216	0.229	0.080	0.393
Mean Temperature of the Coldest Quarter	14	1	-.600(*)	0.012	-.471(*)	0.044	-0.438	0.059	-0.385	0.087	-0.211	0.235	0.173	0.278
Mean Temperature of the Warmest Quarter	14	1	-0.412	0.072	-0.377	0.092	-0.360	0.103	-0.337	0.119	-0.216	0.229	0.079	0.394
Minimum Temperature of the Coldest Month	14	1	-.577(*)	0.015	-0.439	0.058	-0.404	0.076	-0.346	0.113	-0.185	0.263	0.178	0.271
Maximum Temperature of the Warmest Month	14	1	-0.441	0.057	-0.454	0.052	-0.438	0.058	-0.424	0.065	-0.281	0.165	0.017	0.477
Temperature Annual Range	14	1	.542(*)	0.023	0.388	0.085	0.365	0.100	0.295	0.153	0.140	0.317	-0.230	0.215
Mean Diurnal Temperature Range	14	1	0.105	0.360	0.124	0.337	0.181	0.268	0.155	0.298	0.061	0.418	-0.193	0.254
Temperature Seasonality	14	1	-0.152	0.301	0.061	0.417	0.414	0.071	0.308	0.142	0.043	0.442	-0.352	0.108
WorldClim Precipitation Variables														
Annual Precipitation	14	1	0.204	0.242	0.218	0.227	0.238	0.206	0.239	0.206	0.222	0.223	0.104	0.361
Precipitation in the Coldest Quarter	14	1	0.104	0.362	0.143	0.313	0.189	0.259	0.189	0.259	0.166	0.285	0.018	0.476
Precipitation in the Warmest Quarter	14	1	0.281	0.165	0.291	0.156	0.307	0.143	0.301	0.148	0.279	0.167	0.178	0.272
Precipitation in the Driest Quarter	14	1	0.047	0.437	0.108	0.357	0.175	0.274	0.174	0.276	0.144	0.312	-0.046	0.437
Precipitation in the Wettest Quarter	14	1	0.281	0.165	0.291	0.156	0.307	0.143	0.303	0.146	0.283	0.163	0.176	0.274
Precipitation in the Driest Month	14	1	-0.020	0.472	0.041	0.444	0.160	0.292	0.235	0.209	0.163	0.289	-0.138	0.319
Precipitation in the Wettest Month	14	1	0.212	0.234	0.235	0.209	0.260	0.185	0.258	0.186	0.240	0.204	0.126	0.334
Precipitation Seasonality	14	1	-0.203	0.243	-0.180	0.270	-0.187	0.261	-0.185	0.263	-0.175	0.274	-0.093	0.376

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Appendix II. Correlations of environmental variables with microfilarid infection measures.

Table 2b. Correlations of microfilarid intensity in infected flightless cormorants with MODIS-derived land surface temperature variables.

Analysis Extent (Radius)			1km		2km		3km		4km		6km		8km	
	n	t	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p
Daytime Land Surface Temperature Variables														
Annual Mean Daytime Land Surface Temperature	14	1	0.077	0.397	0.000	0.499	-0.047	0.437	-0.107	0.358	-0.135	0.323	-0.107	0.358
Standard Deviation of Annual Mean	14	1	0.180	0.269	0.015	0.480	0.033	0.456	0.289	0.158	.727(**)	0.002	.490(*)	0.038
Merged (n=11, 1-tailed)											.702(**)	0.008	0.412	0.104
Warm Season Mean	14	1	0.112	0.351	0.038	0.449	0.022	0.470	-0.036	0.452	-0.049	0.434	-0.017	0.477
Standard Deviation of the Warm Season Mean	14	1	0.077	0.397	-0.181	0.267	-0.325	0.128	-0.094	0.375	0.337	0.119	0.075	0.399
Cool Season Mean	14	1	0.059	0.420	-0.015	0.480	-0.081	0.392	-0.147	0.308	-0.188	0.260	-0.166	0.286
Standard Deviation of the Cool Season Mean	14	1	0.240	0.204	0.111	0.353	0.134	0.324	0.364	0.101	.697(**)	0.003	.528(*)	0.026
Merged (n=11, 1-tailed)											.680(*)	0.011	0.470	0.072
Warmest Quarter Mean	14	1	0.150	0.304	0.058	0.422	0.052	0.430	0.012	0.484	0.011	0.485	0.027	0.463
Standard Deviation of the Warmest Quarter Mean	14	1	0.028	0.462	-0.194	0.253	-0.233	0.211	-0.042	0.443	0.200	0.246	0.085	0.387
Coolest Quarter Mean	14	1	0.044	0.440	-0.073	0.402	-0.157	0.295	-0.217	0.228	-0.232	0.213	-0.208	0.238
Standard Deviation of the Coolest Quarter Mean	14	1	0.271	0.174	0.207	0.238	0.356	0.106	.617(**)	0.009	.713(**)	0.002	.571(*)	0.017
Merged (n=11, 1-tailed)									.625(*)	0.020	.695(**)	0.009	0.499	0.059
Seasonality (Warm Mean - Cool Mean)	14	1	0.314	0.137	0.220	0.225	0.356	0.105	0.409	0.073	0.450	0.053	0.452	0.052
Seasonality (Warmest Quarter - Coldest Quarter)	14	1	0.361	0.102	0.340	0.117	0.441	0.057	.528(*)	0.026	.542(*)	0.023	.535(*)	0.024
Merged (n=11, 1-tailed)									.543(*)	0.042	.584(*)	0.030	.560(*)	0.037
Nighttime Land Surface Temperature Variables														
Annual Mean Nighttime Land Surface Temperature	14	1	-0.146	0.310	-0.182	0.267	-0.189	0.259	-0.181	0.268	-0.132	0.326	-0.018	0.476
Standard Deviation of Annual Mean	14	1	-0.022	0.471	0.122	0.338	0.239	0.206	0.318	0.134	0.330	0.125	0.283	0.163
Warm Season Mean	14	1	-0.187	0.261	-0.214	0.231	-0.207	0.239	-0.192	0.256	-0.135	0.323	0.004	0.495
Standard Deviation of the Warm Season Mean	14	1	0.003	0.495	0.149	0.306	0.308	0.142	0.377	0.092	0.423	0.066	0.399	0.079
Cool Season Mean	14	1	-0.107	0.358	-0.150	0.305	-0.169	0.282	-0.166	0.285	-0.123	0.338	-0.026	0.465
Standard Deviation of the Cool Season Mean	14	1	-0.018	0.476	0.052	0.430	0.035	0.453	0.098	0.370	0.095	0.373	0.105	0.361
Warmest Quarter Mean	14	1	-0.186	0.263	-0.232	0.212	-0.229	0.215	-0.213	0.233	-0.176	0.273	-0.053	0.429
Standard Deviation of the Warmest Quarter Mean	14	1	0.100	0.367	0.239	0.206	0.396	0.081	0.455	0.051	.459(*)	0.049	0.380	0.090
Merged (n=11, 1-tailed)											0.244	0.235		
Coolest Quarter Mean	14	1	-0.095	0.373	-0.150	0.304	-0.184	0.264	-0.200	0.246	-0.175	0.275	-0.089	0.381
Standard Deviation of the Coolest Quarter Mean	14	1	-0.094	0.374	-0.060	0.419	-0.051	0.432	0.028	0.462	0.060	0.420	0.054	0.427
Seasonality (Warm Mean - Cool Mean)	14	1	-0.168	0.283	-0.097	0.370	0.034	0.454	0.076	0.398	0.084	0.387	0.108	0.357
Seasonality (Warmest Quarter - Coldest Quarter)	14	1	-0.172	0.279	-0.153	0.300	-0.020	0.473	0.088	0.383	0.114	0.349	0.125	0.335
Land Surface Diurnal Temperature Range Variables														
Annual Mean Land Surface Diurnal Temperature Range	14	1	0.137	0.321	0.070	0.406	0.016	0.478	-0.068	0.408	-0.134	0.324	-0.154	0.300
Standard Deviation of Annual Mean	14	1	0.186	0.262	0.026	0.465	0.036	0.451	0.357	0.105	.620(**)	0.009	0.318	0.134
Merged (n=11, 1-tailed)											0.517	0.052		
Warm Season Mean	14	1	0.153	0.301	0.093	0.376	0.063	0.415	-0.022	0.470	-0.068	0.409	-0.061	0.418
Standard Deviation of the Warm Season Mean	14	1	0.052	0.430	-0.274	0.172	-.530(*)	0.026	-0.419	0.068	0.094	0.375	-0.025	0.466
Merged (n=11, 1-tailed)							-.721(**)	0.006	-.565(*)	0.035				
Cool Season Mean	14	1	0.121	0.341	0.054	0.427	-0.007	0.491	-0.089	0.382	-0.165	0.286	-0.210	0.235
Standard Deviation of the Cool Season Mean	14	1	0.247	0.197	0.160	0.292	0.218	0.227	.491(*)	0.037	.740(**)	0.001	.545(*)	0.022
Merged (n=11, 1-tailed)									0.436	0.090	.722(**)	0.006	0.467	0.074
Warmest Quarter Mean	14	1	0.185	0.263	0.108	0.357	0.056	0.424	-0.021	0.471	-0.049	0.434	-0.035	0.452
Standard Deviation of the Warmest Quarter Mean	14	1	0.185	0.264	-0.018	0.476	-0.229	0.216	-0.098	0.370	0.017	0.478	-0.045	0.439
Coolest Quarter Mean	14	1	0.094	0.375	-0.022	0.470	-0.098	0.369	-0.156	0.297	-0.197	0.250	-0.237	0.207
Standard Deviation of the Coolest Quarter Mean	14	1	0.191	0.257	0.183	0.266	0.381	0.090	.665(**)	0.005	.702(**)	0.003	.510(*)	0.031
Merged (n=11, 1-tailed)									.736(**)	0.005	.702(**)	0.008	0.427	0.095
Seasonality (Warm Mean - Cool Mean)	14	1	0.137	0.321	0.140	0.317	0.222	0.223	0.221	0.224	0.253	0.191	0.324	0.130
Seasonality (Warmest Quarter - Coldest Quarter)	14	1	0.237	0.207	0.273	0.173	0.301	0.148	0.305	0.144	0.314	0.137	0.392	0.083

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Table 2c. Correlations of microfilarid intensity in infected flightless cormorants with MODIS-derived total precipitable water vapor and NDVI variables.

