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# Census versus Capture-recapture Method to Estimate Dog Population in Lumlukka District, Pathum Thani Province, Thailand, 2010

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**Abstract**

Although reliable data for dog population is essential for designing an effective strategy for rabies vaccination, it is difficult to precisely estimate the dog population, especially the stray dogs. This study estimated the dog population by census and capture-recapture method (CR), characterized dog population, described practicality and feasibility, and estimated the rabies vaccination coverage. Ten urban and rural areas in Lumlukka District, Pathum Thani Province were randomly selected. Results showed that stray dog population from census was lower than CR estimates in both urban and rural areas. The census showed that the majority of dogs were confined owned dogs in the urban area (70%) and unconfined owned dogs in the rural area (96%). The stray dog population from census was 8.0% in the urban and 4.4% in the rural areas. Rabies vaccination coverage among dogs in the urban was 84% and in the rural was 65%. Although CR method used less time and people than census, it was more complicated. The census method might underestimate the number of stray dogs while the CR failed to include the confined owned dogs. Therefore, the census method could be a preferable method to collect data of owned dogs and CR could provide a better estimate of stray dog population. Both methods could be used to monitor the rabies control program and plan for effective strategy to eradicate rabies in Thailand.

*Keywords*: Capture-recapture, census, dog population, rabies, vaccination coverage, Thailand

## Introduction

Rabies is a zoonosis with almost 100% fatality in both humans and animals. Human deaths due to rabid dog bite occurred mostly in developing countries.[1] Over 96% of the reported rabies cases in animals were dogs while about 95% of human rabies deaths were from the bite of rabid dogs.[2] World Health Organization (WHO) recommends immunization of at least 70% of dog population in each area in order to reach a herd immunity level to prevent rabies outbreaks, along with the integrated management approach such as dog population control and public education.[3]

In Thailand, the first human rabies was reported during 1929. Over the past three decades, the number of human and dog rabies cases have dramatically decreased as a result of the national rabies control program.[4] However, there has been continuous occurrence of rabies infection among dogs and humans.[5] Between January 2008 to 2010, a total of 47 confirmed human rabies cases were reported[6] while there were 489 animal rabies cases from January 2009 to June 2010, with 90% of them were dogs[7]. Major constraints to rabies control in Thailand included failure to reach the national goal of 80% rabies vaccination coverage in dogs, lack of effective dog population management and control, and limited participation of certain local administrations. Furthermore, the current vaccination campaign in dogs was restricted by lack of accurate information on targeted dog population and social-economic factors which might in turn influence owners' decision to vaccinate their dogs.[8]

It is essential to improve population management and rabies vaccination campaigns in dogs to achieve the ultimate goal of rabies free area. Reliable estimates of

size and composition of the entire dog population are necessary to plan for effective control activities. Conducting a census is the standard method to estimate dog population size and composition while other methods are registration and identification. Nevertheless, these methods tend to omit estimates of stray dog population. Stray dogs are common and constitute a significant proportion of dog population in many developing countries, including Thailand which accounted for 70-80% of dogs that bite humans. Studies in Philippines[9], Japan[10] and Sri Lanka[11] applied the capture-recapture method (CR), a method developed to estimate wild animal population. CR is now used to estimate dog population in settings with large number of stray dogs. This approach was used to estimate dog population in Songkhla Province, Thailand as well[12]. The principal aims of this study were to characterize and estimate the dog population by census and CR, determine rabies vaccination coverage in Lumlukka District, Pathum Thani Province, and describe practicality and feasibility of the CR method.

## Methods

The study area was Lumlukka District in Pathum Thani Province which ranked the second highest number of animal rabies cases in 2009, with 30% of cases in Lumlukka District.[7] This district covers 297.7 km$^2$, and comprises of 49 communities in the urban municipal area (0.2 km$^2$) and 103 villages in the rural area (2.6 km$^2$). A total of 10 areas were randomly selected, including five communities in the urban area and five villages in the rural area.

All domestic dogs in Lumlukka District were included in this study. Dogs were classified into two main groups: the owned dog and the stray dog. An owned dog was defined as a dog that belonged to and was regularly fed by a household. It was then subdivided further into either a confined owned dog which was totally confined or let roam free for less than two hours a day, or an unconfined owned dog which was allowed to roam free for two hours or more per day. A stray dog referred to a dog without any defined owner.

