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Prevalence of Infection of Endoparasites and Its Intensity in Small Mammals' Liver Captured from Irrigated Rice Crop Area and Villages

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Abstract— **The research was conducted during November 2018 – January 2019 in two provinces namely West Java and Yogyakarta. The aim of the study was to study the prevalence of infection of endoparasites inhabiting the liver of small mammals and its intensity. Two different habitats, irrigated rice crop area and two villages closed each other were chosen as trapping sites. Sampling was conducted by performing two methods i.e. trapping using snap trap and LTBS (Linear Trap Barrier System) continually. The snap traps (75 pieces) and 30 *bubu* traps were set around the small mammals' habitat. A regular monitoring of the trapping was conducted in the next morning. Animals captured were identified and dissected to observe endoparasites infecting their digestive organs. The total number of samples captured from the two provincial trapping location was 423 individuals. There were four species identified namely *Rattus argentiventer*, *Rattus tanezumi*, *Suncus murinus*, and *Bandicota indica*. Two species of endoparasites were found in the liver of *Taenia taeniaeformis* and *Capillaria hepatica*. Prevalence of infection for both endoparasites was higher in animals captured from irrigated rice crop area compared to the village area. The prevalence of infection for *T. taeniaeformis* was 36.7% and *C. hepatica* was 35.25% from the animals captured in the irrigated rice crop. Their intensity of infection was varied from light, medium to heavy level. Meanwhile, the prevalence of infection for the same endoparasites from the animals captured from the village was lesser. Prevalence of infection for *T. taeniaeformis* infected animals captured in the two villages was 12.31% and 17.6%, respectively. The same situation was also similar for the *C. hepatica* which had their prevalence of 0.7% and 0.8% for the same samples captured from the same habitats. Their intensity was also lower than what we found in animals captured from the irrigated rice crop area.**

Keywords: prevalence of infection, intensity, endoparasite

I. INTRODUCTION

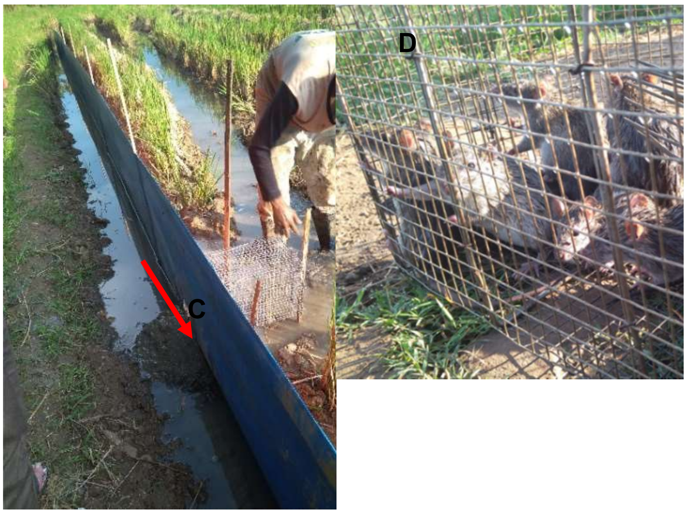
Indonesia is an agricultural country with most people rely on rice as their staple food. The current population is more than 261 millions and tends to increase rapidly with annual population growth rate is 1.34% [1]. As the population grows significantly, rice stock becomes an important issue for the Indonesian government. Some programs and policies have already been prioritized by the government to overcome this situation, for example by increasing rice planted area, maximizing the potential of sub optimal agro-ecosystem, and generating new varieties. These new varieties come with promising characteristics such as resistant to specific pests and/or diseases, high productivity, and tolerant to such abiotic stresses (salinity, stagnant flooding, soil toxicity, etc). However in some areas, pests and diseases cause big looses in rice farming regularly. There are five main pests and diseases on rice crop i.e. stemborer, brown plant hopper, rats, blast, and tungro [2]. Among them, rats always cause rice crop damage annually since they have a very fast reproduction rate. The last three years data indicated that crop damaged by rat range from 66,000 to 104,000ha [2].

Moreover, rats have also been known as a carrier for several potential diseases transmitted to human being which affect their health. It has been reported that some rodents show their role as a vector for several zoonoses [3-17]. Some endoparasites inhabiting their digestive organ were also identified. The member of cestode and nematode are found in liver involving rats and human as their hosts to complete its life cycle [18]. Other study also reported some cases of zoonoses transmitted by rodents which have role in spreading these diseases [19]. A similar study also reported a potential threat of rodent-borne pathogens carried by wild caught Norway rats [20]. A co-occurrence infection of two different cestodes was also found in a particular rodent in France [21]. Such studies on serological detection for *C. hepatica*, a liver nematode of mammals, also supported information of rodent roles in the distribution of some pathogen [22].

