A Survey of Philippine Tabanidae in North Cotabato, Philippines

Elsa A. Gonzaga[1*] and Rolando J. Garduque[2]

Faculty, College of Veterinary Medicine, University of Southern Mindanao, Kabacan, Cotabato

ARTICLE INFORMATION

Article History
Received: 12/7/2015
Received in revised form: 2/16/2016
Accepted: 8/2/2016

Keywords
Control, Nzi fly trap, surra, Tabanidae, *Trypanosoma evansi*¸

**Corresponding author: Elsa A. Gonzaga (elsagonzaga@yahoo.com)*

ABSTRACT

A total of 38,818 tabanids were trapped and identified in five municipalities of North Cotabato using Nzi fly traps from July 2013 to June 2014, namely: Tabanus partitus (77.04%), T. striatus (11.26%), T. reduscens (5.43%), T. philippinensis (0.22%) and Chrysops (0.12%) and the remaining 5.92% were the unidentified tabanids. The species and abundance of tabanid flies were determined in relation to elevation of the area, water source and rainfall pattern. There was a variation in the number of flies trapped between each month and area of collection. The highest number of tabanid flies were trapped in Aleosan (11,349) followed by Mlang (10,733), Kabacan (9,754), Midsayap (4,855) and the least was in Antipas (2,127) all in Cotabato.

Results show that the abundance of tabanid flies in the study areas was influenced by the altitude and the presence of water sources. It was found that the higher the elevation or altitude of the study area, the lesser was the number of flies trapped. The highest total rainfall data was recorded in Arakan (2,131.90) to include the municipality of Antipas. However, Antipas had the lowest number of tabanid flies caught. This finding suggests that rainfall concentration was not enough to influence the abundance of tabanid flies in this study. A decrease in tabanid flies trapped per month from July 2013 to June 2014 indicates that trapping tabanidae flies, the vector of Trypanosoma evansi (surra) infection, is a potential intervention to control surra disease in livestock.

© The Authors and Asia Pacific Higher Education Research Journal

Introduction

Tabanid flies belong to the family *Tabanidae* of the Order Diptera of Class Insecta (Soulsby, 1982; Hill & Mac Donald, 2007). Tabanids are common pest of livestock, especially in ruminants. Their importance results from their bloodthirsty attack on human and other animals. They are blood suckers that can cause extreme annoyance and blood loss due to oozing of blood after the bite. Their attacks result in lowered gains and low milk production in livestock animals. Animals under heavy attack may lose weight or suffer a reduction in daily weight gain and be more susceptible to some disease because of stress. In Mindanao, Philippines, there were four species of *Tabanus* and species of *Chrysops* were collected such as *Tabanus partitus* Walker, *T. ceylonicus* Schiner, *T. philippinensis* Kröber, *T. reducens* Walker and *Chrysops cinctus* Bigot (Dargantes, 2010). *Tabanus striatus* and *T. reduscens* were considered as the primary transmitters of surra (Dargantes, 2010). Tabanids are important in spreading many diseases and among them is surra or animal trypanosomiasis which is endemic in the Philippines.

Surra is considered as one of the most important causes of mortality in livestock and devastating outbreaks have been recorded for the past decades. The Philippine government reports showed that buffalo is the most commonly affected species with reported cases of 3,819, followed by horses with 3, 430 and cattle with 2,005 in the year 1989-1997 (Manuel, 1998). The economic losses caused by surra are considerable. These losses accrue through the effects of disease upon calf production, reduction of draught power in animals, and its effects on meat and milk products.

In as much as surra is classified as a second priority disease among livestock under Administrative Order 12 series of 1992, its prevention and control is very important.

Control of surra may be aimed against either the fly or the trypanosome, and most often the use of chemicals or trypanocides has been widely used because of its ease of administration (Soulsby, 1982). Moreover, it can also be controlled by improving weight and disease resistance of livestock, and by good nutrition and proper labor use (Lang, My, Lan & Phoung, 2001).