### Census Survey

Data of households and a map of selected communities and villages were obtained from Lumlukka Administration Office. Dog population census was performed by interviewing the dog owners at home or a public site in the village. Data on number of dogs in household, gender, breed, type, confinement, and history of rabies vaccination and surgical sterilization were collected. In addition, a rabies vaccination campaign was set up and dogs were provided with rabies vaccination at a public site in the village. The census was conducted in two days, including one working day and a day in weekend as an effort to boost cooperation from dog owners in the communities and villages. Stray dogs were identified by observing and interviewing people in the communities or villages.

The dogs included in the census survey were photographed, and collars with different colors were put on them to differentiate between owned and stray dogs on the same day (Figure 1). A photograph was taken to confirm the identity of each dog in case dogs

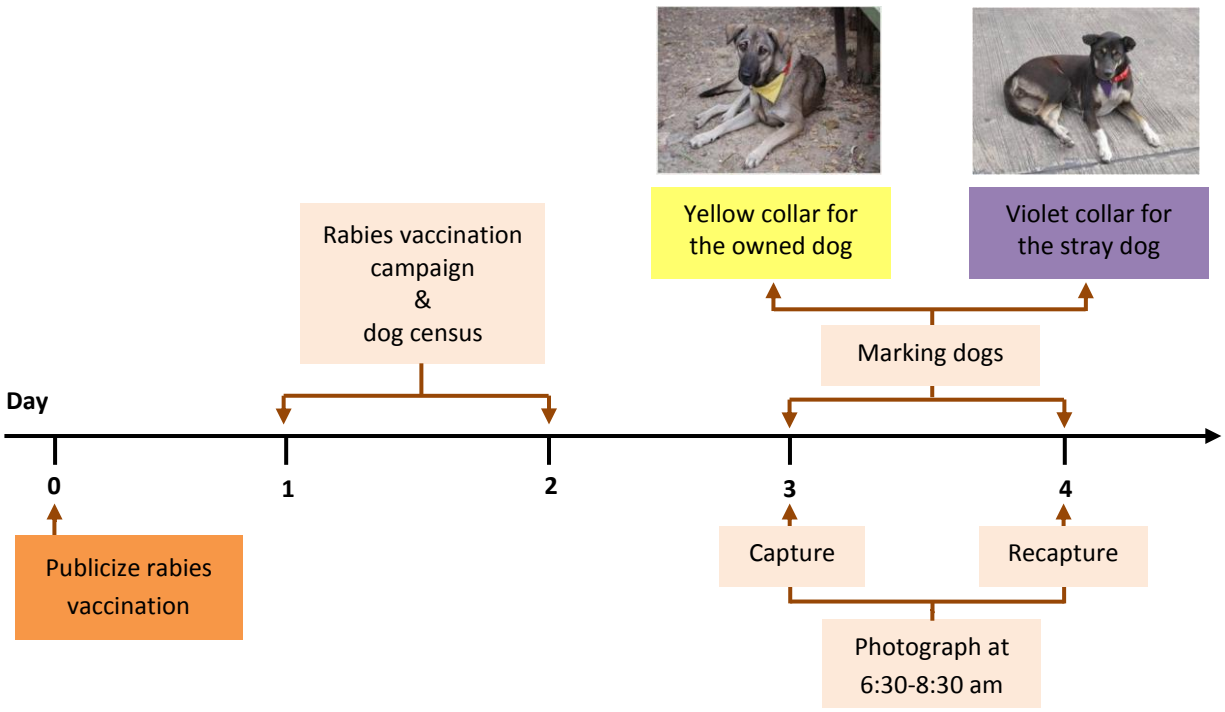


**Figure 1. Diagram illustrating steps and workflow of dog population survey by census and capture-recapture method in Lumlukka District, Pathum Thani Province, Thailand, 2010**

would lose the collars or when there was an aggressive dog that no one could put a collar on.