II. METHOD

The research was conducted during November 2018 through January 2019 in two provincial trapping sites. The two trapping sites in West Java located in two villages (Karawang and Subang); and Yogyakarta which have been positioned in Jogorejo (Sleman). The trapping sites represented both an irrigated rice cropping area and villages which closed to each other. These both sites coverage a large field of rice crop and indicated annual rat problem for years. There are three times cropping season within a year in West Java trapping site. On the other hand, farmers in Yogyakarta trapping location had two rice planting seasons yearly. Most farmers in those two provincial location have practiced traditional and common rice farming system. Most farming work have been done manually without implementing intensive activity relying on a powerful machine.

Sampling procedure was conducted by two trapping methods using LTBS (Linear Trap Barrier System) and setting of snap traps (Fig.1). The first method was performed by applying several lines of the LTBS. Principally, rice field rats were trapped in several plots using a 120 m long plastic fence. Each set of LTBS was supported by six multiple capture wire cone cage live traps (20 x 20 x 50cm) set in a long way [23-26]. LTBS was set on the previous day and leave them for a night then daily monitoring was conducted in the morning. The second method was using snap traps which also have been set a day before. The snap trap dimension was 7.5 x 13.5 cm made from metal and incorporated with a small bait holder attached to the top surface of the trap for providing the bait. The bait used usually are some food which has strong smell such as raw materials or specific processed food. Salty fish, roasted crab, roasted or fresh coconut are common baits which effectively attract the rats and other small mammals. To minimize the bait ineffectiveness, all remaining baits left on the traps were replaced with fresh newly bait on the next morning. All traps were set and located along their run way and close to their habitat (Figure 2). These two trapping methods were conducted for several consecutive days. The animals captured from the traps were identified morphologically, sexed, and recorded all its physical measurement (body weight, tail length, head body length, foot length and ear length) before dissected [27].



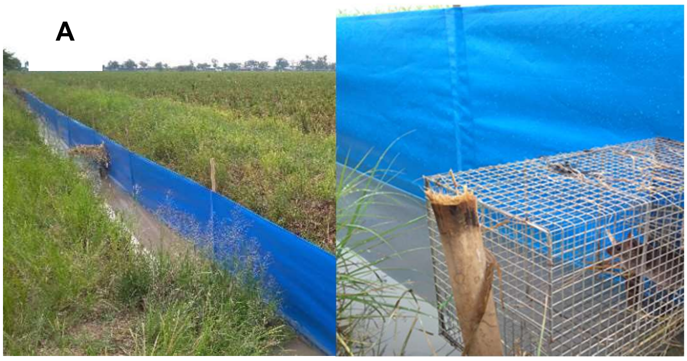


Figure 1. Setting of LTBS by erecting plastic fence supported with multiple capture wire cone cage live traps (bubu traps), Mulyasari – West Java, November 2018 (A. Plastic fence, B. Live trap, C. Mud as access for the rats to the traps, D. Rats captured from an overnight trapping)