Purpose of Research

Despite several control measures applied, eradication of surra has not yet been successfully achieved. Thus, necessitated a thorough study on an effective and efficient disease control strategy and this included the use of NZI traps, chemotherapy for trypanosome-positive animals, use of drug and insect repellent plant, and management through deworming and vitamin supplementation to susceptible animals. This study focused on the abundance and identification of common *Tabanidae* flies in North Cotabato, Philippines. Since livestock are important animals to farmers, the following are the objectives of the study.

1. To establish baseline data on the seasonality and population for the vectors of surra;

2. To determine the environmental factors associated to the vector's abundance; and

3. To identify the most common fly vectors of surra in the study areas in North Cotabato, Philippines.

Literature Review

Surra or trypanosomiasis is caused by *Trypanosoma evansi*, a blood protozoan parasite. It is transmitted mechanically by blood sucking fly vectors (Wilson, 1983) which is non-cyclical in development (Roberts & Janovy, 1996; Soulsby, 1982). In most areas, horse flies of the genus

Tabanus, stable flies (*Stomoxys*), *Lyperosia*, and *Haematopota* have been implicated in the transmission. However, other common vectors of surra such as vampire vats are considered in South America (Roberts & Janovy, 1996). Although many reports claimed that the tabanids were found to be the most important vectors (Soulsby, 1982), it was believed that other hematophagous insects may also be associated with transmission of *T. evansi* among susceptible animals. Generally, the transmission is highest when the feeding interval of vectors is not more than five minutes (MUSCA, 2007). Moreover, Tabanids identified in Mindanao (Region XI and CARAGA) were found important transmitters of *T. evansi* (Dargantes, 2010).

In the Philippines, surra outbreak was associated with the movement of imported Murrah and Bulagarian buffaloes (Luckins, 1999). Furthermore, he observed that the prevalence of surra become endemic around the time of maximum work stress during the agricultural planting season as physical stress, inclement weather, pregnancy, and lactation. Manuel (1998) argued that there were 13 regions identified in the Philippines with surra and among them were Regions 1,2,3 of Luzon and Regions 9,10 and 11 in Mindanao. Recent studies conducted in Region 12 also proved the presence of surra.

The severity and cause of infection of the disease usually depend on the species of the host and the strain of *T.* evansi (Damayanti, 1993). The main clinical signs of surra are anemia (Bowman, 1995; Roberts & Janovy, 1996; Soulsby, 1982; Lang et al., 2001), progressive loss of condition leading to emaciation despite fairly good appetite in many cases, remittent or intermittent mild to moderate fever, extreme leg weakness, edema of pendant parts of the body, paroxysmal tryapanosome parasitemia, depression, recumbency, prostration and death (Bowman, 1995; Roberts & Janovy, 1996; and Soulsby, 1982). Death occurs up to 6 months after onset of signs, but those that recover may serve as carriers (My, 2000). The other significant signs observed in some cases are decreased breeding efficiency; scrotal swelling in bulls, rams and bucks; failure to come into heat (anestrus) in female ruminants (Dargantes, Campbell, Copeman, & Reid, 2005); and various reproductive and neurological disorders resulting into death of the affected animals (Manuel, 1998).