### Capture-recapture (CR) Method

After the census survey, the CR was conducted for two consecutive days. Capture (by photograph) took place on the first day at 6:30-8:30 am when most stray dogs were present in the public areas[10]. The researcher photographed any visible dogs while walking through the communities or villages. Locations and number of dog were also recorded. Similar activities were repeated at the same period of time on the second day for recapture. Dogs were then identified by characteristics, including type of fur, body, tail and color seen in the photographs as well as color of the collar. However, confined owned dogs were not included in the CR since the method only allows counting the dogs that can be captured outside the houses while the researcher was walking across the community.

The number of dogs derived between capture and recapture were differentiated, counted and recorded. Information on time spent and the number of staff assisting in each survey method was also recorded.

### Data Analysis

Information obtained was characterized and vaccination coverage was estimated. The time spent and man-power used for both survey methods per study site were described by person-hours (the number of staff multiplied by working hours for each person). An estimated dog population by CR ($\hat{N}$) was calculated with 95% CI using the Chapman estimator from the survey toolbox[12].

$$\hat{N} = \frac{(n+1)(M+1)}{(m+1)} - 1$$

where
M = Total number of dog found on the 1st day (Capture)
n = Total number of dogs found on the 2nd day (Recapture)
m = Number of dogs found on both days

The percent difference (% Difference) between estimates from census and CR data was calculated by the below formula.[13]

$$\% \text{ Difference} = \frac{N_C - N_{CR}}{N_C} \times 100$$

where
$N_C$ = Census population
$N_{CR}$ = Estimated population from CR

## Results

### Characteristics of Dog Population and Rabies Vaccination Coverage

The census estimated a total of 1,680 dogs in 10 study sites, including 820 dogs in the urban area and 860 dogs in the rural area. In the urban area, majority of the owned dogs were confined (69.6%) which was in contrast with the rural area where all of them were reported as unconfined (95.6%). The stray dogs found in the urban and rural areas were 8.0% and 4.4% respectively. Medium-sized dogs (approximate 11-25 kg) were most common in both areas. Surgically sterilized dogs were accounted for 22.2% in the urban and 5.2% in the rural areas (Table 1). The age-sex population pyramid showed that most dogs aged between one day to two years, followed by 2-4 years (Figure 2).

**Table 1. Characteristics of dogs in Lumlukka District, Pathum Thani Province, Thailand, 2010 (n=1,680)**

| Characteristic | Urban | | Rural | |
|---|---|---|---|---|
| | Number | Percent | Number | Percent |
| Gender (n=1,599) | | | | |
| Male | 422 | 53.6 | 430 | 53.0 |
| Female | 366 | 46.4 | 381 | 47.0 |
| Type of dog | | | | |
| Confined owned | 571 | 69.6 | 0 | 0 |
| Unconfined owned | 183 | 22.3 | 822 | 95.6 |
| Stray | 66 | 8.0 | 38 | 4.4 |
| Breed (n=1,667) | | | | |
| Large | 31 | 3.8 | 9 | 1.0 |
| Medium | 584 | 72.4 | 784 | 91.2 |
| Small | 192 | 23.8 | 67 | 7.8 |
| Received rabies vaccination in the previous year | | | | |
| Yes | 621 | 75.7 | 505 | 58.7 |
| No | 115 | 14.0 | 271 | 31.5 |
| Do not know | 84 | 10.2 | 84 | 9.8 |
| Surgically sterilized | | | | |
| Yes | 182 | 22.2 | 45 | 5.2 |
| No | 542 | 66.1 | 755 | 87.8 |
| Do not know | 96 | 11.7 | 60 | 7.0 |

Rabies vaccination coverage in the previous year was 84.4% in the urban and 65.1% in the rural areas. The vaccine coverages in the urban and rural areas were similarly low for unconfined owned dogs (66-67%) and stray dogs (45-48%). However, the owned dogs had vaccination coverage higher than the stray dogs in both urban (OR = 8.39, 95% CI = 4.67-15.07) and rural (OR = 2.07, 95% CI = 0.93-4.60) areas,

