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Mapping the Potential Distribution of *Bandicota indica*, Vector of Zoonoses in Thailand, by Use of Remote Sensing and Geographic Information Systems (a Case of Nakhon Pathom Province)

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ABSTRACT.– Space technologies have been used increasingly for assessing the risk of infection by vector-borne diseases, providing tools for delimiting the distribution of vectors. As rodent-borne diseases are a growing concern in Thailand since the emergence of leptospirosis starting in 1998, this study was set up to determine the hazard, related to the potential presence of the main rodent with medical importance, *Bandicota indica* (Bechstein, 1800), the great bandicoot rat, widely distributed in the country. It was conducted in Nakhon Pathom province (west of Bangkok, Thailand) following a large rodent sampling. Habitats of *Bandicota indica* were delimited using a Landsat 5 Thematic Mapper image and Multiscope remote sensing software (Fleximage, France). Environmental variables, related to its ecology, were identified by describing the place and surroundings of each capture. An extrapolation to the entire province could generate the potential distribution of Bandicoot rats. This delineation helped at first to improve further sampling of *Bandicota indica* and adapt the model to other study areas. Furthermore it allowed developing researches on the dynamics of rodents and the risk of transmission of rodent-borne diseases.

KEY WORDS: Rodents, *Bandicota indica*, geographic information system, remote sensing, Thailand

INTRODUCTION

Predicting epidemics is a great challenge for epidemiologists regarding the emergence or re-emergence of infectious diseases. The use of remote sensing and geographic information

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systems are tools of great potential for a near real-time linkage between epidemiology and environmental characteristics. Beside disease incidence and prevalence in vectors and hosts, geography is a main source of information for epidemiological studies, making a link between environmental and social approaches. Space technologies - Geographic Information System (GIS), Remote Sensing (RS) and Global Positioning Systems (GPS) - are therefore becoming more widely used in this field, especially for the monitoring of tropical diseases (de Lepper et al. 1995; Gatrell, 1999).

The historical association of wild animals - especially rodents - with some human endemic diseases is well documented. Rodents are known as major vectors and reservoirs of several zoonotic diseases of various aetiologies (Acha et al., 1980): viral (hantavirus, arenavirus or haemorrhagic fevers), bacterial (pestis, leptospirosis, plague), rickettsial or parasitic (helminthiasis). The transmission occurs either directly, by contaminating food with urine or faeces (i.e. leptospirosis) or indirectly such as fleas biting first an infected rat and then a person (i.e. plague), or even by airborne transmission (i.e. hantaviruses). The occurrence of an infectious zoonosis at either endemic or epidemic situation is directly linked to the presence and emergence of its vector and/or reservoir. However knowledge concerning the enzootic nature of such diseases in relation to the ecology of rodent vectors and even more the understanding of the environmental changes that make a disease emerge has rarely been studied (Glass et al., 2000).

Since 1995 Thailand has reported a rapid increase in incidences of leptospirosis, with very high incidences in 2000 (14,287 cases and 362 deaths) and 2001 (10,114 cases and 168 deaths) and a decrease later, according to the Ministry of Public Health (Weekly Epidemiological Reports). Researches on leptospirosis in Thailand have dealt with the assessment of human prevalence and a search for risk factors (Tangkanakul, 2000). Other emerging rodent-borne diseases include scrub typhus and hantaviruses, which have been documented in the recent years. Hantavirus circulation, a causative agents of hemorrhagic fever with renal syndrome, has been demonstrated (Nitatpattana et al., 2000) and human cases of hantaviruses related diseases have also recently been recorded (Suputthamongkol et al. 2005) in Thailand, while worldwide, epidemics occurred mainly in North America (Boone et al., 2000).