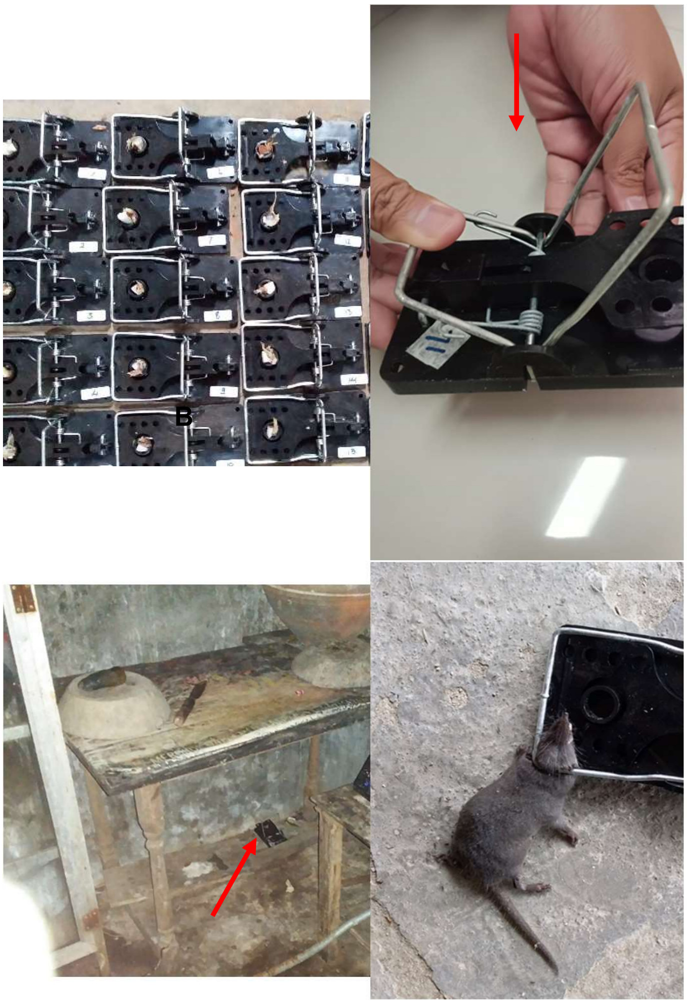


Figure 2. Trapping using snap trap with specific bait put in small bait holder attached to the trap (red arrow on the left upper photo) which located close to its runway (red arrow on the left lower photo) within a house, Karawang – West Java, November 2018

All killed animals trapped by those two methods were dissected to visually screen the endoprasites inhabiting the liver. The species of the endoparasites were identified and its intensity was recorded by scoring system [18]. The infected animals were counted and its intensity for every single species of endoparasite was recorded. Based on these data then we can examine the value for their prevalence of infection and its intensity. All dissecting and trapping work have always followed the procedural matters.

.III. RESULTS

A total of 423 animals captured from the trapping have been done in both provincial sites. This number was split as follows: 131 animals trapped from the village; 167 individuals caught from rice cropping area and both collected in the same province i.e. West Java. The rest of 125 animals were collected from village in Yogyakarta. Based on the trapping results, we have identified four species of animals i.e. *Rattus argentiventer*, *Rattus tanezumi*,

TABLE I. PROPORTION OF SMALL MAMMAL SPECIES CAPTURED FROM TWO PROVINCES IN DIFFERENT HABITAT TYPES, NOVEMBER 2018-JANUARY 2019

Location of capture	**Location Type**	**Proportion (%)**					
		R.argentiventer	***R.tanezumi***	*B.indica*	*S.murinus*	Unidentified	Overall
West Java	Rice cropping area	167 (100)	0	0	0	0	167
West Java	Village	23 (17.6)	15 (11.5)	19 (14.5)	73 (55.7)	1 (0.8)	131
Yogyakarta	Village	7 (5.6)	66 (52.8)	1 (0.8)	51 (40.8)	0	125

Suncus murinus and *Bandicota indica*. All captured animals ranged from a litter of, young, to matured individuals including the females with pregnancy. As displayed in Table 1, there was a tendency for diversity of animal species captured from the village. Those four animal species were found in the village location type, even though the distribution is slightly different. In West Java village *S. murinus* dominated the population with the highest number (55.7%) of individuals captured. Additionally, the other three species distributed evenly with slight different proportions. Meanwhile from the trapping of village in Yogyakarta there was a tendency that *R.tanezumi* (52.8%) and *S.murinus* (40.8%) competed each other to dominate the population. *B. indica* and *R. argentiventer* were the two species with less proportion (<10%). However in terms of the differences of habitat type, the trapping showed that rice field rats (*R.argentiventer*) was the dominant species captured in rice cropping area since all the small mammals captured were identified as *R.argentiventer*.

One species among the animals captured which does not belong to the rodent group was *S. murinus*. This species is member of the order Insectivora, which is the third largest mammalian order, containing more than 450 species [28]. Similar to other insectivores, this species have a very high metabolism and they store very little fat [29-30]. They breed throughout the year and their pregnancy rates was very with rainfall patterns [31-33]. This variation is likely due to a tight correlation between rainfall and insects population since insects are their primary diet [34]. *S. murinus* dwells around humans and affects public health in urban areas because it likely is associated with many diseases [35]. These information was in line with the findings of study that they tended to share its habitat with other member of rodent in village habitat. Most of them were sampled from inside the houses and storages during the trapping.

