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Mosquito Nets Installation in Livestock Sheds as a Basis of Accelerated Malaria Vector Control Development

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Abstract

The decrease in the incidence of malaria has only reached 66.67%, from the target of 90% in 2030; *Anopheles spp* mosquitoes are zoophilic, So mosquitoes are more numerous in cattle sheds. The research is intended to change vector control policies by considering livestock sheds to accelerate malaria elimination. This study was a Pre-experiment with the design of the static group comparison, mosquito capture used a *spot survey* of six houses; three houses have goat sheds and three cowshed houses; mosquito catching with WHO guidelines that one house there are two catchers; likewise in cattle sheds. Arrests were made *all night* from 06.00 pm-06.00 am. The results, the ratio of *Anopheles spp* mosquitoes caught in livestock sheds is 36.5 times more than at home; while the vector is 2.5 more. The results of the statistical analysis are significant (p=0,000). Livestock sheds can be used as an alternative to malaria vector control to accelerate the decrease in density so that the incidence of malaria also decreases.

Introduction

Malaria from 2015 to 2022 has decreased from around 300 to below 100 per 1000 population (WHO, 2022). This decrease is due to two controls, namely malaria treatment and vector control. The treatment used using artemisinin-based combination therapy (ACT) has a significant impact (Tse, Korsik, and Todd, 2019), vector control is done with indoor residual spraying (IRS) (Makhanthisa et al., 2022) and insecticide-treated nets (ITN) installed on all beds of residents in malaria-endemic areas (Mrema et al., 2023). ITN is a risk factor for malaria cases (Sutarto et al., 2019). Another thing to look out for is migration surveillance (Ahmad, Isworo and Indriani, 2018).

The WHO target of elimination by 2030 is to reduce the incidence by 90% from 2015, currently worldwide can reduce 66.67%. Control of Anopheles spp. mosquitoes through these two programs are less effective, this is because mosquitoes are zoophilic (Mrema et al., 2023), and mostly feed on the blood of warm-blooded animals, especially mammals, mosquitoes are attracted to the results of the body's metabolism, namely in the form of CO2 and odor (Alonso San Alberto et al., 2022). Efforts to reduce the density of Anopheles spp. mosquitoes are the keywords for the success of breaking the chain of malaria transmission because these mosquitoes are the main vector of transmission. Controlling mosquito density up to 90% can reduce the number of bites from 300/year to 30/year so that the prevalence of malaria decreases (Manson, 2009). Vector

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control efforts must be maximized, to reduce the incidence of malaria (Kouassi et al., 2023). Purworejo Regency in 2022 is the only one that has not been eliminated, although it can reduce cases in 2015 by 1400 cases, and in 2020 there were no cases of malaria, in 2021 Purworejo Regency saw a spike in cases. The largest distribution in the Loano sub-district was 77 cases, and in Krajan sub-district 57% or 44 cases, the results of epidemiological investigations were known to be an index of indigenous cases with P. falciparum and on September 25 there were 14 cases in one night.

Research on installing insecticide-treated mosquito nets in livestock sheds has not yet made program recommendations to be implemented. This research is a preliminary study to determine two basic things, namely whether there are more livestock pens than at home and which two models of mosquito nets are better for getting more mosquitoes. The results of this research are the academic basis for the development of the installation of insecticide-treated mosquito nets in livestock sheds. The purpose of this study to prove the number of mosquitoes caught based on location, namely in houses and livestock sheds, and the best mosquito net model preferred by mosquitoes perched, secondly proves the cluster model between breeding, resting, and feeding no more than 400m.

Methods

This study was used to determine the best model of mosquito nets, as a new model of livestock cage-based malaria control, compared to previously based at home. Mosquitoes move freely in nature, so getting vectors when catching mosquitoes cannot be done randomly, but follows WHO standard procedures. This is intended to obtain vectors, so theoretical bases and field data are needed so that the chances of obtaining malaria vectors are greater. Two criteria of the arrest station include: first, Malaria sufferers are in groups. The results of the study of malaria cases in Krajan hamlet were 57% or 44 cases and on September 25 there were 14 cases in one night, within a radius of less than 400 m; second, The existence of livestock sheds and breeding places, the transmission model is in the form of clusters (Katale and Gemechu, 2023).