This study deals with the identification and delineation of one of the main rodents receiving attention from the medical community in Thailand, *Bandicota indica* (Bechstein, 1800), in order to assess the human exposure to rodent-borne diseases. *Bandicota indica* (Great Bandicoot) is a large-size rat (average morphology of the samples: head+body = 235 mm, tail = 191 mm), common in lowland rice fields (Boonsong et al., 1988; Chaimanee, 1998; Aplin et al., 2003). This species, found throughout Southeast Asia, immigrated recently into Thailand with the development of agriculture. Great Bandicoot rats are now major pests in agricultural and urban settings (Nowak, 1983) and involved in the transmission of diseases, especially leptospirosis. They usually dig large burrows at the edge of fields, as they are good swimmers and divers. In Thailand, people hunt them for food, increasing the risk of getting infected.

MATERIALS AND METHODS

Field Site

By its location, connecting the Asian continent to the Indo-Malayan peninsula, Thailand benefits from a large diversity of geographical and climatic characteristics resulting in a great biodiversity. Populations of rodents reflect this richness with a large variety of species, in every biotope. Nakhon Pathom province is located in the central plain of Thailand, 56km to the west of Bangkok

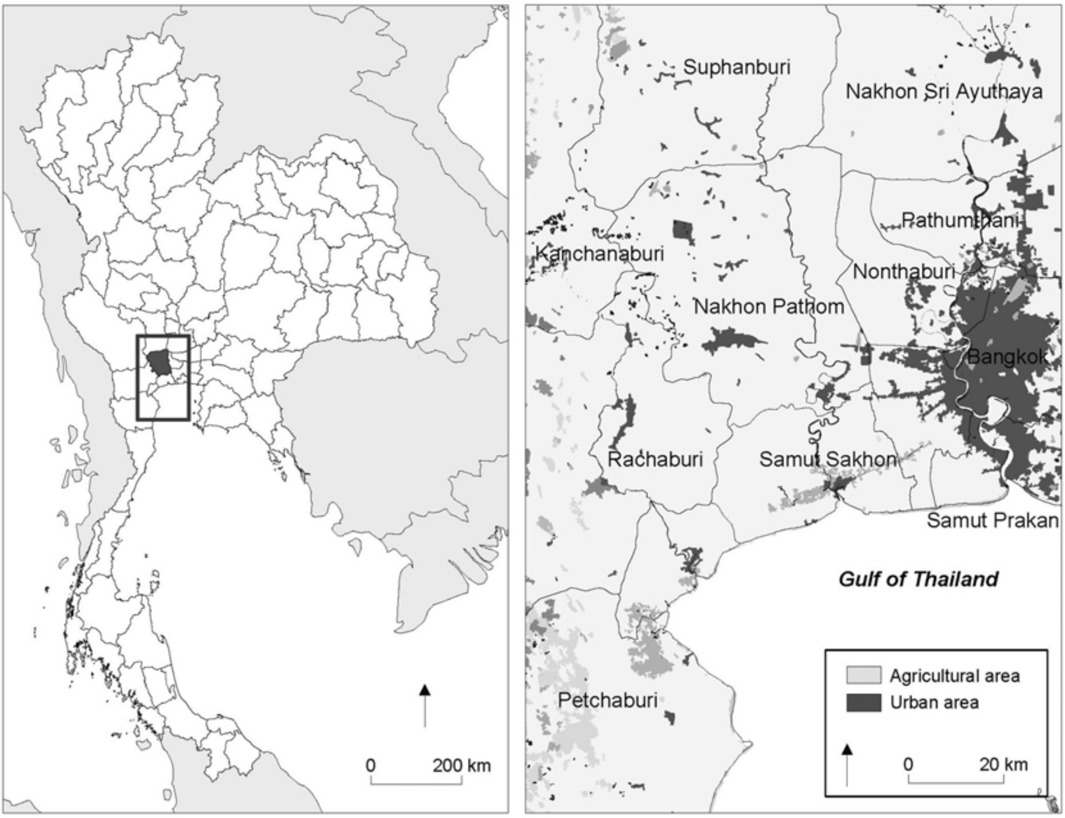


FIGURE 1. Location of Nakhon Pathom Province in Thailand

metropolitan area (Figure 1). The proximity of the capital and its flat topography helped the development of an intensive rice production and aquaculture over the 2,168.327 sq. km of the province. Nakhon Pathom is organized in seven districts (amphoes) and 104 sub-districts (tambons).