Analysis Extent (Radius)			1km		2km		3km		4km		6km		8km	
	n	t	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p
Total Precipitable Water Vapor Variables														
Annual Mean Total Precipitable Water Vapor	14	1	.511(*)	0.031	0.377	0.092	0.335	0.121	0.305	0.144	0.160	0.292	0.113	0.351
Standard Deviation of Annual Mean	14	1	0.232	0.212	0.241	0.203	0.249	0.196	0.205	0.241	0.205	0.241	0.279	0.167
Wet Season Mean	14	1	.497(*)	0.035	0.386	0.086	0.362	0.102	0.348	0.111	0.239	0.205	0.200	0.246
Standard Deviation of Wet Season Mean	14	1	0.017	0.476	-0.088	0.383	-0.129	0.330	-0.177	0.272	-0.198	0.248	-0.125	0.335
Dry Season Mean	14	1	0.414	0.071	0.289	0.159	0.230	0.214	0.185	0.263	0.017	0.478	-0.028	0.462
Standard Deviation of Dry Season Mean	14	1	0.093	0.377	0.233	0.212	0.276	0.169	0.280	0.166	0.309	0.141	0.322	0.131
Wettest Quarter Mean	14	1	.517(*)	0.029	0.415	0.070	0.396	0.081	0.370	0.096	0.243	0.201	0.195	0.252
Standard Deviation of Wettest Quarter Mean	14	1	-0.016	0.478	-0.147	0.308	-0.134	0.324	-0.183	0.266	-0.158	0.295	-0.045	0.439
Driest Quarter Mean	14	1	0.265	0.180	0.127	0.333	0.073	0.402	0.024	0.468	-0.164	0.288	-0.199	0.248
Standard Deviation of Driest Quarter Mean	14	1	0.027	0.463	0.025	0.466	0.041	0.445	0.097	0.370	0.208	0.238	0.255	0.189
Seasonality (Wet Mean - Dry Mean)	14	1	0.226	0.219	0.275	0.171	0.301	0.148	0.322	0.130	0.329	0.125	0.344	0.115
Seasonality (Wettest Mean - Driest Mean)	14	1	0.353	0.108	0.416	0.069	0.433	0.061	0.439	0.058	0.412	0.071	0.395	0.081
NDVI Variables														
MODIS Annual Mean NDVI	14	1	.668(**)	0.004	.469(*)	0.045	.465(*)	0.047	.470(*)	0.045	0.445	0.055	0.205	0.241
Standard Deviation of Annual Mean	14	1	0.118	0.344	0.138	0.319	0.233	0.212	0.269	0.176	0.378	0.091	0.344	0.115
Wet Season Mean	14	1	.685(**)	0.003	.502(*)	0.034	.490(*)	0.037	.483(*)	0.040	0.439	0.058	0.194	0.253
Standard Deviation of Wet Season Mean	14	1	0.071	0.405	0.154	0.299	0.294	0.153	0.297	0.151	0.426	0.065	0.330	0.125
Dry Season Mean	14	1	.631(**)	0.008	0.415	0.070	0.419	0.068	0.439	0.058	0.434	0.061	0.212	0.233
Standard Deviation of Dry Season Mean	14	1	0.165	0.287	0.100	0.367	0.111	0.353	0.150	0.304	0.234	0.211	0.274	0.172
Wettest Quarter Mean	14	1	.606(*)	0.011	.482(*)	0.040	.522(*)	0.028	.520(*)	0.028	.460(*)	0.049	0.197	0.250
Standard Deviation of Wettest Quarter Mean	14	1	-0.190	0.258	-0.047	0.437	0.157	0.297	0.222	0.222	0.433	0.061	0.379	0.091
Driest Quarter Mean	14	1	.600(*)	0.012	0.399	0.079	0.435	0.060	.489(*)	0.038	.564(*)	0.018	0.355	0.106
Merged	14	1	.629(*)	0.019	.553(*)	0.039	.527(*)	0.048	.534(*)	0.045	.559(*)	0.037	0.260	0.220
Standard Deviation of Driest Quarter Mean	14	1	0.212	0.234	0.120	0.342	0.184	0.265	0.280	0.166	0.393	0.082	0.362	0.102
Seasonality (Wet Season - Dry Season)	14	1	0.250	0.194	0.383	0.088	0.414	0.070	0.390	0.084	0.279	0.167	0.096	0.373
Seasonality (Wettest Season - Driest Season)	14	1	0.220	0.225	0.377	0.092	.458(*)	0.050	0.404	0.076	0.205	0.241	0.013	0.482

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Appendix II. Correlations of environmental variables with microfilarid infection measures.

Table 2d. Correlations of microfilarid intensity in infected flightless cormorants with variables from higher-resolution satellite imagery

Analysis Extent (Radius)	n	t	1km *r*	1km p	2km *r*	2km p	3km *r*	3km p	4km *r*	4km p	6km *r*	6km p	8km *r*	8km p
Land Surface Temperature Variables (High-Resolution)														
Landsat Land Surface Temperature	14	1	-0.064	0.414	-0.083	0.389	-0.244	0.200	-0.290	0.157	-0.285	0.162	-0.316	0.135
Landsat Land Surface Temperature Heterogeneity	14	1	0.392	0.083	0.354	0.107	0.349	0.111	0.240	0.204	0.193	0.254	0.191	0.256
ASTER Dry Season Land Surface Temperature	12	1	-0.172	0.297	0.094	0.385	-0.087	0.394	-0.181	0.286	-0.283	0.186	-0.181	0.286
ASTER Dry Season Land Surface Temperature Heterogeneity	12	1	.517(*)	0.043	0.486	0.055	0.418	0.088	0.398	0.100	0.366	0.121	0.356	0.128
ASTER Wet Season Land Surface Temperature	14	1	0.079	0.394	0.089	0.382	-0.086	0.386	-0.227	0.217	-0.406	0.075	-0.353	0.108
ASTER Wet Season Land Surface Temperature Heterogeneity	14	1	.692(**)	0.003	.532(*)	0.025	0.397	0.080	0.373	0.095	0.288	0.159	0.199	0.248
ASTER Land Surface Temperature Seasonality	12	1	0.192	0.275	0.093	0.387	0.033	0.460	0.009	0.489	-0.055	0.433	-0.106	0.372
NDVI Variables (High-Resolution)														
Landsat Mean NDVI, 3/16/01	14	1	.595(*)	0.012	0.383	0.088	0.365	0.100	0.347	0.112	0.244	0.200	0.030	0.459
ASTER Mean NDVI, Dry Season Composite Image	14	1	.618(**)	0.009	0.434	0.060	0.419	0.068	0.402	0.077	0.353	0.108	0.134	0.324
ASTER Mean NDVI, Wet Season Composite Image	14	1	.660(**)	0.005	.493(*)	0.037	.464(*)	0.047	0.447	0.055	0.377	0.092	0.184	0.265
ASTER NDVI Seasonality (Wet Season - Dry Season)	14	1	0.188	0.260	0.277	0.169	0.266	0.179	0.287	0.160	0.222	0.223	0.168	0.283
Tasseled Cap Transformation Indices														
Landsat Tasseled Cap Brightness Index, 3/16/01	12	1	0.450	0.106	0.394	0.163	0.370	0.192	0.341	0.233	0.203	0.487	-0.016	0.956
Landsat Tasseled Cap Greenness Index, 3/16/01	14	1	0.455	0.051	0.236	0.208	0.223	0.222	0.214	0.231	0.158	0.295	0.025	0.466
Landsat Tasseled Cap Wetness Index, 3/16/01	14	1	-0.400	0.078	-0.354	0.107	-0.370	0.096	-0.358	0.105	-0.260	0.185	-0.055	0.426
ASTER Dry Season Tasseled Cap Brightness Index	12	2	0.486	0.110	0.497	0.101	0.394	0.206	0.322	0.308	0.169	0.600	0.005	0.988
ASTER Dry Season Tasseled Cap Greenness Index	12	1	.549(*)	0.032	.527(*)	0.039	.537(*)	0.036	.536(*)	0.036	0.354	0.130	-0.017	0.479
ASTER Dry Season Tasseled Cap Wetness Index	12	1	-0.254	0.213	-0.042	0.448	-0.049	0.440	-0.235	0.231	-0.165	0.304	0.192	0.276
ASTER Wet Season Tasseled Cap Brightness Index	14	2	0.520	0.057	.570(*)	0.033	0.470	0.090	0.392	0.166	0.210	0.471	0.001	0.998
ASTER Wet Season Tasseled Cap Greenness Index	14	1	.601(*)	0.011	.472(*)	0.044	.468(*)	0.046	.464(*)	0.047	0.403	0.077	0.194	0.253
ASTER Wet Season Tasseled Cap Wetness Index	14	1	-.469(*)	0.045	-0.339	0.118	-0.402	0.077	-0.439	0.058	-0.420	0.067	-0.204	0.242
Modeled Soil Moisture Index (From ASTER Imagery)														
Modeled Soil Moisture Index	14	1	-0.436	0.060	-0.409	0.073	-0.305	0.145	-0.116	0.347	0.175	0.274	0.281	0.165