The type of diagnostic test used in the detection of infections vary according to the epidemiological characteristics of the disease and the strategy of control. To improve diagnostic efficiency, many parasitological and serological techniques have been developed (Luckins, 1999). However, these tests cannot always detect current infections because the level of parasitemia fluctuates (particularly during chronic stage of infection) and antibodies that are not present during the first few weeks of infection can persist after chemotherapy (Davison, Thrusfield, Husein, Partoutomo, Rae, & Luckins, 1999). Diagnosis of infection by conventional parasitological techniques is satisfactory in animals with acute or subacute infection where trypanosomes are present in large numbers in the peripheral blood, but it is often more difficult in chronic or latent infections when parasitemia may be intermittent or very low (Aquino et al., 1999). It was also found that diagnosis of surra carried out by demonstration of trypanosomes in blood, cerebrospinal fluid, fixed tissues or lymph (Roberts & Janovy, 1996) is not very efficient especially when the disease is of a chronic infection (Roberts & Janovy, 1996; Soulsby, 1982). Thus, other tests like Mouse Inoculation Test (MIT), and serological tests were conducted and found more efficient (Wilson, 1983). In addition, Dargantes (2010), employed MIT, Microhematocrit Centrifuge Technique, Polymerase Chain Reaction and serological test (CATT) in the diagnosis of surra in livestock. The current control regimen applied in the Philippines is annual sero-testing for surra and only treating sero-positive animals but it was not regarded as effective control (Dobson, Dobson, Dargantes, Mercado, & Reid,

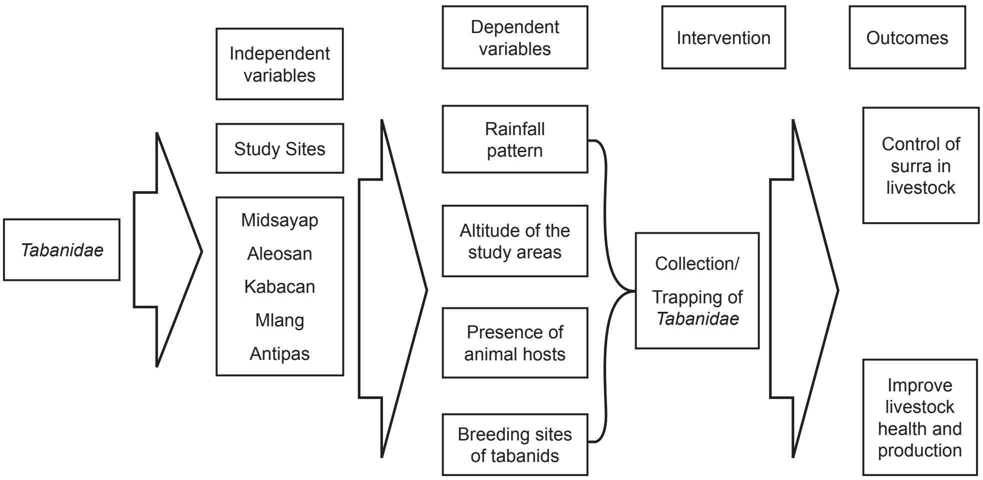


Figure 1. Research paradigm showing the relationship between the independent variables, dependent variables, intervention and outcomes

2009). Other control measures include control of vector by spraying and dipping of animals, spraying of insecticides on the breeding areas and clearing of vegetation (Soulsby, 1982). Some literatures stated that fly traps are currently used in other countries particularly in Africa. Intact, Dargantes (2010) reported that using traps in Region XI and CARAGA to catch flies for examination is effective. Moreover, it was observed in a recent study conducted by Mercado (*pers comm.* 2012) that fly traps could be a potential resource for the control of tabanids.

Figure 1 shows the research paradigm on the relationship between the independent variables, dependent variables, intervention and outcomes of the study. Tabanidae are found in almost all areas but may vary in their abundance. Their abundance depends on the availability of animal hosts for the female tabanids to suck blood, rainfall or water sources as the growing sites of the larvae and pupae. Since tabanids are blood suckers they inflict pain to the host and transmit blood protozoan parasites, the *Trypanosoma evansi,* the cause of surra. Thus, collecting or trapping tabanids as one of the interventions will reduce the population of tabanids and eventually control the disease surra in livestock and finally improve their health and production.

Methodology

The study was conducted from July 2013 to June 2014 in five municipalities (Midsayap, Aleosan, Kabacan, Mlang and Antipas) in north Cotabato, Philippines with three barangays per municipality (Fig 2).