Sampling of Rodents

Rodents were trapped in 1998 and 1999 within eight different zones, which were geographically referenced by their centre with a global positioning system (GPS). Around these eight centre points, live traps with similar baits were arranged within a radius of 20 metres, inside or outside houses. The time trapping was equal in each site. Data recorded for each rodent trapped, included morphological data, age (juvenile or mature), sex, origin and ecological data describing the environmental location of the trap. Several biological specimens were taken for further analysis (serology, virus isolation). Eighteen species of rats or mice were described among the 428 rodents trapped in Nakhon Pathom. *Bandicota indica* was the main species (172 specimens) and consequently considered for this study.

Image Data

Few studies have used remotely sensed data for forecasting rodent-borne diseases. Remote sensing was used to link environmental conditions with Hantavirus Pulmonary Syndrome risk the following year, in the south-western United States (Glass, 2000) and environmental data with Sin Nombre virus infections in Nevada and California (Boone, 2000). Satellite sensor images provide synoptic

TABLE 1. Repartition of the land use classes (according to their size in hectares) and number of *Bandicota indica* trapped at each catching site

Land use classes	Surface area of each land use class in catching sites (ha)								Total
	1	2	3	4	5	6	7	8	
Grasslands	-	-	-	-	62.4	-	-	-	62.4
Bare lands	58.9	3.4	-	-	-	-	-	-	62.3
Crops	-	-	0.6	293.5	-	-	8.3	-	302.4
Flooded fields	34.6	20.2	67.0	3.2	22.1	-	12.0	144.3	303.4
Mixed agriculture	96.3	168.5	124.5	15.9	92.6	-	1.1	-	498.9
Paddy	-	20.7	-	-	-	-	182.9	168.2	371.8
Suburban	123.3	-	11.2	-	85.8	-	6.3	-	226.6
Urban and built-up lands	-	52.5	108.3	-	6.6	312.5	0.2	-	480.1
Other classes (where rodents cannot live)	0.9	48.7	2.4	1.4	44.5	1.5	103.2	1.5	204.1
Total site area	**314**	**314**	**314**	**314**	**314**	**314**	**314**	**314**	**2512**
Rodents trapped (/ site)	**41**	**9**	**70**	**46**	**4**	**0**	**2**	**0**	**172**