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Table 2e. Correlations of microfilarid intensity in infected flightless cormorants with topographic variables.

Analysis Extent (Radius)	n	t	1km *r*	1km p	2km *r*	2km p	3km *r*	3km p	4km *r*	4km p	6km *r*	6km p	8km *r*	8km p
Topographic Variables														
Mean Elevation	14	1	0.118	0.345	0.211	0.234	0.255	0.190	0.249	0.195	0.152	0.302	-0.119	0.342
Mean Slope	14	1	0.228	0.216	0.284	0.163	0.304	0.146	0.287	0.159	0.196	0.251	0.084	0.387
Mean Aspect	14	1	-0.031	0.459	0.100	0.367	0.087	0.383	0.073	0.402	0.129	0.330	0.140	0.316
Proportion of Contiguous Land Surface Within Radius	14	1	-0.184	0.265	-0.263	0.182	-0.176	0.274	-0.103	0.363	0.007	0.490	0.038	0.449

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Table 2f. Correlations of microfilarid intensity in infected flightless cormorants with results of principal components analyses.

Analysis Extent (Radius)	n	t	1km *r*	1km p	2km *r*	2km p	3km *r*	3km p	4km *r*	4km p	6km *r*	6km p	8km *r*	8km p
Data Set Principal Components														
PC1 of WORLDCLIM Temperature Variables (99.8%)	14	1	-.525(*)	0.027	-0.430	0.062	-0.398	0.079	-0.358	0.104	-0.216	0.229	0.095	0.373
PC1 of WORLDCLIM Precipitation Variables (98.3%)	14	1	0.222	0.222	0.236	0.208	0.256	0.189	0.255	0.189	0.237	0.207	0.123	0.338
PC1 of MODIS Land Surface Temperature Variables (96.6%)	14	1	0.080	0.392	-0.013	0.482	-0.057	0.424	-0.107	0.358	-0.118	0.344	-0.088	0.383
PC1 of MODIS Total Precipitable Water Vapor Variables (64.2%)	14	1	0.377	0.092	0.293	0.155	0.242	0.202	0.174	0.276	0.033	0.455	-0.002	0.497
PC2 of MODIS Total Precipitable Water Vapor Variables (31.5%)	14	1	-.483(*)	0.040	-.469(*)	0.045	-0.456	0.051	-0.420	0.067	-0.347	0.112	-0.313	0.138
PC1 of MODIS NDVI Variables (87.2%)	14	1	.585(*)	0.014	0.451	0.053	.487(*)	0.039	.500(*)	0.034	.494(*)	0.036	0.251	0.193
PC2 of MODIS NDVI Variables (6.7%)	14	1	0.175	0.275	-0.086	0.385	-0.159	0.294	-0.127	0.332	0.012	0.484	0.113	0.350
PC1 of Topographic Variables (86.6%)	14	1	0.030	0.459	0.186	0.262	0.233	0.211	0.230	0.214	0.161	0.292	-0.064	0.414
PC2 of Topographic Variables (13.4%)	14	1	-0.022	0.470	0.089	0.381	0.049	0.434	0.016	0.478	0.091	0.379	0.194	0.254
All-Layers PCA Components														
PC1 (88.5%)	14	1	-0.159	0.294	0.107	0.358	0.212	0.233	0.244	0.200	0.237	0.208	0.067	0.409
PC2 (7.9%)	14	1	0.178	0.272	0.008	0.490	0.033	0.456	0.041	0.445	-0.003	0.496	-0.143	0.313
PC3 (3.0%)	14	1	0.053	0.428	0.085	0.386	0.044	0.440	0.006	0.492	0.053	0.428	0.091	0.378
PC4 (0.4%)	14	1	-0.159	0.294	-0.197	0.250	-0.203	0.243	-0.202	0.244	-0.232	0.213	-0.186	0.262

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Table 3a. Correlations of microfilarid infection prevalence in Galapagos penguins with WorldClim variables.

Analysis Extent (Radius)	n	t	1km *r*	1km p	2km *r*	2km p	3km *r*	3km p	4km *r*	4km p	6km *r*	6km p	8km *r*	8km p
WorldClim Temperature Variables														
Annual Mean Temperature	10	1	0.166	0.347	0.220	0.301	0.235	0.288	0.230	0.292	0.237	0.286	0.247	0.277
Mean Temperature of the Driest Quarter	10	1	0.293	0.240	0.320	0.220	0.319	0.220	0.308	0.229	0.273	0.256	0.274	0.255
Mean Temperature of the Wettest Quarter	10	1	0.246	0.278	0.249	0.276	0.255	0.271	0.241	0.282	0.246	0.279	0.258	0.268
Mean Temperature of the Coldest Quarter	10	1	0.094	0.412	0.171	0.343	0.204	0.314	0.206	0.312	0.218	0.302	0.229	0.293
Mean Temperature of the Warmest Quarter	10	1	0.246	0.278	0.249	0.276	0.255	0.271	0.244	0.280	0.251	0.274	0.265	0.263
Minimum Temperature of the Coldest Month	10	1	0.138	0.372	0.190	0.328	0.222	0.299	0.220	0.300	0.228	0.294	0.237	0.286
Maximum Temperature of the Warmest Month	10	1	0.003	0.498	0.133	0.377	0.167	0.348	0.177	0.338	0.227	0.294	0.242	0.282
Temperature Annual Range	10	1	-0.225	0.298	-0.214	0.308	-0.241	0.283	-0.232	0.290	-0.227	0.294	-0.238	0.287
Mean Diurnal Temperature Range	10	1	-0.360	0.190	-0.321	0.219	-0.305	0.231	-0.294	0.240	-0.279	0.252	-0.283	0.248
Temperature Seasonality	10	1	0.193	0.324	-0.035	0.467	-0.132	0.378	-0.155	0.357	-0.176	0.339	-0.181	0.334
WorldClim Precipitation Variables														
Annual Precipitation	10	1	0.394	0.167	0.317	0.222	0.216	0.304	0.099	0.408	0.007	0.493	-0.015	0.486
Precipitation in the Coldest Quarter	10	1	0.329	0.213	0.198	0.319	0.068	0.438	-0.038	0.464	-0.082	0.423	-0.108	0.399
Precipitation in the Warmest Quarter	10	1	0.330	0.212	0.274	0.265	0.224	0.297	0.164	0.349	0.092	0.414	0.072	0.433
Precipitation in the Driest Quarter	10	1	0.330	0.212	0.169	0.345	0.047	0.456	-0.046	0.457	-0.085	0.421	-0.113	0.395
Precipitation in the Wettest Quarter	10	1	0.330	0.212	0.274	0.265	0.206	0.312	0.128	0.362	0.052	0.452	0.030	0.472
Precipitation in the Driest Month	10	1	0.327	0.215	0.111	0.397	-0.024	0.478	-0.054	0.449	-0.099	0.407	-0.116	0.392
Precipitation in the Wettest Month	10	1	0.374	0.181	0.313	0.225	0.230	0.292	0.133	0.377	0.044	0.458	0.028	0.474
Precipitation Seasonality	10	1	-0.418	0.151	-0.379	0.177	-0.327	0.215	-0.271	0.258	-0.215	0.305	-0.191	0.325

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Appendix II. Correlations of environmental variables with microfilarid infection measures.

Table 3b. Correlations of microfilarid infection prevalence in Galapagos penguins with MODIS-derived land surface temperature variables.