Method of catching mosquitoes Anopheles spp. As for the method of catching mosquitoes Anopheles spp., there are three criteria, namely: first, the catching procedure used WHO recommendations, there were six mosquito catchers spread over three houses; Each of the two catchers lasted for one hour with details of 40 minutes inside the house, 10 minutes of moving and 10 minutes outside the house. The other two people in the cattle shed; second, the method of catching with spot surveys is all-night arrest starting at 06.00 pm to 06.00 am. This method complements routine observations and obtains a representation of the presence of mosquitoes including species and the number of mosquitoes caught. The mosquito-catching procedure is carried out with the Standard Operating Procedure for performing a Human Landing Catch at James Cook University. The results of the capture were put in paper cups, differentiated every hour of capture time based on location and model of mosquito nets; third, the catching was made in six houses, with three goat sheds and three cowsheds.

Types of research: Pre-experiment, the Selection of sample point locations is carried out in a non-probabilistic way (AlHaqwi et al., 2023) based on WHO criteria, with the design of the static group comparison (Anggraini, Murni and Sakur, 2018). The treatment is in the form of installing mosquito nets in livestock pens as a new method to prove that Anopheles spp mosquitoes in livestock sheds are more abundant than at home. A positive control was used in the study: the number of mosquitoes caught in the home; there are three models of mosquito nets installed, namely open in front, on the side, and closed around the cage. Installation of mosquito nets with the following criteria: first, the mosquito net is installed 30cm from the lowest roof of the cage, this is intended to provide sufficient airflow to the livestock inside; second, the distance of mosquito nets from the walls of the cage is 90 cm, this is to avoid reaching the heads of farm animals; third, the bottom of the mosquito net is tied to bamboo slats to avoid blowing wind.

The data was analyzed as follows: Coordinate data of mosquito catching, breeding,

and patient location determination points were analyzed by spatial analysis (Katale and Gemechu, 2023); The number of mosquitoes caught based on location and model of mosquito nets was analyzed with a one-way ANOVA (Meredith, Furuya-Kanamori and Yakob, 2019) if normality requirements are met, if not, then use Krusskal Wallis, if significant further tests are carried out.

Results and Discussion

The location of the arrest was carried out in Krajan Hamlet, Loano District, Purworejo Regency, the results of the spatial analysis look at a circle of 100 m, the presence of breeding, vectors, and cases in a radius of less than 400m, so they are cluster-shaped, The picture is as follows:

The results of spatial analysis (figure 1) showed the gathering of malaria patients, livestock sheds, breeding, Anopheles spp. mosquitoes and malaria vectors, in a radius between 100-400m so that it is cluster-shaped. The Kemejing Dukuh Krajan Village area is a hilly area of Menoreh, very lush between intertwined plant canopies, thus blocking sunlight from penetrating the ground directly, between hills flow small rivers. Rainfall 1495-3449 mm/year. High rainfall, low temperatures, and high humidity have a significant impact on malaria prevalence (Oheneba-Dornyo et al., 2022).

Malaria is always associated with environmental conditions and geography including height (Kubana et al., 2023) The condition of malaria in Purworejo is closely related to hilly environmental conditions, and limited road access, The community is very dependent on the availability of raw materials in nature such as perennials and abundant bamboo groves, and the abundance of water sources as breeding place larvae ensures the survival of Anopheles spp mosquitoes so that malaria transmission occurs (Table 2), The condition of remote villages like this is a contributor to malaria cases (Rosas-Aguirre et al., 2021) .