A. Prevalence of infection

From the total of 423 trapped animals, most of them were found infected with at least one parasite. *R. argentiventer*, *R. tanezumi* and *S. murinus.* They were found to harbor two species of helminths. *Bandicota indica* was the only host with a single infection by a parasite from Cestode class. Among the hosts, *R. argentiventer* was also found to have the highest record of single and double infections (Table 2). On the other hand *R. tanezumi* occupied the second rank for the same record. However compared to *R. argentiventer*, this host indicated around 26% for the proportion number of single infection and 3% for the double infection, respectively. It seems that *R. argentiventer* was the most preferred host for the parasite either to live singly or compete with others. All *B. indica* with single infection record were infected by the same species of parasite (*Taeniae taeniaeformis*) one member of Cestode group. Majority of the hosts indicated higher proportion of the single infection instead of double infection.

TABLE II. THE NUMBER OF HELMINTH INFECTIONS IN FOUR SMALL MAMMALS TRAPPED IN VILLAGE AND RICE CROPPING AREA IN WEST JAVA AND YOGYAKARTA

Mammal Host	**Single Infection**	**Double Infection**	**Total**
Rattus argentiventer	76	31	107
Rattus tanezumi	20	1	21
Bandicota indica	7	0	7
Suncus murinus	0	1	1
Total Infection	103	33	136

The results indicated that the highest prevalence of infection for *T.taeniaformis* and *C.hepatica* were from the animals captured from the rice cropping area (Table 3). Their prevalence have the same values which were 37.72% for both species. Moreover, the prevalence of infection of *T.taeniaeformis* from two locations has indicated less than 20%. Similar trend was also depicted by *C.hepatica* which have 0.7% and 0.8% for the value of prevalence of infection respectively. However those values were much lesser compared to the values of the *T.taeniaeformis* prevalence. These values were recorded from the animals trapped from two different provinces. Most rodents found with severe characteristics of *C. hepatica* lesion in the liver; but on the examination of the lesion we were not able to detect any worms.

TABLE III. PREVALENCE OF INFECTION OF *T. TAENIAEFORMIS* AND *C. HEPATICA* IN INFECTED SMALL MAMMALS' LIVER CAPTURED FROM WEST JAVA AND YOGYAKARTA, NOVEMBER 2018 – JANUARY 2019

Trapping location	Location Type	Prevalence of infection (%)	
		T.taeniaeformis	*C.hepatica*
West Java	Village (N=131)	12.97	0.7
	Rice cropping area (N=167)	37.72	37.72
Yogyakarta	Village (N=125)	17.6	0.8

The intensity of infection of *C.hepatica* ranged from light to extremely heavy which categorized by scoring system based on the number of lobes infected and its damages [18]. The animals captured from rice cropping area showed more diverse intensity of infection for the *C.hepatica*, light to extremely heavy, compared to the animals captured from the other locations (Table 4). The intensity for the light level almost reached 50% from the total of animals captured. Moreover, *C.hepatica* has the intensity of infection 100% for either the heavy or light level in two villages from two different provinces. Even though this value was higher compared to the intensity of infection of *C.hepatica* in animals captured from rice cropping area, it only came from one infected animal. In general, extremely heavy infection of *C. hepatica* was only found in trapped hosts from West Java, although the value was less than 10%.

TABLE IV. INTENSITY OF *CAPILLARIA HEPATICA* INFECTION IN THE LIVER (AND NUMBER OF LOBES INVOLVED) IN INFECTED SMALL MAMMALS CAPTURED FROM WEST JAVA AND YOGYAKARTA, NOVEMBER 2018 – JANUARY 2019

Trapping location (Habitat)	Intensity of infection				
	Light (1-2 lobes)	**Light (>2 lobes)**	Heavy (1-2 lobes)	Moderate (all lobes)	Extremely heavy
West Java (Village) (N=1)	0	0	100	0	0
West Java (rice cropping area) (N=63)	49.21	39.68	0	3.17	7.94
Yogyakarta (Village) (N=1)	100	0	0	0	0

Intensity of infection for *T.taeniaeformis* indicated similar trend in infected animals captured from different habitats in West Java trapping sites (Table 5). Both light and moderate intensity of infection were found in these animal groups. However, there was no animal found from West Java and Yogyakarta with heavy intensity of infection which is indicated by the presence of more than four cysts. All animals captured from Yogyakarta indicated light infection for this endoparasite species. There was no animals infected by *T.taeniformis* in moderate and heavy intensity of infection. The cysts have white color which consisted of worm parasites merge in a particular transparent fluid filled the cyst cavity wall. When the cysts were pull out from the liver tissues, they have similar shape as a small ball. If the ball skin was torn, *T.taeniaeformis* were found inside with widen scolex and segmented elongated body.