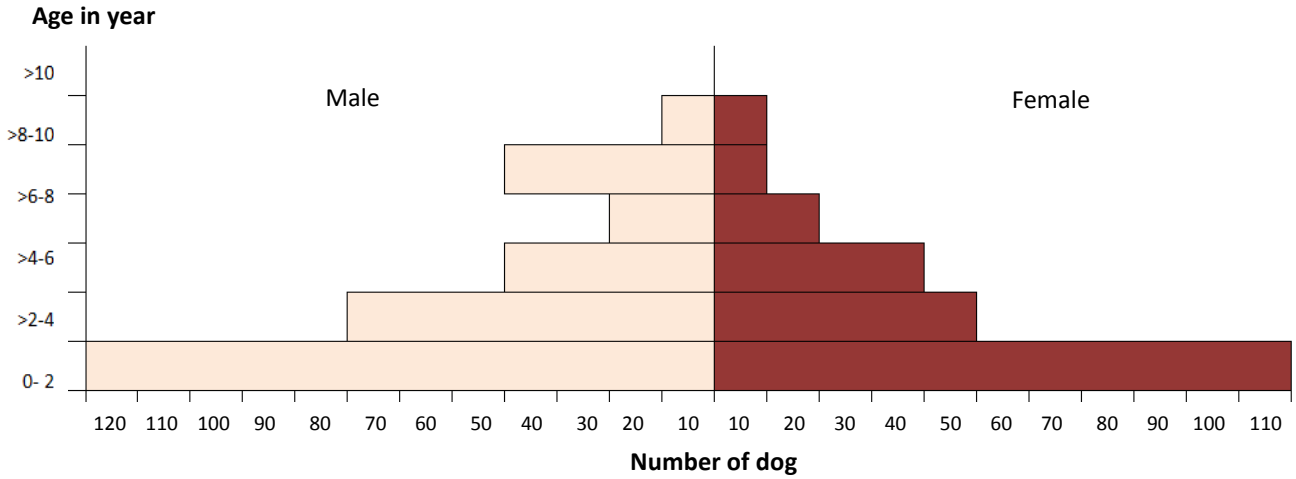


**Figure 2. Age-sex pyramid of dog population from census method in Lumlukka District, Pathum Thani Province, Thailand, 2010**

especially among the confined owned dogs (Table 2). In the urban area, ratio of dog per household was 1:1.2 (820:973) and ratio of dog per human population was1:3.9 (742:2,916). In the rural area, the ratio of dog per household was 1:0.9 (860:781) and the ratio of dog per human population was 1:3.0 (860:2,583).

### Dog Population Estimation by Census and CR

Total 571 confined owned dogs were identified by the census survey in the urban area. Unconfined owned-dog population estimated by CR (288) was higher than that of the census (183) in the urban area and was inversed in the rural area. The owned dogs estimated by CR was 57.4% higher in the urban and 8.5% lower in the rural area compared with the census population. The estimated stray dog population by CR was higher than that of from census in both areas, with 18.2% higher in the urban and 76.3% higher in the rural area. Total population estimated by CR was 47.0% more than that of the census in the urban area. The results estimated by CR and census were very similar while the estimate by CR was 4.8% lower than that of the census in the rural area (Table 3).

### Practicality and Feasibility of Census versus CR

Time spent on performing census and CR per study site was 12 hours (6 hours per day) and four hours (2 hours per day) respectively. Person-time consumed per study site was 96 person-hours for census and 18 person-hours for CR. Census was performed during working hours while CR was done in the early morning (6:30-8:30 am). Personnel carrying out the census were veterinarians and assistants (livestock volunteers, municipality officers and community health volunteers). As for CR, the team members of the survey were researchers and community health volunteers.

Some constraints arose from performing CR were inability to put collar on aggressive dogs, missing collars, difficulty to see the collars due to long dog fur, and unable to take clear photographs for the running dogs. We were not able to mark 11.7% (196/1,680) of dogs by a collar or photographed on the day of census.