Analysis Extent (Radius)			1km		2km		3km		4km		6km		8km	
	n	t	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p
Daytime Land Surface Temperature Variables														
Annual Mean Daytime Land Surface Temperature	10	1	0.390	0.132	0.541	0.053	.560(*)	0.046	.582(*)	0.039	.568(*)	0.043	.568(*)	0.043
Merged	8	1	.654(*)	0.039	.702(*)	0.026	.708(*)	0.025	.696(*)	0.028	.664(*)	0.036	.663(*)	0.037
Standard Deviation of Annual Mean	10	1	0.267	0.228	0.422	0.112	0.401	0.125	0.366	0.149	0.196	0.293	0.053	0.442
Warm Season Mean	10	1	0.343	0.166	0.497	0.072	0.512	0.065	.553(*)	0.049	.553(*)	0.049	.561(*)	0.046
Merged	8	1	.658(*)	0.038	.709(*)	0.025	.697(*)	0.027	.687(*)	0.030	.665(*)	0.036	.678(*)	0.032
Standard Deviation of the Warm Season Mean	10	1	0.437	0.103	0.545	0.052	.562(*)	0.045	0.534	0.056	0.361	0.153	0.258	0.236
Cool Season Mean	10	1	0.415	0.116	.555(*)	0.048	.578(*)	0.040	.593(*)	0.036	.572(*)	0.042	.566(*)	0.044
Merged	8	1	.643(*)	0.043	.683(*)	0.031	.699(*)	0.027	.685(*)	0.030	.650(*)	0.040	.640(*)	0.044
Standard Deviation of the Cool Season Mean	10	1	0.205	0.285	0.409	0.120	0.383	0.137	0.340	0.168	0.204	0.286	0.076	0.417
Warmest Quarter Mean	10	1	0.328	0.177	0.475	0.083	0.480	0.080	0.538	0.054	0.546	0.051	.566(*)	0.044
Merged	8	1	.690(*)	0.029	.718(*)	0.023	.693(*)	0.028	.683(*)	0.031	.669(*)	0.035	.690(*)	0.029
Standard Deviation of the Warmest Quarter Mean	10	1	0.498	0.071	.590(*)	0.036	.603(*)	0.032	.565(*)	0.044	0.442	0.101	0.371	0.146
Merged (n=8, 1-tailed)					0.536	0.085	.625(*)	0.049	.676(*)	0.033	0.600	0.058	0.474	0.118
Coolest Quarter Mean	10	1	0.404	0.123	.557(*)	0.047	.593(*)	0.035	.607(*)	0.031	.582(*)	0.039	.572(*)	0.042
Merged (n=8, 1-tailed)					.676(*)	0.033	.707(*)	0.025	.696(*)	0.028	.661(*)	0.037	.645(*)	0.042
Standard Deviation of the Coolest Quarter Mean	10	1	0.267	0.228	0.460	0.091	0.425	0.110	0.387	0.134	0.326	0.179	0.198	0.291
Seasonality (Warm Mean - Cool Mean)	10	1	-0.471	0.085	-0.405	0.123	-0.412	0.118	-0.367	0.149	-0.261	0.233	-0.213	0.278
Seasonality (Warmest Quarter - Coldest Quarter)	10	1	-0.446	0.098	-0.485	0.078	-.553(*)	0.049	-0.498	0.072	-0.385	0.136	-0.273	0.223
Nighttime Land Surface Temperature Variables														
Annual Mean Nighttime Land Surface Temperature	10	1	0.547	0.051	.574(*)	0.041	.554(*)	0.048	0.537	0.055	0.509	0.067	0.507	0.068
Standard Deviation of Annual Mean	10	1	-.598(*)	0.034	-.579(*)	0.040	-.561(*)	0.046	-.579(*)	0.040	-0.519	0.062	-0.518	0.062
Warm Season Mean	10	1	0.420	0.114	0.478	0.081	0.460	0.091	0.451	0.095	0.428	0.108	0.432	0.106
Standard Deviation of the Warm Season Mean	10	1	-0.446	0.098	-0.447	0.098	-0.389	0.133	-0.409	0.120	-0.271	0.225	-0.373	0.144
Cool Season Mean	10	1	.600(*)	0.033	.615(*)	0.029	.601(*)	0.033	.584(*)	0.038	.559(*)	0.047	.554(*)	0.048
Merged	8	1	0.334	0.209	0.393	0.168	0.426	0.146	0.439	0.138	0.465	0.123	0.493	0.108
Standard Deviation of the Cool Season Mean	10	1	-0.399	0.126	-0.463	0.089	-0.479	0.081	-0.495	0.073	-0.531	0.057	-0.530	0.058
Warmest Quarter Mean	10	1	0.282	0.215	0.356	0.156	0.345	0.165	0.355	0.157	0.334	0.173	0.350	0.161
Standard Deviation of the Warmest Quarter Mean	10	1	-0.337	0.171	-0.403	0.124	-0.368	0.148	-0.399	0.126	-0.222	0.269	-0.378	0.141
Coolest Quarter Mean	10	1	.624(*)	0.027	.636(*)	0.024	.626(*)	0.027	.610(*)	0.031	.587(*)	0.037	.579(*)	0.040
Merged	8	1	0.376	0.179	0.424	0.148	0.453	0.130	0.466	0.122	0.492	0.108	0.519	0.094
Standard Deviation of the Coolest Quarter Mean	10	1	-0.116	0.375	-0.200	0.290	-0.226	0.265	-0.254	0.240	-0.292	0.207	-0.295	0.204
Seasonality (Warm Mean - Cool Mean)	10	1	-.574(*)	0.041	-.558(*)	0.047	-.579(*)	0.040	-.565(*)	0.044	-.557(*)	0.047	-0.518	0.063
Merged	8	1	-0.390	0.170	-0.457	0.127	-0.530	0.088	-0.530	0.088	-0.513	0.097	-0.499	0.104
Seasonality (Warmest Quarter - Coldest Quarter)	10	1	-0.533	0.056	-0.536	0.055	-.562(*)	0.045	-0.549	0.050	-.556(*)	0.048	-0.509	0.066
Merged	8	1	-0.209	0.310	-0.251	0.275	-0.316	0.223	-0.326	0.215	-0.339	0.206	-0.337	0.208
Land Surface Diurnal Temperature Range Variables														
Annual Mean Land Surface Diurnal Temperature Range	10	1	0.237	0.255	0.474	0.083	0.513	0.065	.553(*)	0.049	0.538	0.054	0.536	0.055
Merged	8	1	.667(*)	0.035	.746(*)	0.017	.759(*)	0.014	.742(*)	0.018	.677(*)	0.033	.653(*)	0.040
Standard Deviation of Annual Mean	10	1	0.258	0.236	0.388	0.134	0.426	0.110	0.414	0.117	0.254	0.239	0.107	0.385
Warm Season Mean	10	1	0.254	0.239	0.466	0.088	0.499	0.071	.554(*)	0.048	0.548	0.050	.552(*)	0.049
Merged	8	1	.667(*)	0.035	.748(*)	0.016	.747(*)	0.017	.735(*)	0.019	.686(*)	0.030	.680(*)	0.032
Standard Deviation of the Warm Season Mean	10	1	0.177	0.312	0.366	0.149	0.491	0.075	0.513	0.065	0.280	0.217	0.081	0.412
Cool Season Mean	10	1	0.224	0.267	0.462	0.090	0.507	0.067	0.543	0.052	0.523	0.061	0.514	0.064
Merged	8	1	.657(*)	0.038	.730(*)	0.020	.752(*)	0.016	.735(*)	0.019	.662(*)	0.037	.624(*)	0.049
Standard Deviation of the Cool Season Mean	10	1	0.304	0.197	0.427	0.109	0.428	0.108	0.395	0.129	0.276	0.220	0.186	0.304
Warmest Quarter Mean	10	1	0.224	0.267	0.417	0.115	0.456	0.093	0.535	0.055	.553(*)	0.049	.568(*)	0.043
Merged	8	1	.631(*)	0.047	.730(*)	0.020	.744(*)	0.017	.748(*)	0.016	.714(*)	0.023	.712(*)	0.024
Standard Deviation of the Warmest Quarter Mean	10	1	0.096	0.396	0.292	0.206	0.528	0.058	0.495	0.073	0.269	0.227	-0.027	0.471
Coolest Quarter Mean	10	1	0.211	0.279	0.471	0.085	0.536	0.055	.564(*)	0.045	0.530	0.057	0.515	0.064
Merged	8	1	.644(*)	0.042	.744(*)	0.017	.788(*)	0.010	.766(*)	0.013	.683(*)	0.031	.634(*)	0.046
Standard Deviation of the Coolest Quarter Mean	10	1	0.304	0.197	0.439	0.102	0.400	0.126	0.356	0.156	0.266	0.228	0.168	0.321
Seasonality (Warm Mean - Cool Mean)	10	1	-0.052	0.443	-0.108	0.383	-0.127	0.363	-0.119	0.372	-0.107	0.384	-0.105	0.387
Seasonality (Warmest Quarter - Coldest Quarter)	10	1	-0.087	0.406	-0.276	0.220	-0.379	0.140	-0.380	0.140	-0.278	0.218	-0.201	0.289

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Table 3c. Correlations of microfilarid infection prevalence in Galapagos penguins with MODIS-derived total precipitable water vapor and NDVI variables.