TABLE V. INTENSITY (%) OF *T. TAENIAEFORMIS* INFECTION IN THE INFECTED SMALL MAMMALS' LIVER CAPTURED FROM WEST JAVA AND YOGYAKARTA, NOVEMBER 2018 – JANUARY 2019

Trapping location (Habitat)	Intensity of infection		
	Light (1-2 cysts)	Moderate (2-4 cysts)	Heavy (>4 cycsts)
West Java (Village) (N=17)	88.23	11.76	0
West Java (rice cropping area) (N=63)	87.3	12.5	0
Yogyakarta (Village) (N=22)	100	0	0

IV. DISCUSSION

Based on the animals captured from three different locations, it is indicated that there was a link between host species and the habitats where they were trapped. It seems that the animals prefer to stay in a particular habitat for the sake of searching their food easily. For example in rice cropping area, rice field rat (*R.argentiventer*) was the solely single species which had been trapped. This was due to that rice crop is the main food for *R.argentiventer* especially in its generative stage to support their breeding performance. The availability of rice crop at maximum tillering stage (early generative stage) was the trigger for males' maturity of this species [36-37]. Rice booting stage offered a positive effect on rice field rats' breeding. This crop stage coincided with the rice field rat reproduction to start [38]. Another study [39] found that rice crop is the most favorable diet for *R.argentiventer*. Based on that study on stomach content analysis, their main food is rice crop with different composition depends on the stage of rice crop itself. A continuing similar study also revealed that endosperm is the main content of their stomach when the rice crop is in generative stage. Meanwhile, the main proportion in the stomach is rice stem during the vegetative stage of rice crop [40]. Previous studies also indicated that rodent species show habitat preference [41-43] and this information may have some consequences in term of disease transmission ecology in relation to habitat as emphasized for other rodent borne diseases [44].

Furthermore, we collected higher proportion of the house shrew or musk shrew (*S.murinus*) compared to *R.argentiventer* from both village habitat. This finding is concurrent with previous studies mentioning that *S.murinus* were found in urban and rural environments and breed within a year entirely [35, 45-50]. This species exists inside or around dwellings of humans and influences public health in urban areas due to it likely is linked with many diseases [35]. They are categorized as member of the order Insectivora, which is accounted as the third largest mammalian order, comprising of more than 450 species. *S. murinus* have a very high metabolism, one of unique characteristics for Insectivores and they deposit very small quantity of fat [29-30]. In the wild, this species breed at all times of the year, and their pregnancy rates fluctuate with rainfall patterns [31-33]. This disparity is likely caused by rainfall and insect populations firmly connected since insects are the musk shrews' main diet [34].

In terms of the number of host infected, *R.argentiventer* depicted the highest quantity among others, either for single or double infection (Table 2). This is due to their movement between rice field and village after harvesting (land preparation) for seeking alternative food and refuge habitats temporarily. Their presence in the border of village and rice field allows its predators (cat and others) to attack them and predation occurs [26]. This such movement might affect more exchange of these rice field rats between rice field and surrounding rural environments. The more they substitute each other the more it will impact on increasing of the prevalence of infection for particular parasites which already infected them and will transmit among them as we know that in some cases they involve other animals as intermediate host for completing parasite life cycles. It has been recognized for years that generally rodents have dual roles regarding pathogen distribution. Rodents are categorized as reservoirs when they harbor disease-causing organisms and thus serve as potential sources of disease outbreaks, but always through a vector (tick, sand-fly etc). Meanwhile when the rodents act as carriers, they show no or limited disease symptoms but harbor the disease-causing agent, and capable of passing it directly onto humans [51]. Therefore, there are two pathogen routes i.e. direct, with rodents as carriers, and indirect way, as they take a part as reservoirs. This finding supports the previous records that rodents have two important roles in the transmission and distribution of zoonotic disease. They could be reservoirs as they amplify pathogens from their environment. The second role is as carriers. For years, rodents have been identified as a serious pest because they attack crops, stored products, infrastructure, and their role in the transmission of pathogens to human and livestock [52]. Additionally, previous study in Southeast Asia also revealed that the highest helminth species richness was found in *R. tanezumi*, *R. norvegicus* and *R. argentiventer*, which are found in more human-dominated habitats such as agricultural areas or human neighborhoods [44].