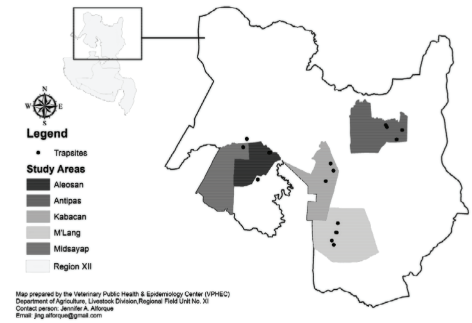


Figure 2. Map showing the study areas and collection sites

(GPS Navigator-eTrex® H, Garmin International Incorporated, Taiwan)

Three Nzi traps (developed by Steve Mihok at ICIPE in Kenya) in each barangay were set up at least 50 meters away from each other to catch tabanid flies (Figure 3). Trapping was undertaken in identified areas where carabaos, cattle, horses or goats were visible with suitable breeding areas for flies. Trapped flies were collected twice a week and were air-dried, identified and classified

Figure 3. Sample of installation of Nzi traps in one of the study areas (New Panay, Aleosan, Cotabato)

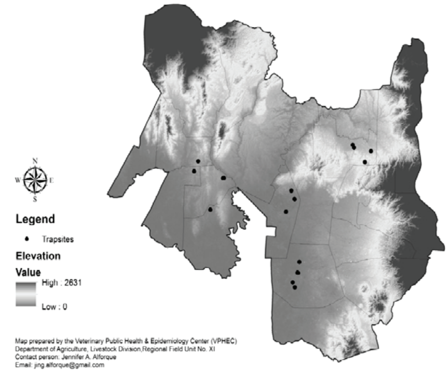


Figure 5. Map showing the elevation of the study area and different collection sites

(GPS Navigator-eTrex® H, Garmin International Incorporated, Taiwan)

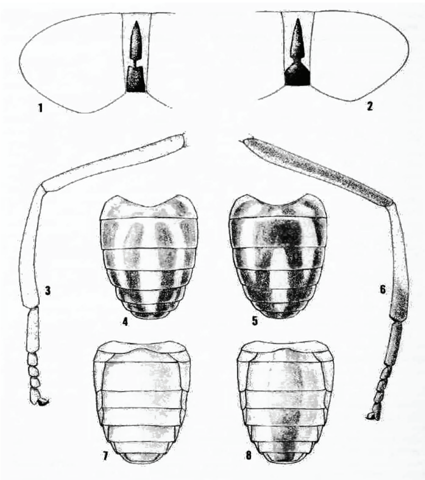


Figure 4. The structure of different species of Tabanus for identification 1 – 2 Head, frontal view, 3,6, foreleg, lateral view, 4-5, abdomen, dorsal view, 7-8, abdomen, ventral view, 1,3,7, Tabanus triceps, 2,5,6,8, T. striatus, 4, T. partitus (Burger & Thompson, 1981).

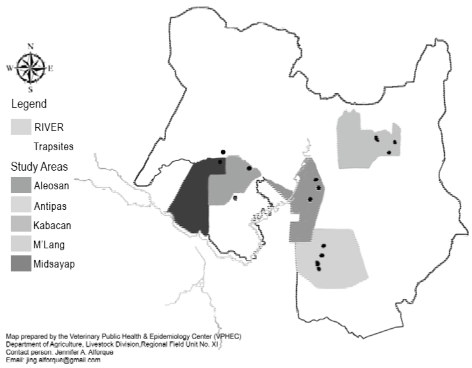


Figure 6. Map showing the river network of the study area

(GPS Navigator-eTrex® H, Garmin International Incorporated, Taiwan)

according to their genera as vectors of surra. All trapped *Tabanidae* flies were counted and recorded per month. Identification of flies was based on the reference used by Philip (1959), Burger and Thompson (1981) (Figure 4), other published references and during a training at Central Mindanao University, Musuan, Bukidnon, Philippines.