Analysis Extent (Radius)			1km		2km		3km		4km		6km		8km	
	n	t	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p
Total Precipitable Water Vapor Variables														
Annual Mean Total Precipitable Water Vapor	10	1	-0.286	0.211	0.099	0.393	-0.381	0.139	-0.365	0.150	-0.310	0.192	-0.261	0.233
Merged (n=8, 1-tailed)											-.662(*)	0.037	-.678(*)	0.032
Standard Deviation of Annual Mean	10	1	-0.165	0.325	-0.100	0.392	-0.108	0.383	-0.162	0.328	-0.158	0.331	-0.173	0.316
Merged (n=8, 1-tailed)													-.625(*)	0.049
Wet Season Mean	10	1	-0.362	0.152	-0.376	0.142	-0.423	0.112	-0.412	0.118	-0.376	0.142	-0.350	0.161
Merged (n=8, 1-tailed)									-.627(*)	0.048	-.673(*)	0.034	-.699(*)	0.027
Standard Deviation of Wet Season Mean	10	1	-0.046	0.450	-0.001	0.499	-0.001	0.499	-0.007	0.492	0.041	0.455	0.048	0.447
Dry Season Mean	10	1	-0.144	0.345	-0.181	0.308	-0.259	0.235	-0.223	0.268	-0.128	0.362	-0.058	0.437
Standard Deviation of Dry Season Mean	10	1	0.325	0.180	0.406	0.122	0.377	0.142	0.284	0.214	0.201	0.289	0.150	0.340
Merged (n=8, 1-tailed)									-.624(*)	0.049	-.668(*)	0.035	-.679(*)	0.032
Wettest Quarter Mean	10	1	-0.266	0.229	-0.279	0.217	-0.326	0.179	-0.319	0.185	-0.276	0.220	-0.257	0.237
Standard Deviation of Wettest Quarter Mean	10	1	-0.231	0.261	-0.241	0.251	-0.278	0.219	-0.305	0.195	-0.269	0.226	-0.272	0.223
Driest Quarter Mean	10	1	-0.309	0.193	-0.343	0.166	-0.409	0.120	-0.389	0.134	-0.272	0.223	-0.184	0.306
Standard Deviation of Driest Quarter Mean	10	1	0.157	0.333	0.206	0.284	0.145	0.344	0.089	0.403	-0.077	0.416	-0.209	0.281
Merged (n=8, 1-tailed)									-.667(*)	0.035	-.715(*)	0.023	-.716(*)	0.023
Seasonality (Wet Mean - Dry Mean)	10	1	-0.432	0.106	-0.401	0.126	-0.414	0.117	-0.417	0.115	-0.430	0.107	-0.442	0.100
Seasonality (Wettest Mean - Driest Mean)	10	1	-0.137	0.353	-0.110	0.382	-0.148	0.342	-0.163	0.326	-0.168	0.322	-0.188	0.302
NDVI Variables														
MODIS Annual Mean NDVI	10	1	-0.013	0.486	-0.134	0.357	-0.174	0.315	-0.205	0.285	-0.221	0.270	-0.279	0.217
Standard Deviation of Annual Mean	10	1	0.006	0.493	-0.148	0.341	-0.186	0.303	-0.208	0.282	-0.212	0.278	-0.223	0.268
Wet Season Mean	10	1	-0.074	0.419	-0.173	0.316	-0.214	0.276	-0.238	0.254	-0.255	0.239	-0.311	0.191
Standard Deviation of Wet Season Mean	10	1	-0.063	0.432	-0.190	0.299	-0.256	0.238	-0.252	0.242	-0.262	0.232	-0.286	0.212
Dry Season Mean	10	1	0.085	0.408	-0.066	0.428	-0.108	0.383	-0.145	0.345	-0.155	0.335	-0.205	0.285
Standard Deviation of Dry Season Mean	10	1	0.111	0.380	-0.078	0.415	-0.079	0.414	-0.123	0.368	-0.120	0.371	-0.107	0.385
Wettest Quarter Mean	10	1	-0.022	0.476	-0.115	0.376	-0.159	0.330	-0.186	0.304	-0.202	0.288	-0.246	0.246
Standard Deviation of Wettest Quarter Mean	10	1	0.131	0.359	0.034	0.463	-0.067	0.428	-0.098	0.393	-0.177	0.312	-0.269	0.226
Driest Quarter Mean	10	1	0.016	0.482	-0.132	0.358	-0.152	0.337	-0.200	0.290	-0.232	0.259	-0.285	0.213
Standard Deviation of Driest Quarter Mean	10	1	-0.009	0.490	-0.184	0.306	-0.135	0.355	-0.181	0.308	-0.168	0.321	-0.120	0.371
Seasonality (Wet Season - Dry Season)	10	1	-0.345	0.165	-0.363	0.151	-0.401	0.125	-0.382	0.138	-0.367	0.149	-0.376	0.142
Seasonality (Wettest Season - Driest Season)	10	1	-0.059	0.436	-0.086	0.407	-0.152	0.338	-0.158	0.332	-0.159	0.330	-0.176	0.313

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Appendix II. Correlations of environmental variables with microfilarid infection measures.

Table 3d. Correlations of microfilarid infection prevalence in Galapagos penguins with variables from higher-resolution satellite imagery.

Analysis Extent (Radius)			1km		2km		3km		4km		6km		8km	
	n	t	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p
Land Surface Temperature Variables (High-Resolution)														
Landsat Land Surface Temperature	10	1	0.269	0.226	0.359	0.154	0.386	0.135	0.412	0.118	0.479	0.080	0.513	0.065
Landsat Land Surface Temperature Heterogeneity	10	1	-0.007	0.492	-0.130	0.360	-0.191	0.298	-0.213	0.278	-0.258	0.236	-0.205	0.285
ASTER Dry Season Land Surface Temperature	7	1	-0.197	0.336	0.041	0.465	0.131	0.390	0.134	0.388	0.178	0.351	0.281	0.270
ASTER Dry Season Land Surface Temperature Heterogeneity	7	1	0.433	0.166	0.009	0.493	-0.131	0.389	-0.238	0.303	-0.196	0.337	-0.220	0.318
ASTER Wet Season Land Surface Temperature	9	1	0.194	0.309	0.369	0.164	0.412	0.135	0.435	0.121	0.479	0.098	0.472	0.100
ASTER Wet Season Land Surface Temperature Heterogeneity	9	1	-0.045	0.454	-0.324	0.198	-0.353	0.176	-0.409	0.137	-0.387	0.151	-0.342	0.184
ASTER Land Surface Temperature Seasonality	7	1	0.144	0.379	-0.347	0.223	-0.344	0.225	-0.204	0.331	-0.141	0.382	-0.372	0.205
NDVI Variables (High-Resolution)														
Landsat Mean NDVI, 3/16/01	10	1	-0.163	0.327	-0.240	0.253	-0.250	0.243	-0.258	0.236	-0.270	0.225	-0.323	0.181
ASTER Mean NDVI, Dry Season Composite Image	10	1	-0.130	0.360	-0.223	0.268	-0.235	0.257	-0.249	0.244	-0.259	0.235	-0.303	0.198
ASTER Mean NDVI, Wet Season Composite Image	10	1	-0.110	0.381	-0.200	0.290	-0.203	0.287	-0.205	0.285	-0.190	0.299	-0.209	0.281
ASTER NDVI Seasonality (Wet Season - Dry Season)	10	1	-0.024	0.474	0.046	0.449	0.029	0.469	0.007	0.493	0.008	0.491	0.036	0.461
Tasseled Cap Transformation Indices														
Landsat Tasseled Cap Brightness Index, 3/16/01	10	1	-0.348	0.324	-0.354	0.315	-0.346	0.328	-0.339	0.338	-0.344	0.330	-0.380	0.279
Landsat Tasseled Cap Greenness Index, 3/16/01	10	1	0.002	0.497	-0.085	0.407	-0.094	0.398	-0.100	0.392	-0.109	0.383	-0.130	0.360
Landsat Tasseled Cap Wetness Index, 3/16/01	10	1	0.228	0.263	0.195	0.295	0.220	0.270	0.236	0.256	0.205	0.285	0.224	0.267
ASTER Dry Season Tasseled Cap Brightness Index	7	2	-0.039	0.934	-0.021	0.964	-0.087	0.426	-0.109	0.816	-0.105	0.823	-0.130	0.781
ASTER Dry Season Tasseled Cap Greenness Index	7	1	0.054	0.455	-0.066	0.444	-0.083	0.430	-0.101	0.415	-0.128	0.392	-0.172	0.356
ASTER Dry Season Tasseled Cap Wetness Index	7	1	-0.075	0.436	-0.005	0.496	0.013	0.489	0.044	0.462	0.094	0.420	0.144	0.379
ASTER Wet Season Tasseled Cap Brightness Index	10	1	-0.514	0.157	-0.493	0.178	-0.491	0.179	-0.494	0.176	-0.478	0.193	-0.501	0.169
ASTER Wet Season Tasseled Cap Greenness Index	10	1	-0.251	0.257	-0.350	0.178	-0.366	0.166	-0.377	0.158	-0.391	0.149	-0.430	0.124
ASTER Wet Season Tasseled Cap Wetness Index	10	1	0.171	0.330	0.245	0.262	0.281	0.232	0.297	0.219	0.314	0.205	0.359	0.171
Modeled Soil Surface Moisture Index (From ASTER Imagery)														
Modeled Soil Moisture Index	10	1	-0.054	0.445	-0.297	0.219	-0.409	0.137	-0.461	0.106	-0.567	0.056	-0.497	0.087

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Table 3e. Correlations of microfilarid infection prevalence in Galapagos penguins with topographic variables.