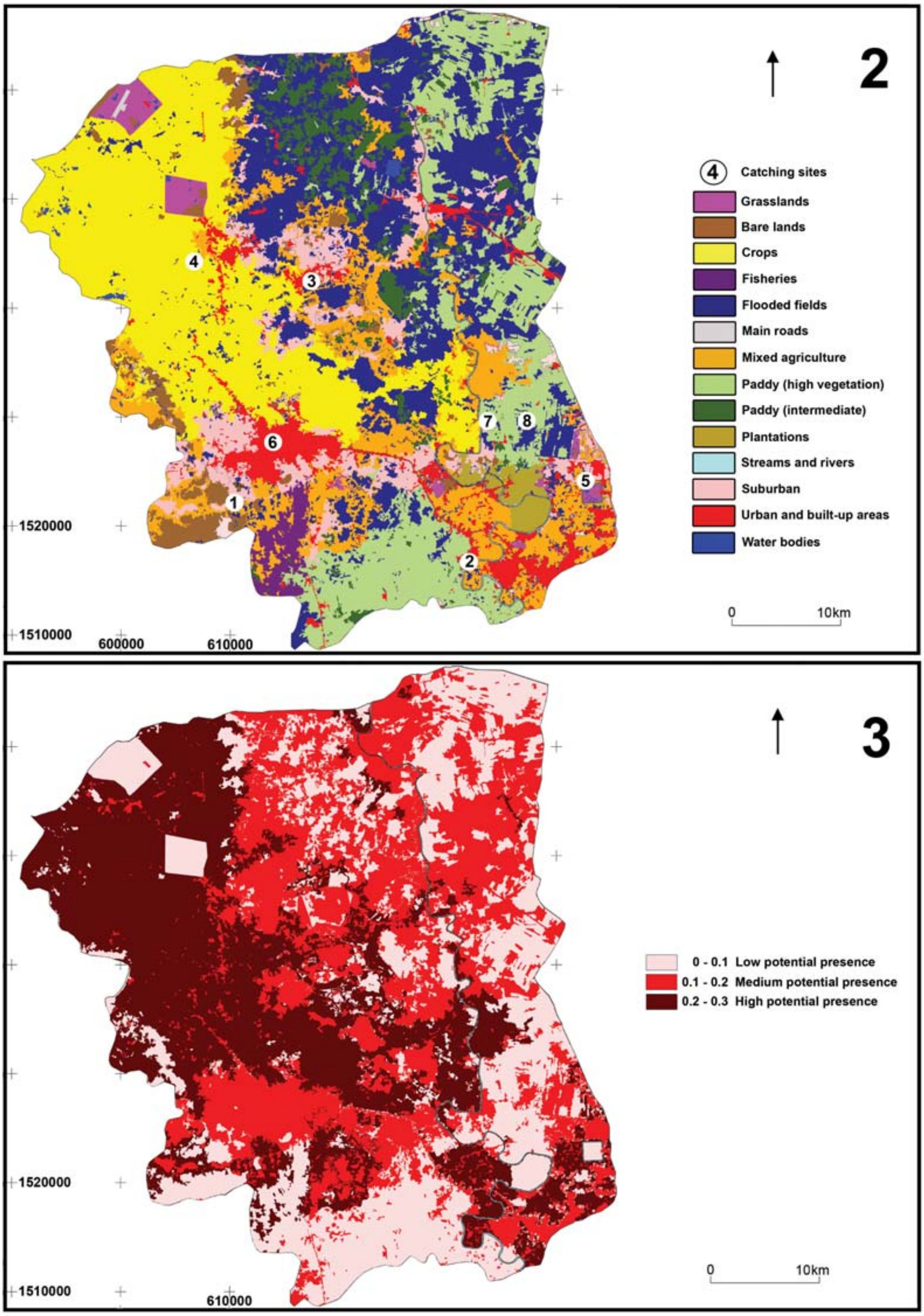
views allowing a structural description of the land cover and then the interpretation of the land use, hydrology, elevation and human occurrence. All these variables contribute to the epidemiology of rodent-borne diseases by determining the ecology of the vectors. Therefore we analysed a satellite sensor image to extract the spatial organization of the land cover and then interpret it as land use classes. A near cloud-free Landsat 5 Thematic Mapper (TM) image, acquired on 11th June 1997, was kindly provided by NRCT (National Research Council of Thailand). The spatial resolution of this image, i.e. 30 meters per pixel, is quite low but conveniently related to the large study area, allowing the delineation of land use classes.

Extraction of the Land Use Characteristics from a Satellite Sensor Image

In order to integrate the land use cover into a GIS within the hazard analysis framework, this cover should show, in each polygon, coherent regions, which express characteristics of the presence of *Bandicota indica*. The image was analyzed using Multiscope 3.1, remote sensing software developed by Fleximage - EADS Matra. The land use was divided in 14 classes, characteristic of possible rodent habitats, according to the land use observed during field surveys. The name of each class comes from the land use classification realized by the Thai Department of Land Development. Multiscope 3.1 allows the definition of homogeneous areas around a selected pixel using an algorithm based on a comparison of the RGB (red-green-blue) value, intensity value or hue value of the selected pixel with its neighbourhood. This layer was then vectorized and exported into SavGIS, a GIS software developed by IRD.