**Table 2. Rabies vaccination coverage among different types of dog in the urban and rural areas from census method, Lumlukka District, Pathum Thani Province, Thailand, 2010**

| Area | Total | History of vaccination | | | Vaccine coverage among dogs with known vaccination history |
|---|---|---|---|---|---|
| | | Yes | No | Do not know | |
| Urban | | | | | |
| Confined | 571 | 488 | 31 | 52 | 94.0 |
| Unconfined | 183 | 109 | 55 | 19 | 66.5 |
| Stray | 66 | 24 | 29 | 13 | 45.3 |
| *Total* | *820* | *621* | *115* | *84* | *84.4* |
| Rural | | | | | |
| Unconfined | 822 | 493 | 258 | 71 | 65.7 |
| Stray | 38 | 12 | 13 | 13 | 48.0 |
| *Total* | *860* | *505* | *271* | *84* | *65.1* |

**Table 3. Dog population estimated by census and capture-recapture method in Lumlukka District, Pathum Thani Province, Thailand, 2010**

| Type of dog | Population from census | Capture | Recapture | | Estimated population from CR | 95% CI | % Difference |
|---|---|---|---|---|---|---|---|
| | | | Total | Marked | | | |
| Urban Area | | | | | | | |
| Unconfined owned | 183 | 178 | 199 | 123 | 288 | 270.42-305.01 | -57.4 |
| Stray | 66 | 52 | 39 | 26 | 78 | 65.91-89.13 | -18.2 |
| *Total* | *249* | *230* | *238* | *149* | *366* | *345.85-388.27* | *-47.0* |
| Rural Area | | | | | | | |
| Unconfined owned | 822 | 562 | 573 | 428 | 752 | 742.48-762.10 | 8.5 |
| Stray | 38 | 45 | 54 | 36 | 67 | 61.88-72.88 | -76.3 |
| *Total* | *860* | *607* | *627* | *464* | *819* | *816.89-823.57* | *4.8* |

## Discussion

Stray dog population identified from the census survey in both urban and rural areas were lower than the estimates from CR, which supported the results from the previous studies that estimated dog population by census survey[11]. However, CR cannot be used to count the confined owned dogs. Although the method cannot distinguish types of dog without having sign or mark, this study conferred the particular limitation by putting different colors of collar for owned and stray dogs, and performing CR survey soon after. However, reporting bias might still exist.

The unconfined owned dog population estimated by CR was higher than that of census in the urban and lower in the rural area, which might be due to the fact that some confined owned dogs released for daily excretion in the urban area might include in the estimated population. On the other hand, in the rural area, all owned dogs were defined as unconfined and this might fail to cover all of them. Thus, in the future CR surveys, confined and unconfined owned dogs should be marked differently, and the definitions for confined and unconfined owned dogs should be reviewed to improve the survey method.

Dog population census during the time of rabies vaccination campaign had gained some advantages. It reduced time of house-to-house visit to collect data, promoted people cooperation, and obtained general information (demographic, management practices and history of vaccination) and data to evaluate the vaccination coverage. Data from census showed that there were more male dogs than females. Although it was consistent with another study[14], it might show a bias of population in male dogs. The population composition consisted of dogs under two years old as the majority, implying the increasing trend of dog population and the need to control by the appropriate method. In circumstance when there is no reliable data available, dog population was estimated in relation to human population. The dog population per human population in this study was closed to the estimated ratio reported from the studies in Philippines[9] and Japan[10].

Data obtained in the census survey also showed the distinguished characteristics of dog population, and the management between the urban and rural areas. When compared with the rural area, the urban had higher proportion of small breed dogs, confined owned dogs, dogs received the rabies vaccination in the previous year and surgically sterilized dogs. Furthermore, dog proportion that received the rabies vaccination was higher among the confined owned dogs than that of the unconfined owned dogs. A practice of dog confinement appeared to correlate with receiving the rabies vaccination and being surgically sterilized. In fact, those unconfined owned dogs are at higher risk of infecting rabies by exposing to stray dogs which pose a major source of rabies transmission[15].

The rabies vaccination coverages in dogs from this study were 84.4% in the urban and 65.1% in the rural area. The vaccination coverages in the rural was still lower than the national goal of 80% and have not met the WHO recommendation yet[3]. Low vaccination coverage could be a potential factor for high occurrence of rabies in the area. Besides, this estimated vaccination coverage might be over-estimated if most of stray dogs were unvaccinated and some owners made the false report.

## Conclusion

Application of census and CR to estimate dog population required some additional technical adjustment and prior knowledge on the characteristics of dog population and the environment. No single methods could truly estimate the dog population in the setting similar to the study area in

Thailand. However, these two methods could complement each other. The findings from this study provided important information to monitor rabies control program and plan for effective strategy for rabies control and eradication in Thailand.

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