Analysis Extent (Radius)			1km		2km		3km		4km		6km		8km	
	n	t	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p
Topographic Variables														
Mean Elevation	8	1	-0.066	0.433	-0.103	0.396	-0.125	0.374	-0.129	0.370	-0.140	0.360	-0.131	0.369
Mean Slope	8	1	-0.119	0.380	-0.173	0.328	-0.196	0.307	-0.217	0.287	-0.234	0.272	-0.231	0.275
Mean Aspect	8	1	-0.224	0.281	-0.414	0.134	-0.478	0.096	-0.466	0.103	-0.533	0.070	-0.548	0.063
Proportion of Contiguous Land Surface Within Radius	10	1	0.338	0.170	0.370	0.146	0.436	0.104	0.484	0.078	0.536	0.055	**.562(*)**	**0.045**
											Merged (n=8, 1-tailed)		0.495	0.106

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Table 3f. Correlations of microfilarid prevalence in Galapagos penguins with results of principal components analyses.

Analysis Extent (Radius)			1km		2km		3km		4km		6km		8km	
	n	t	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p
Data Set Principal Components														
PC1 of WORLDCLIM Temperature Variables (99.8%)	8	1	0.192	0.324	0.233	0.289	0.245	0.280	0.237	0.286	0.242	0.282	0.252	0.274
PC1 of WORLDCLIM Precipitation Variables (98.3%)	8	1	0.380	0.176	0.307	0.230	0.216	0.304	0.107	0.400	0.018	0.483	-0.004	0.496
PC1 of MODIS Land Surface Temperature Variables (96.6%)	10	1	0.389	0.133	0.534	0.056	**.553(*)**	**0.049**	**.577(*)**	**0.040**	**.566(*)**	**0.044**	**.569(*)**	**0.043**
Merged	8	1	**.632(*)**	**0.046**	**.684(*)**	**0.031**	**.689(*)**	**0.029**	**.679(*)**	**0.032**	**.657(*)**	**0.038**	**.662(*)**	**0.037**
PC1 of MODIS Total Precipitable Water Vapor Variables (64.2%)	10	1	-0.280	0.216	-0.337	0.170	-0.406	0.122	-0.377	0.141	-0.271	0.225	-0.179	0.310
PC2 of MODIS Total Precipitable Water Vapor Variables (31.5%)	10	1	0.301	0.199	0.325	0.180	0.361	0.153	0.340	0.168	0.316	0.187	0.301	0.199
PC1 of MODIS NDVI Variables (87.2%)	10	1	-0.022	0.476	-0.141	0.349	-0.183	0.306	-0.213	0.277	-0.233	0.259	-0.287	0.211
PC2 of MODIS NDVI Variables (6.7%)	10	1	0.213	0.278	0.129	0.362	0.191	0.299	0.171	0.319	0.161	0.328	0.159	0.330
PC1 of Topographic Variables (86.6%)	10	1	-0.147	0.343	-0.174	0.315	-0.165	0.324	-0.150	0.340	-0.148	0.342	-0.132	0.358
PC2 of Topographic Variables (13.4%)	10	1	-0.286	0.211	-0.465	0.088	-0.435	0.105	-0.337	0.170	-0.295	0.204	-0.286	0.211
All-Layers PCA Components														
PC1 (88.5%)	8	1	0.436	0.104	0.406	0.122	0.340	0.168	0.274	0.222	0.175	0.314	0.158	0.332
PC2 (7.9%)	8	1	-0.500	0.070	-0.527	0.059	-0.481	0.080	-0.436	0.104	-0.400	0.126	-0.387	0.135
PC3 (3.0%)	8	1	-0.102	0.390	-0.182	0.307	-0.181	0.308	-0.153	0.337	-0.169	0.321	-0.176	0.313
PC4 (0.4%)	8	1	-0.007	0.492	0.166	0.324	0.232	0.259	0.245	0.247	0.290	0.208	0.308	0.193

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Table 4a. Correlations of microfilarid intensity in infected Galapagos Penguins with WorldClim variables.

Analysis Extent (Radius)			1km		2km		3km		4km		6km		8km	
	n	t	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p
WorldClim Temperature Variables														
Annual Mean Temperature	7	1	0.199	0.334	0.213	0.323	0.225	0.314	0.219	0.318	0.210	0.325	0.194	0.338
Mean Temperature of the Driest Quarter	7	1	-0.047	0.461	0.032	0.473	0.057	0.451	0.078	0.434	0.077	0.435	0.052	0.456
Mean Temperature of the Wettest Quarter	7	1	0.209	0.326	0.222	0.316	0.225	0.314	0.219	0.318	0.216	0.321	0.202	0.332
Mean Temperature of the Coldest Quarter	7	1	0.147	0.377	0.196	0.337	0.217	0.320	0.210	0.325	0.206	0.329	0.189	0.343
Mean Temperature of the Warmest Quarter	7	1	0.209	0.326	0.222	0.316	0.225	0.314	0.219	0.318	0.216	0.321	0.202	0.332
Minimum Temperature of the Coldest Month	7	1	0.176	0.353	0.208	0.327	0.225	0.314	0.215	0.322	0.210	0.326	0.192	0.340
Maximum Temperature of the Warmest Month	7	1	0.075	0.437	0.140	0.382	0.156	0.369	0.155	0.370	0.176	0.353	0.157	0.368
Temperature Annual Range	7	1	-0.234	0.306	-0.237	0.305	-0.249	0.295	-0.232	0.308	-0.217	0.320	-0.199	0.335
Mean Diurnal Temperature Range	7	1	-0.297	0.259	-0.278	0.273	-0.275	0.275	-0.256	0.290	-0.240	0.302	-0.221	0.317
Temperature Seasonality	7	1	-0.045	0.461	-0.155	0.370	-0.194	0.339	-0.196	0.337	-0.192	0.340	-0.171	0.357
WorldClim Precipitation Variables														
Annual Precipitation	7	1	-0.061	0.448	-0.125	0.395	-0.172	0.356	-0.195	0.338	-0.199	0.334	-0.187	0.344
Precipitation in the Coldest Quarter	7	1	-0.265	0.283	-0.342	0.226	-0.356	0.217	-0.308	0.251	-0.258	0.288	-0.242	0.301
Precipitation in the Warmest Quarter	7	1	0.094	0.421	0.040	0.466	0.004	0.497	-0.034	0.471	-0.068	0.442	-0.060	0.449
Precipitation in the Driest Quarter	7	1	-0.276	0.275	-0.341	0.227	-0.337	0.230	-0.284	0.269	-0.248	0.296	-0.237	0.305
Precipitation in the Wettest Quarter	7	1	0.094	0.421	0.040	0.466	-0.010	0.491	-0.059	0.450	-0.095	0.420	-0.090	0.424
Precipitation in the Driest Month	7	1	-0.281	0.271	-0.322	0.241	-0.361	0.213	-0.286	0.267	-0.217	0.320	-0.211	0.325
Precipitation in the Wettest Month	7	1	0.052	0.456	-0.010	0.492	-0.069	0.441	-0.116	0.402	-0.148	0.376	-0.140	0.382
Precipitation Seasonality	7	1	0.211	0.324	0.246	0.297	0.288	0.266	0.294	0.261	0.285	0.268	0.258	0.288

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Appendix II. Correlations of environmental variables with microfilarid infection measures.

Table 4b. Correlations of microfilarid intensity in infected Galapagos Penguins with MODIS-derived land surface temperature variables.