Environmental parameters such as elevation (Figure 5), river network (Figure 6), land contour (Figure 7) and land use (Figure 8) were taken by the researchers at the start of the study using a handheld global positioning system (GPS) navigator (eTrex® H, Garmin International Incorporated, Taiwan); and rainfall data for 12 months were obtained from the nearest Agro-climatologial stations in the study area.

Data Gathering

The number and genera of flies caught as vector of *T. evansi* was gathered using the Nzi fly trap, the rainfall pattern was taken from the nearest Philippine

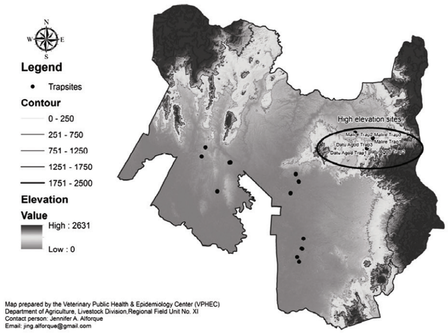


Figure 7. Map showing the altitude of the collection Sites

(GPS Navigator-eTrex® H, Garmin International Incorporated, Taiwan)

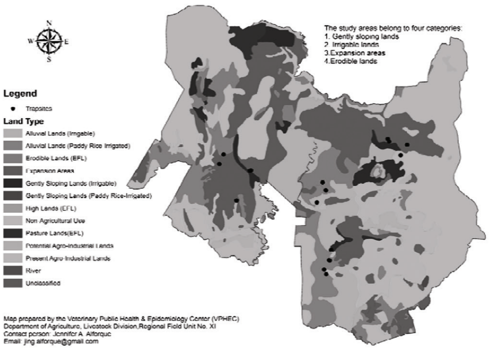


Figure 8. Map showing the land type of the collection sites of the study area

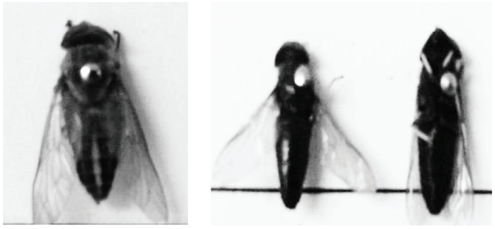
(GPS Navigator-eTrex® H, Garmin International Incorporated, Taiwan)

Atmospheric Geophysical Astronomical Services Administration (PAGASA) weather station , and the topography, altitude, and river network availability of the area, and other breeding places of tabanid flies were gathered using handheld global positioning system (GPS) navigator.

Results and Discussion

Two genera of *Tabanidae* flies were found, the *Tabanus* and *Chrysops.* There were four species of *Tabanus* identified namely: *Tabanus partitus, T. striatus, T. reduscens* and *T. philippinensis* (Figure 9). Other tabanid flies were labeled as unidentified because they were damaged and their morphology was no longer clear. It was found that the color markings of the abdomen of most of the unidentified flies (Figure 10) were vague

a. Tabanus philipinensis *b. Tabanus partitus*



c. Tabanus striatus *d. Tabanus reduscens*

e. Chrysops spp

Figure 9. Different species of tabanid flies identified during the study

Figure 10. Damaged flies due to improper drying and were eaten by ants

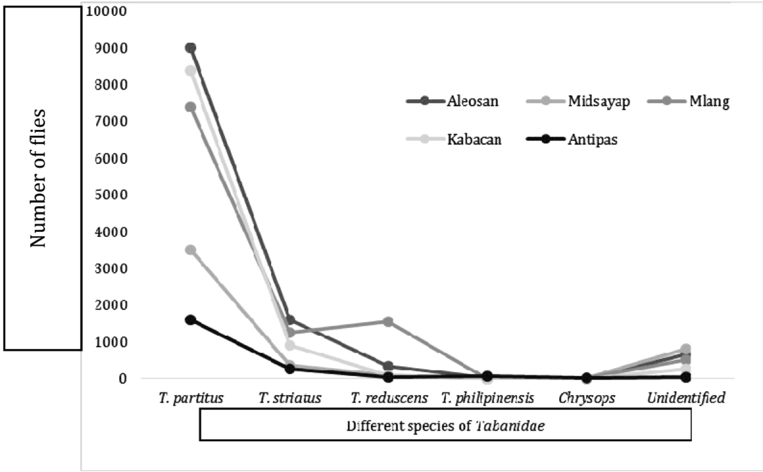


Figure 11. The number and species of Tabanidae trapped and identified from the study areas

and were not properly air-dried due to rain and some flies were partially eaten by ants.