In 2021 in Purworejo Regency, Central Java Province, there were extraordinary events and the most cases in the Banyuasin Health Center area, Loano District. The number of cases is 135, the highest in Kemejing village with 77 cases and the highest in Krajan hamlet with 44 cases in the same village, with the peak of cases occurring in September, during the dry season, and tends to fall until December. The distribution is as follows:

The peak of malaria in Krajan village occurred in September (Figure 2), This month is known as the dry season, if there is a spike

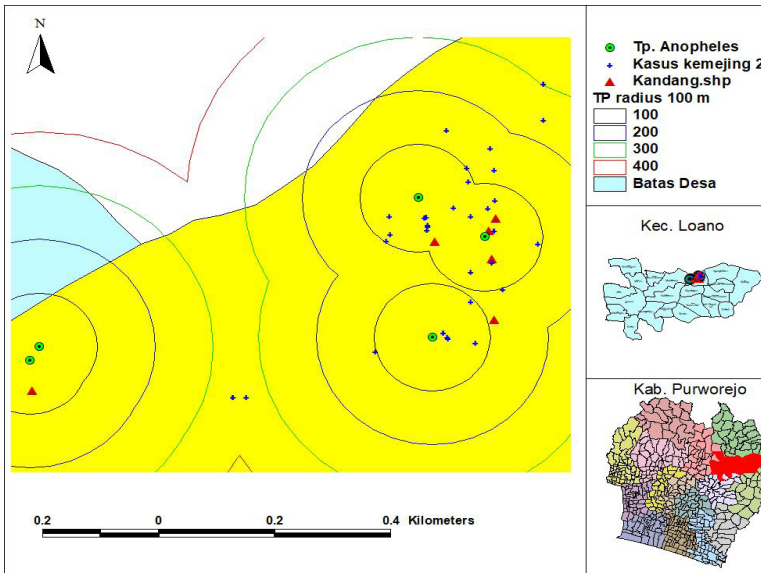

Figure 1. Satellite images of breeding, livestock sheds, and sufferers in Krajan Hamlet, Kemejing Village

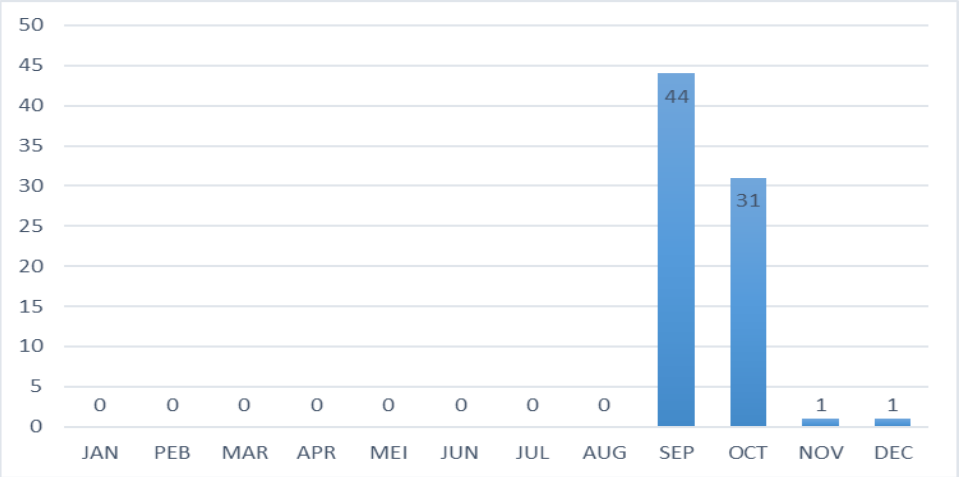

Figure 2. Distribution of Malaria Cases in Krajan Hamlet According to Time at Banyuasin Health Center, Purworejo Regency, Year 2021

in malaria cases in this season shows an abundance of environmental carrying capacity in the form of many breeding along dry rivers that leave puddles and small springs (Cross et al., 2021), Second, the existence of a plant canopy that blocks sunlight from entering the soil surface, so it becomes a good resting for mosquitoes(Villena, Ryan and Murdock, 2022) and third, the adaptability of Anopheles spp. mosquitoes can also adapt to dry seasons, Adaptability is carried out by mechanically closing the spiracles using a valve mechanism is a physiological adaptation that reduces water loss in insects (Katusi et al., 2022), So that mosquitoes can surpass their sporogony age and transmission will occur (Guissou et al., 2022).