Analysis Extent (Radius)			1km		2km		3km		4km		6km		8km	
	n	t	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p
Daytime Land Surface Temperature Variables														
Annual Mean Daytime Land Surface Temperature	8	1	0.334	0.210	0.312	0.226	0.288	0.245	0.296	0.238	0.301	0.234	0.281	0.250
Standard Deviation of Annual Mean	8	1	0.340	0.205	0.370	0.183	0.366	0.186	0.348	0.199	0.185	0.331	0.062	0.442
Warm Season Mean	8	1	0.425	0.147	0.358	0.192	0.318	0.222	0.316	0.223	0.328	0.214	0.313	0.225
Standard Deviation of the Warm Season Mean	8	1	0.393	0.168	0.444	0.135	0.509	0.099	0.489	0.109	0.242	0.282	0.107	0.400
Cool Season Mean	8	1	0.268	0.261	0.273	0.257	0.262	0.265	0.282	0.249	0.288	0.245	0.263	0.265
Standard Deviation of the Cool Season Mean	8	1	0.277	0.253	0.313	0.225	0.299	0.236	0.275	0.255	0.143	0.368	0.038	0.464
Warmest Quarter Mean	8	1	0.375	0.180	0.313	0.225	0.295	0.239	0.315	0.223	0.334	0.209	0.311	0.227
Standard Deviation of the Warmest Quarter Mean	8	1	0.439	0.138	0.529	0.089	0.543	0.082	0.445	0.134	0.333	0.210	0.290	0.243
Coolest Quarter Mean	8	1	0.278	0.253	0.250	0.275	0.237	0.286	0.264	0.264	0.271	0.258	0.244	0.280
Standard Deviation of the Coolest Quarter Mean	8	1	0.261	0.266	0.355	0.194	0.422	0.149	0.433	0.142	0.304	0.232	0.139	0.371
Seasonality (Warm Mean - Cool Mean)	8	1	0.382	0.175	0.304	0.232	0.269	0.260	0.244	0.280	0.313	0.225	0.317	0.222
Seasonality (Warmest Quarter - Coldest Quarter)	8	1	-0.016	0.485	0.041	0.461	0.102	0.405	0.134	0.376	0.235	0.288	0.236	0.287
Nighttime Land Surface Temperature Variables														
Annual Mean Nighttime Land Surface Temperature	8	1	0.448	0.133	0.429	0.144	0.406	0.159	0.387	0.171	0.352	0.196	0.325	0.216
Standard Deviation of Annual Mean	8	1	-0.205	0.313	-0.352	0.197	-0.449	0.132	-0.525	0.091	-0.459	0.126	-0.345	0.201
Warm Season Mean	8	1	0.409	0.157	0.417	0.152	0.401	0.162	0.389	0.170	0.359	0.191	0.331	0.211
Standard Deviation of the Warm Season Mean	8	1	0.027	0.474	-0.245	0.279	-0.415	0.153	-0.569	0.070	-0.570	0.070	-0.399	0.164
Cool Season Mean	8	1	0.475	0.117	0.438	0.139	0.408	0.158	0.384	0.174	0.346	0.201	0.320	0.219
Standard Deviation of the Cool Season Mean	8	1	-0.284	0.248	-0.306	0.231	-0.332	0.211	-0.343	0.203	-0.359	0.192	-0.359	0.192
Warmest Quarter Mean	8	1	0.341	0.204	0.357	0.193	0.333	0.210	0.317	0.222	0.294	0.240	0.269	0.260
Standard Deviation of the Warmest Quarter Mean	8	1	-0.020	0.481	-0.177	0.337	-0.234	0.288	-0.302	0.233	-0.279	0.252	-0.218	0.302
Coolest Quarter Mean	8	1	0.429	0.144	0.397	0.165	0.371	0.183	0.347	0.200	0.309	0.228	0.283	0.249
Standard Deviation of the Coolest Quarter Mean	8	1	-0.488	0.110	-0.462	0.124	-0.477	0.116	-0.461	0.125	-0.412	0.155	-0.396	0.166
Seasonality (Warm Mean - Cool Mean)	8	1	-0.480	0.114	-0.376	0.179	-0.302	0.234	-0.218	0.302	-0.124	0.385	-0.058	0.446
Seasonality (Warmest Quarter - Coldest Quarter)	8	1	-0.328	0.214	-0.307	0.230	-0.326	0.215	-0.287	0.245	-0.187	0.328	-0.134	0.376
Land Surface Diurnal Temperature Range Variables														
Annual Mean Land Surface Diurnal Temperature Range	8	1	0.213	0.306	0.213	0.307	0.207	0.311	0.240	0.284	0.263	0.264	0.246	0.279
Standard Deviation of Annual Mean	8	1	0.283	0.249	0.345	0.201	0.358	0.192	0.318	0.221	0.136	0.374	0.010	0.491
Warm Season Mean	8	1	0.365	0.187	0.313	0.225	0.288	0.244	0.292	0.241	0.310	0.227	0.291	0.242
Standard Deviation of the Warm Season Mean	8	1	0.370	0.183	0.457	0.127	0.495	0.106	0.366	0.186	-0.021	0.481	-0.126	0.383
Cool Season Mean	8	1	0.121	0.388	0.142	0.369	0.150	0.361	0.203	0.315	0.231	0.291	0.215	0.305
Standard Deviation of the Cool Season Mean	8	1	0.237	0.286	0.303	0.233	0.323	0.218	0.298	0.237	0.193	0.324	0.119	0.390
Warmest Quarter Mean	8	1	0.286	0.246	0.190	0.326	0.203	0.315	0.239	0.284	0.284	0.248	0.272	0.257
Standard Deviation of the Warmest Quarter Mean	8	1	0.187	0.329	0.451	0.131	0.538	0.085	0.381	0.176	0.027	0.475	-0.032	0.470
Coolest Quarter Mean	8	1	0.148	0.364	0.121	0.387	0.137	0.373	0.196	0.321	0.225	0.296	0.208	0.310
Standard Deviation of the Coolest Quarter Mean	8	1	0.232	0.290	0.334	0.210	0.386	0.172	0.373	0.181	0.274	0.256	0.147	0.364
Seasonality (Warm Mean - Cool Mean)	8	1	0.432	0.143	0.395	0.166	0.392	0.168	0.312	0.226	0.265	0.263	0.233	0.289
Seasonality (Warmest Quarter - Coldest Quarter)	8	1	0.140	0.371	0.087	0.419	0.098	0.409	0.035	0.467	0.064	0.440	0.075	0.430

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Table 4c. Correlations of microfilarid intensity in infected Galapagos Penguins with MODIS-derived total precipitable water vapor and NDVI variables.

Analysis Extent (Radius)			1km		2km		3km		4km		6km		8km	
	n	t	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p
Total Precipitable Water Vapor Variables														
Annual Mean Total Precipitable Water Vapor	8	1	-0.067	0.437	0.164	0.349	0.037	0.465	0.124	0.385	0.325	0.216	0.363	0.188
Standard Deviation of Annual Mean	8	1	0.020	0.482	0.028	0.474	0.013	0.488	0.003	0.497	0.115	0.393	0.113	0.395
Wet Season Mean	8	1	0.058	0.446	0.083	0.422	0.136	0.374	0.195	0.321	0.322	0.218	0.342	0.203
Standard Deviation of Wet Season Mean	8	1	-0.311	0.227	-0.371	0.183	-0.406	0.159	-0.410	0.157	-0.297	0.238	-0.257	0.269
Dry Season Mean	8	1	-0.219	0.302	-0.184	0.331	-0.121	0.388	-0.032	0.470	0.201	0.316	0.245	0.279
Standard Deviation of Dry Season Mean	8	1	0.008	0.492	0.334	0.209	0.379	0.177	0.419	0.150	0.465	0.123	0.481	0.114
Wettest Quarter Mean	8	1	0.025	0.477	0.022	0.479	0.045	0.458	0.077	0.428	0.129	0.381	0.097	0.410
Standard Deviation of Wettest Quarter Mean	8	1	0.156	0.356	0.127	0.382	0.047	0.456	0.022	0.479	0.225	0.296	0.242	0.282
Driest Quarter Mean	8	1	-0.360	0.191	-0.322	0.218	-0.279	0.252	-0.210	0.309	-0.005	0.495	0.042	0.461
Standard Deviation of Driest Quarter Mean	8	1	0.100	0.407	0.419	0.151	0.553	0.077	**.636(*)**	**0.045**	0.600	0.058	0.549	0.079
							Merged (n=6, 1-tailed)		0.698	0.062				
Seasonality (Wet Mean - Dry Mean)	8	1	0.283	0.249	0.268	0.260	0.231	0.291	0.233	0.289	0.179	0.336	0.122	0.387
Seasonality (Wettest Mean - Driest Mean)	8	1	0.259	0.268	0.215	0.305	0.162	0.351	0.145	0.366	0.073	0.432	0.019	0.482
NDVI Variables														
MODIS Annual Mean NDVI	8	1	-0.547	0.080	-0.354	0.195	-0.254	0.272	-0.255	0.271	-0.259	0.268	-0.256	0.271
Standard Deviation of Annual Mean	8	1	-0.512	0.098	-0.446	0.134	-0.338	0.207	-0.363	0.188	-0.401	0.162	-0.388	0.173
Wet Season Mean	8	1	-0.516	0.095	-0.349	0.198	-0.255	0.271	-0.253	0.273	-0.258	0.269	-0.260	0.267
Standard Deviation of Wet Season Mean	8	1	-0.558	0.075	-0.477	0.116	-0.348	0.199	-0.351	0.197	-0.376	0.180	-0.375	0.180
Dry Season Mean	8	1	-0.584	0.064	-0.357	0.192	-0.249	0.276	-0.257	0.269	-0.256	0.270	-0.235	0.288
Standard Deviation of Dry Season Mean	8	1	-0.437	0.140	-0.374	0.180	-0.269	0.260	-0.335	0.209	-0.389	0.170	-0.331	0.211
Wettest Quarter Mean	8	1	-0.493	0.107	-0.344	0.202	-0.259	0.268	-0.257	0.270	-0.260	0.267	-0.265	0.263
Standard Deviation of Wettest Quarter Mean	8	1	-0.566	0.072	-0.415	0.153	-0.201	0.317	-0.228	0.294	-0.301	0.234	-0.328	0.214
Driest Quarter Mean	8	1	**-.635(*)**	**0.045**	-0.392	0.168	-0.261	0.266	-0.278	0.253	-0.265	0.263	-0.216	0.304
Standard Deviation of Driest Quarter Mean	8	1	-0.460	0.126	-0.362	0.189	-0.200	0.317	-0.271	0.258	-0.308	0.229	-0.235	0.287
Seasonality (Wet Season - Dry Season)	8	1	-0.359	0.192	-0.313	0.225	-0.253	0.273	-0.235	0.288	-0.243	0.281	-0.254	0.272
Seasonality (Wettest Season - Driest Season)	8	1	-0.305	0.231	-0.265	0.263	-0.238	0.285	-0.222	0.299	-0.234	0.289	-0.242	0.282

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Appendix II. Correlations of environmental variables with microfilarid infection measures.