Abundance of tabanid flies according to place and period of collection

The number of flies trapped varied between study areas during the 12 months collection from July 2013 to June 2014 in five municipalities in north Cotabato, Philippines. A total of 38,818 tabanids were trapped and the highest number of tabanid flies were trapped in Aleosan (11,349) followed by Mlang (10,733), Kabacan (9,754), Midsayap (4,855) and the least was in Antipas (2,127) (Figure 10). These flies were identified, namely: *Tabanus partitus* (77.04%), *T. striatus* (11.26%), *T. reduscens* (5.43%), *T. philippinensis* (0.22%) *and Chrysops* (0.12%) and the remaining 5.92% were unidentified tabanids (Figure 10).

Statistical analysis (ANOVA) revealed that the number of species of tabanids differ significantly (p=0.00). The comparison of means by Tukey's test indicates that the greatest number of species of tabanids was of *T. partitus.* Furthermore, statistical analysis revealed that there was no significant difference (p>0.05) in the species of tabanid flies identified and counted based on the place of the study. This result indicates that different species of the family *Tabanidae* were present in the five municipalities.

The different species of *Tabanidae* in the study areas were presented in Figure 11. It was found that trapped *T. partitus* and *T. striatus* were highest in Aleosan with 9,005 and 1,599 flies, respectively. There were more *T. reduscens* in Mlang (1,550) compared to the other species of tabanids in other study sites. *Chrysops* and *T. philipinensis* on the other hand, were highest in Antipas with 26 and 63, respectively, and no *Chrysops* was found in Kabacan and *T. philipinensis* in Mlang. This means that the different species of tabanids vary in their diversity in the different study areas. The variation in the species of flies per area would require further investigation.

Most unidentified tabanids were found in Midsayap (799) and the least was from Antipas (52). The unidentified tabanids were due to their damaged wings, abdomen and heads. The wing venation and abdomen are the basis in identifying up to the species level of these flies. However, these parts were damaged due to improper air drying and due to ants.

The variation in the number of tabanid flies found could be due to the biology of the flies as cited by Soulsby (1982) that larger