Anopheles spp mosquitoes are indicators of potential transmission both vectors and those that have not. In Table 1, the number of Anopheles spp mosquitoes in livestock sheds is 36.5 times more than at home, while for vectors namely An. balabacensis, maculatus, and aconitus 2.5 times more, and if added with vector potentials namely An. vagus 28.5 times more than at home. In the goat shed 4.5 times more than at home, while the number of vectors is 1.5 times greater; while in the cowshed dominated by An. vagus 4.3 times more than other species or 81.25%. The number of mosquitoes caught in cages was 58.9% caught in mosquito nets. The results of his arrest are as follows:

The results of catching Anopheles mosquitoes are three types of vectors in

Table 1. Results of Anopheles spp Mosquito Capture by Location of Capture

Species	Sum Mosquitoes in Goat Shed			Sum Mosquitoes in Cowshed		
	Shed	Nets	House	Shed	Nets	House
An. maculatus	0	1	0	0	0	0
An. balabacensis	1	1	2	0	1	0
An. vagus	0	2	0	20	32	0
An. kochi	1	0	0	2	2	0
An. barbirostris	2	1	0	4	2	0
An. aconitus	0	0	0	0	1	0
Total	4	5	2	26	38	0

Source: processed primary data

Purworejo Regency, namely An. balabacensis, An.maculatus and An.aconitus (Cahyaningrum and Sulistyawati, 2018), All three have different habitats. An.balabacensisi lives in hills with forests as in Purworejo (Malijan et al., 2021), in Lampung, Indonesia confirmed the same vector as Plasmodium knowlesi and lives in forests (Wibowo et al., 2020), so in Sabah Malaysia, this vector is dominant in the forest (Chua et al., 2019). An.maculatus is also near forests and hills (Henderson et al., 2023), An. balabacensis and Anopheles maculatus can have malaria infection hazard rates of statistical significance (Permana et al., 2022).

An. Aconitus has a slightly different habitat, which lives near waters, is found in houses and livestock sheds, and likes unpolluted clean waters (Yuniawan, Utomo and Arwati, 2019). This is what makes Purworejo a comfortable habitat for all types of Anopheles spp species (Table 1), This is what can explain the formation of clusters of malaria sufferers, feeding in the form of human shelters and livestock sheds (Afnaniya, Santjaka and Bahri, 2023), and breeding that supports each other. An. vagus although has not been declared as a vector in Purworejo, has been confirmed as a vector using ELISA in Kulon Progo, but it has not been confirmed microscopically, although the two are still one epidemiological region. Other research results were also found An. balabacensis, An. aconitus, An. barbirostris, An. vagus, An. anularis, An. kochi, An. maculatus, An. indifinitus, and An. subpictus (Raharjo et al., 2015), the same method is also used in Maluku(Sejati, Ardhitya and Sofiana, 2015).

58.9% caught in mosquito nets, so there are two functions of mosquito nets, namely a place to rest after mosquitoes suck blood and as a barrier for mosquitoes from the cage to go to the nearest resident's house (Brown et al., 2018; Mofua et al., 2019). The results of catching malaria vectors in cages are higher than at home (table 1) this is due to the presence of cages no more than 5 meters from the house, so primary vectors are also found in cages in greater numbers, this result is to refute that in livestock sheds there are no primary vectors. Other research results in Indonesia, Anopheles balabacensis is found in homes and livestock sheds, so it is indiscriminate meaning it bites just any human as well as livestock, this is the uniqueness that exists in Purworejo, Central Java Province, Indonesia. Therefore these results served as the basis for the development of long-lasting insecticidal nets (LLINs) used in cattle sheds. The primary vector was captured 1.5m from the residence, while the secondary vector was captured >5m (Katusi et al., 2023).