Table 4d. Correlations of microfilarid intensity in infected Galapagos Penguins with variables based on higher-resolution satellite imagery.

Analysis Extent (Radius)			1km		2km		3km		4km		6km		8km	
	n	t	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p
Land Surface Temperature Variables (High-Resolution)														
Landsat Land Surface Temperature	8	1	0.412	0.155	0.362	0.189	0.316	0.223	0.323	0.218	0.355	0.194	0.379	0.177
Landsat Land Surface Temperature Heterogeneity	8	1	-0.044	0.459	-0.289	0.244	-0.268	0.261	-0.255	0.271	-0.253	0.273	-0.270	0.259
ASTER Dry Season Land Surface Temperature	6	1	0.304	0.279	0.205	0.349	0.189	0.360	0.178	0.368	0.198	0.353	0.149	0.389
ASTER Dry Season Land Surface Temperature Heterogeneity	6	1	-0.589	0.109	-0.481	0.167	-0.351	0.247	-0.319	0.269	-0.312	0.274	-0.399	0.217
ASTER Wet Season Land Surface Temperature	7	1	0.219	0.318	0.149	0.375	0.116	0.402	0.141	0.382	0.173	0.356	0.114	0.403
ASTER Wet Season Land Surface Temperature Heterogeneity	7	1	-0.532	0.109	-0.359	0.214	-0.241	0.302	-0.197	0.336	-0.220	0.318	-0.211	0.325
ASTER Land Surface Temperature Seasonality	6	1	-0.612	0.098	-0.143	0.394	-0.068	0.449	0.193	0.357	0.228	0.332	0.121	0.410
NDVI Variables (High-Resolution)														
Landsat Mean NDVI, 3/16/01	8	1	-0.482	0.114	-0.282	0.250	-0.213	0.306	-0.199	0.318	-0.187	0.328	-0.187	0.329
ASTER Mean NDVI, Dry Season Composite Image	8	1	-0.380	0.176	-0.205	0.313	-0.149	0.362	-0.138	0.372	-0.148	0.364	-0.145	0.366
ASTER Mean NDVI, Wet Season Composite Image	8	1	-0.368	0.185	-0.264	0.264	-0.218	0.302	-0.210	0.309	-0.202	0.315	-0.191	0.326
ASTER NDVI Seasonality (Wet Season - Dry Season)	8	1	-0.324	0.217	-0.413	0.155	-0.375	0.180	-0.346	0.201	-0.297	0.238	-0.303	0.233
Tasseled Cap Transformation Indices														
Landsat Tasseled Cap Brightness Index, 3/16/01	8	2	-0.490	0.218	-0.323	0.434	-0.283	0.497	-0.253	0.545	-0.234	0.577	-0.241	0.566
Landsat Tasseled Cap Greenness Index, 3/16/01	8	1	-0.296	0.238	-0.186	0.330	-0.137	0.373	-0.145	0.366	-0.141	0.370	-0.129	0.381
Landsat Tasseled Cap Wetness Index, 3/16/01	8	1	0.417	0.152	0.293	0.240	0.260	0.267	0.247	0.277	0.238	0.285	0.242	0.282
ASTER Dry Season Tasseled Cap Brightness Index	6	2	-0.453	0.367	-0.198	0.707	-0.189	0.719	-0.114	0.829	-0.011	0.983	0.018	0.972
ASTER Dry Season Tasseled Cap Greenness Index	6	1	-0.391	0.222	-0.240	0.324	-0.208	0.347	-0.204	0.349	-0.208	0.346	-0.187	0.361
ASTER Dry Season Tasseled Cap Wetness Index	6	1	0.363	0.240	0.223	0.336	0.155	0.385	0.160	0.381	0.192	0.358	0.183	0.364
ASTER Wet Season Tasseled Cap Brightness Index	7	2	-0.427	0.339	-0.232	0.617	-0.205	0.659	-0.149	0.750	-0.069	0.883	-0.033	0.944
ASTER Wet Season Tasseled Cap Greenness Index	7	1	-0.314	0.246	-0.194	0.338	-0.169	0.359	-0.172	0.356	-0.172	0.356	-0.153	0.371
ASTER Wet Season Tasseled Cap Wetness Index	7	1	0.263	0.285	0.149	0.375	0.114	0.404	0.118	0.401	0.125	0.395	0.097	0.418
Modeled Soil Surface Moisture Index (From ASTER Imagery)														
Modeled Soil Moisture Index	7	1	0.017	0.486	0.111	0.406	0.070	0.441	0.017	0.486	-0.066	0.444	0.098	0.417

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Table 4e. Correlations of microfilarid intensity in infected Galapagos Penguins with topographic variables.

Analysis Extent (Radius)			1km		2km		3km		4km		6km		8km	
	n	t	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p
Topographic Variables														
Mean Elevation	7	1	-0.185	0.345	-0.232	0.308	-0.249	0.295	-0.247	0.297	-0.238	0.304	-0.220	0.318
Mean Slope	7	1	-0.233	0.307	-0.271	0.278	-0.271	0.278	-0.264	0.284	-0.260	0.287	-0.253	0.292
Mean Aspect	7	1	0.031	0.473	0.111	0.407	0.093	0.421	0.296	0.259	0.328	0.236	0.336	0.231
Proportion of Contiguous Land Surface Within Radius	8	1	0.223	0.298	0.218	0.302	0.209	0.310	0.219	0.301	0.229	0.293	0.247	0.277

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient

Table 4f. Correlations of microfilarid intensity in infected Galapagos penguins with results of principal components analyses.

Analysis Extent (Radius)			1km		2km		3km		4km		6km		8km	
	n	t	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p	*r*	p
Principal Components of Data Sets														
PC1 of WORLDCLIM Temperature Variables (99.8%)	7	1	0.121	0.398	0.169	0.358	0.186	0.344	0.187	0.344	0.188	0.343	0.171	0.357
PC1 of WORLDCLIM Precipitation Variables (98.3%)	7	1	-0.017	0.485	-0.079	0.433	-0.128	0.392	-0.162	0.364	-0.177	0.352	-0.167	0.360
PC1 of MODIS Land Surface Temperature Variables (96.6%)	8	1	0.341	0.204	0.314	0.225	0.294	0.240	0.304	0.232	0.311	0.227	0.290	0.243
PC1 of MODIS Total Precipitable Water Vapor Variables (64.2%)	8	1	-0.272	0.257	-0.184	0.332	-0.169	0.345	-0.075	0.430	0.188	0.328	0.211	0.308
PC2 of MODIS Total Precipitable Water Vapor Variables (31.5%)	8	1	-0.130	0.380	-0.137	0.373	-0.114	0.394	-0.156	0.356	-0.150	0.361	-0.150	0.361
PC1 of MODIS NDVI Variables (87.2%)	8	1	-0.553	0.078	-0.380	0.176	-0.274	0.255	-0.279	0.252	-0.294	0.240	-0.300	0.235
PC2 of MODIS NDVI Variables (6.7%)	8	1	0.041	0.462	0.091	0.415	0.134	0.376	0.105	0.402	0.120	0.388	0.139	0.372
PC1 of Topographic Variables (86.6%)	8	1	-0.095	0.411	-0.156	0.356	-0.191	0.325	-0.180	0.335	-0.174	0.340	-0.154	0.358
PC2 of Topographic Variables (13.4%)	8	1	-0.023	0.478	0.056	0.447	0.071	0.434	0.201	0.317	0.207	0.311	0.190	0.326
All-Layers PCA Components														
PC1 (88.5%)	8	1	0.145	0.366	0.067	0.438	0.002	0.498	-0.035	0.467	-0.076	0.429	-0.071	0.434
PC2 (7.9%)	8	1	-0.221	0.299	-0.262	0.266	-0.270	0.259	-0.271	0.258	-0.258	0.268	-0.242	0.282
PC3 (3.0%)	8	1	0.175	0.339	0.201	0.316	0.209	0.310	0.371	0.183	0.400	0.163	0.391	0.169
PC4 (0.4%)	8	1	-0.058	0.446	-0.062	0.442	0.007	0.494	-0.027	0.475	0.028	0.474	0.018	0.483

(*) Correlation is significant at the 0.05 level; (**) Correlation is significant at the 0.01 level; n=number of sites assessed; t=1-tailed or 2-tailed test; *r*=Pearson's correlation coefficient