Assessment of the Potential Presence of **Bandicota indica**

The living area of one rodent is estimated to be within a one-kilometre radius of the trap. Land use characteristics were extracted and described around the 8 catching sites by creating buffers in the land use layer. At each catching site, information was recorded regarding: 1) the number of rodents caught and, 2) a description of the land use within each buffer (314 hectares corresponding to a one-kilometre radius) by giving the repartition of each land use class (Table 1). In order to associate *Bandicota indica* species with the repartition of each land use class, we intersected these two datasets by calculating the sum for each site of the proportion of area occupied by the given class multiplied by the proportion of rats trapped in this site. For each land use class, we obtained the index using the following formula: Bi-index = $\sum(i=1 \text{ to } 8)$ {[(Si) / (St)] * [(Ri) / (Rt)]} with: Si = Surface



FIGURES 2-3. (**2**) Land use classification in Nakhon Pathom province (extracted from Landsat 5 TM image, 11/06/97). (**3**) Potential presence of *Bandicota indica* in Nakhon Pathom province

area of the given land use class inside site "i"; St = total surface area per site (= 314 ha); Ri = number of rodents trapped inside site "i"; Rt = total number of rodents trapped (= 172).

Then we used this index, weighted by the percentage of rats found in each class of land use, to assess the potential presence of *Bandicota indica*.

RESULTS

The province of Nakhon Pathom appears mainly as agricultural fields (83.5% of the total area) and dedicated to rice production (Fig. 2). The three classes of paddy fields (i.e. flooded fields, paddy (intermediate) and paddy (high vegetation)), grouped together, represent 42.5% of the total surface area. Considering the ecology of *Bandicota indica*, its potential presence is directly assessed from the type of land use. It is a field species (74.5% of all rodents trapped), which is rarely found around (21%) or inside houses (4.5%). The index assessing its potential presence, Bi-index, in each land use class takes values from 0 to 0.283 (Table 2) with the maximum for the "mixed agriculture" class, meaning a high probability to find *Bandicota indica*. Using the map of land use and this index, we created the map of potential presence of *Bandicota indica* in Nakhon Pathom province (Fig. 3). This map expresses its ecology as a field rat. The first class (27.6% of all surfaces), which describes the areas with a low presence of *Bandicota indica*, corresponds to grasslands, plantations and wetlands. The second one (35.7% of all surfaces) groups together urban and suburban areas. We observed during the sampling that *Bandicota indica* is also attracted by the human presence, which provides for rodents the opportunity to find food. The last class (36.6% of all surfaces) represents the agricultural fields themselves (crops or paddy) and some heterogeneous areas in transition between agricultural and urban classes. These areas are often bare lands or classified into mixed agriculture and are places where rats will find refuge in proximity of larger fields.

TABLE 2. Index for the potential presence of *Bandicota indica* (Bi-index)

Land use classes	Bi-index
Grasslands	0.005
Bare lands	0.045
Crops	0.251
Flooded fields	0.121
Mixed agriculture	0.283
Paddy	0.010
Suburban	0.115
Urban and built-up lands	0.150
Others	0.020
Total	**1.000**

DISCUSSION

Regarding the variety of the land use classes, the low number of catching points can be a limiting factor for the accuracy of the description of rodent biotopes. Further samplings in the same province will probably help to improve the model.

The method used in this research can be extended and applied to other wild species even other genus or families and furthermore to study rodent-borne diseases (i.e. leptospirosis, scrub typhus, hantavirus related diseases). It also can be extended to other regions with different biotopes for mapping the distribution of the same species.

The next step of the ongoing study will be to integrate this approach in a predictive model of rodent-borne disease epidemics. Space imageries and technologies take a great part in this model by describing the presence of the reservoirs or vectors. By processing these analyses at different dates we should be able to show the dynamics of rodents and better understand their implications for the emergence of diseases.

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