The presence of Anopheles larvae is an indicator of the presence of adult Anopheles mosquitoes and the survival of mosquitoes as well as the potential for malaria transmission. Larval surveys were conducted at a radius of 400 m, on malaria transmission clusters. The results survey of larval/pupae in Table 2. in some types of habitats close to residential areas after rearing is identified An. balabacensis; and An. maculatus. The location of the discovery of malaria vector breeding places in a radius of 100 m and 200 m from the distribution of malaria cases. As for the full result:

The results of larvae capture after rearing the results are the same as adult mosquito capture, thus there is a relationship between larvae and adult mosquitoes in one epidemiological area (Yuniawan, Utomo and

Table 2. Results of Larval Identification by Habitat Type

Habitat Type	Sum	Positive	Category	Rearing Results	Description
Puddle and tire treads	3	1	Pupae larvae	An. balabacensis	Pupae 4, instar 2 1 larvae
Potential breeding	16	0	-	-	riverside
Breeding	3	2	larvae	An. balabacensis An. maculatus An. aconitus	1 There were aquatic plants

Source: Processed Primary Data

Arwati, 2019), This is related to environmental conditions as the main habitat of both adult mosquitoes and larvae(Rohani et al., 2018). Larva An. Balabacensis is in car tire marks and excavated soil(Rohani et al., 2018) In the shade, slightly rocky, the presence of plankton. So did An. maculatus, while An. Aconitus occurs in breeding existing aquatic plants and rice fields(Maretasari et al., 2019). The results of statistical analysis according to the location and model of mosquito nets are as follows:

The results of the test are statistically significant, while the results of further tests are also significant the most in cowsheds (p=0,000), with cows getting the most mosquitoes, while any model of mosquito nets has the same number of mosquitoes caught. The significance of the cage of the location of this capture is due to the presence of mosquitoes in livestock cages because female mosquitoes have nerve cells, called cpA neurons that have receptors to detect carbon dioxide (CO2) and odor (Alonso San Alberto et al., 2022), So that mosquitoes can feel clumps of exhaled air, mosquitoes are also attracted to human skin even in the absence of carbon dioxide. Other research results show an increase in carboxylic acids in the skin brings more mosquitoes, as well as lactic acid (De Obaldia et al., 2022). Odors result from metabolic processes (Emami, Hajkazemian and Mozūraitis, 2019). Both are gases, so they are free to move following the pressure difference from cold to warmer air (Jung et al., 2023).

It is known that all three fishing sites are significant, with the most cowsheds, another study is the same, namely mosquitoes are caught in cowsheds three times more than in goat sheds (Tchouassi et al., 2016). The smell produced depends on the type of animal food(Janni, 2020). At the study site, the food is relatively the same, namely grass, so the influence of food is relatively the same and the process of urine decomposition, the results of research using cow urine were developed to attract malaria vectors and other mosquitoes(Katusi et al., 2022). The results of statistical analysis showed no difference in the number of mosquitoes caught in mosquito nets (p = 0.534; Table 3), This confirms that mosquitoes come from all directions randomly, although the number of mosquitoes caught in the side mosquito nets is higher. There have been no studies that discuss the model of installing mosquito nets related to the number of mosquitoes caught. The installation of this non-insecticide mosquito

Table 3. Results of Statistical Analysis

Location	Average	Homogenitas	Krusskal Wallis	Post Hoc (U Mann Whitney)		
				Between locations	Mean p Different	
House	0,028	0,000	0,000	Cow House and Barn	-1,750	0,000
Cowshed	1,778			House and goat shed	-0,222	0,000
Goat shed	0,25			Cowsheds and goat sheds	-1,528	0,000

Model mosquito net	Average	Homogeneity	Anova test
Open in front	1.000	0,116	0,534
Open next to	1.280		
Covered everything	0,75		

net is based on the behavior of mosquitoes after biting rest indoors and outdoors (Saili et al., 2023), as well as in cattle sheds (Eshetu, Eligo and Massebo, 2023). The mosquito net model is intended to ensure air circulation in the cage so that farm animals remain comfortable. Thus the ability of the mosquito net model to reduce mosquito dust is the same, if for practical purposes opening in front is preferred.

Conclusion

Mosquitoes caught in mosquito nets in livestock sheds are more numerous and significant than at home; breeding, resting, feeding vectors and malaria patients are in the same cluster less than 400m; any model of mosquito net has the same ability to be infested by Anopheles spp mosquitoes.

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