Regarding the type of trapping location, the highest prevalence of infection for both parasites was indicated by animals trapped in rice cropping area (Table 3). The prevalence for both parasites showed similar values. In this circumstance, the resident infected rodent might be the source of the parasites. Such studies reported that these infected rodent population could cause nonstop recurring infections in the cultivate environment, with all the negative concerns for both livestock and farmers [53]. Moreover, the accurate risk features of livestock-pathogen-human-wildlife dealings is not yet distinguished for numerous pathogens. It has been documented that rodents are reservoirs for such illness fever, but their exact role in pathogen maintenance, geographic distribution and transmission still persists to be clarified [54-55]. It is a challenge to explain rodent's contribution in terms of wildlife and domestic cycles of a certain pathogen infection that can work individually. This is due to that it will overlap in several cases as lots of field are occupied by both domestic and wild animals, which in turn, create a difficulty to resolve their precise contribution [54].

Based on the intensity of infection of endoparasites records, both species have the highest proportion of light infection (Table 4 and 5). However, *T. taeniaeformis* indicated higher proportion of the light intensity compared to *C. hepatica*. This situation might be influenced by the life cycle of each parasite. As reported that the *C.hepatica* has direct life cycle, it only requires a single host if embryonated eggs are ingested. Non embryonated eggs which are delivered are unchanged via the intestinal tract in a few days. The ova, when ingested, pass onto the caecum where they hatch and the larvae enter the porta circulation and then the liver where they mature and mate within four weeks. A few parasites may spread through the portal filter and migrate to the other internal organs. Both male and female worms die, the female thereby releasing thousands of eggs. The ova undertake growth but stay in the liver until the death of the host. Reinfection may appear if the host liver is eaten by other animals, or in ingestion of soil containing viable ova [56]. Therefore, the intensity of infection of *C.hepatica* seems to be correlated solely with their single host density.
In contrast with *T.taeniaeformis*, this parasite has intermediate and definitive hosts for their life cycle [57-59]. Rodents as the intermediate hosts harbor the larvae in their livers and the wild and domestic cat as the definitive hosts harbor the adult tapeworm in their intestines [58]. Other study reported that definitive host may harbor more than a single adult *T.taeniaeformis* and the more frequent their connection with a particular geographic area and/or the greater their abundance, the greater it is the chance for large numbers of ova to accumulate in the habitat [59-60]. Taenia ova are also recognized to be highly resistant to certain environmental conditions including temperature [61], certain chemicals [62], and humidity [63]. This situation support their ova to stay alive longer in the suitable environment until they are ingested by the hosts. Age of the intermediate host (rodents) also contributes to the infection levels since the subadults usually indicate limited foraging activity relatively. The study also mentioned that rodents may hold a phase of high susceptibility for infection by *T.taeniaeformis* which occurs between 25-30 days of age in mice and 25-60 days of age in rats [57]. Similar studies also indicated that *T.taeniaeformis* cause life-long infections in intermediate hosts and is more prevalent in older animals [56, 63-66]. These characteristics are also contributed by the special defecation behavior of domestic cats which usually burry their droppings into loose soil where taeniid eggs are less exposed to adverse weather conditions. Therefore, all of these aspects might be some reasons for the higher proportion of rats having light infection of *T.taeniaeformis*.

Based on this study, there is a big risk for human especially farmers who deal with any farming work and might interact with rodents. It would be good if any related institutions care for them by providing massive information about the importance of rodents to their life. This could be done by educating them in a small discussion with similar cases. Their awareness to the risk is expected to be built and they can learn each other for minimizing parasite cycles run.

Therefore, a healthy life will be achieved from a family level and then continued to distribute to a bigger community. Since it has been known that rodents and human are the same member of Mammals which have a big chance for getting transmitted diseases.

V. CONCLUSION

We found that there were two species of endoparasites inhabiting small mammals liver i.e. *Taenia taeniaeformis* and *Capillaria hepatica*. *T.taeniaeformis* has higher prevalence of infection compared to *C.hepatica* in both location types. However, animals which are especially captured from rice cropping area had similar prevalence of infection for both endoparasites (37.72%). Small mammals which have been trapped as their hosts were *R. argentiventer*, *R. tanezumi*, *S. murinus* and *B. indica*. Among host species, *R.argentiventer* indicated the highest proportion for the endoparasite infection either for single or double infection. Most animals showed light intensity of infection for both endoparasites. It seems that there was a link between infection of the endoparasites and their life cycle characteristic involving such intermediate and definitive hosts. Therefore, a continuing study was required to explore more understanding about this relationship.

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