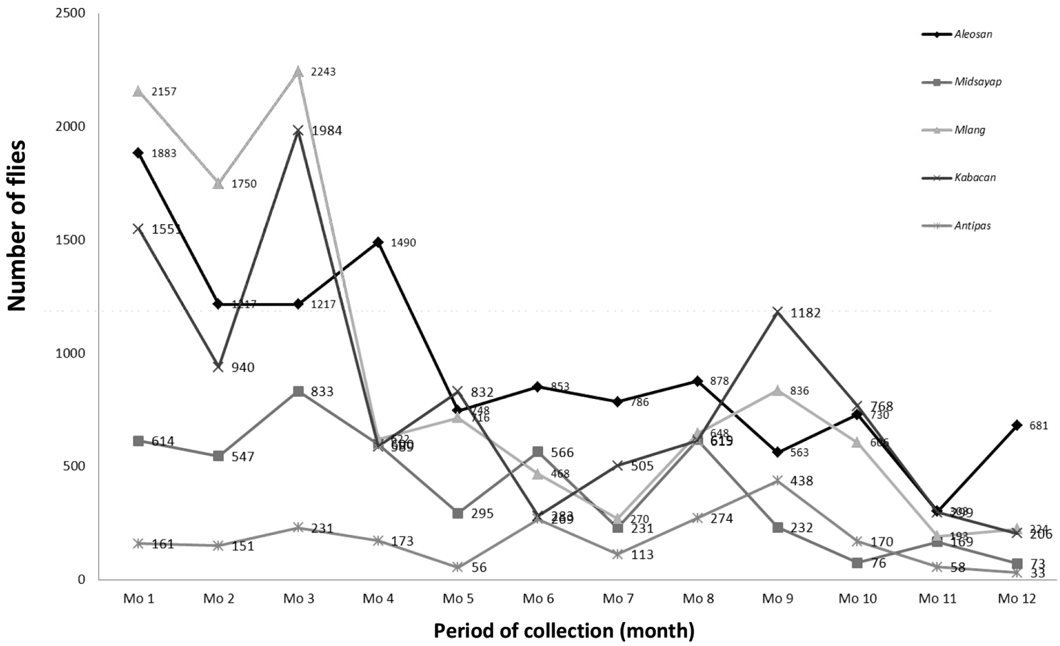


Figure 12. The total number of tabanid flies trapped in selected barangays in five municipalities for 12-month period courtesy from Garduque, 2014.

species of *Tabanus* lay 500-600 eggs and 300 eggs for the smaller species. However, *Tabanus philippinensis* was the largest among the species found but only a very few were observed. Furthermore, Soulsby (1982) mentioned that the whole life cycle takes about 4-5 months under favorable condition to complete which could probably be due to those adult tabanids were attracted to the trap, however, those that were still in their larval and pupal stages in their water habitat emerge a few months after the setting up of the fly trap causing a fluctuating number of flies trapped.

Furthermore, usually there is only *one generation produced a year and some species need more than two years to complete development* as cited in http://www.parasitipedia.net and life cycle of tabanids require from two months to two years, depending on the species and the geographical location (Foil & Hogsette, 1994).

The variation in the number of flies caught was also due to damaged Nzi fly traps. Some traps were damaged due to strong wind brought by a typhoon starting in the month of July 2013. Some traps were destroyed by livestock tethered close to the set up fly traps especially the kids, calves and caracalves which were allowed to run with their dam resulting in no flies caught. But, these factors were observed in almost all fly traps placed in the area.

Abundance of tabanid flies according to the altitude and water sources

The altitude of the study areas varied and the lowest altitude was from Mlang (39.56), followed by Kabacan (49.22), Aleosan (82.22); Midsayap (101.22) and the highest was in Antipas with 186.56 meters above sea level as recorded by the handheld GPS navigator. The abundance of tabanid flies as seen in the graph (Figure 12) in five municipalities is influenced by the altitude of the area but not by the rainfall at different collection periods (Figure 13 a, b, c, and d fly graph) (Mlang graph is not reflected in Figure 13 because of the unavailability of Agro-climatological station in the area), and the presence of water source. Based on the results as shown in Figure 13, there was a negative correlation between the altitude of the place and the abundance of tabanids (R^2= 0.878, p= 0.002).

All barangays included in the study have water sources or irrigation canal surrounding the area as one of the requirements. This is necessary for the tabanid flies to complete the development of their life cycle. Bowman (1995) and Soulsby (1982) pointed out the importance of water when the larvae emerge from the eggs. Although they did not mention the amount of water needed to further develop the larval stage, they found that even the mere presence of mud containing other insect larvae, crustaceans, snails, earthworms, young frogs, and plant and other organic tissues serve as food of the larvae since they are aggressive carnivorous and saprophagous in characteristic. Squitier (2014) mentioned that the larvae of *Tabanidae* are biohydrous and semi-biohydrous. The study areas in Aleosan has a creek, and has areas that are aquatic, semi aquatic and terrestrial. *Chrysops* prefer areas with high water content, whereas, *Tabanus* prefer drier substrates. However, the actual amount of water available in study areas were not considered and measured. On the other hand, Mlang and Kabacan are lowland irrigated ricefield areas which provide an ideal habitat for the larval stages to develop. This state explains the abundance of tabanid flies in Aleosan, Mlang and Kabacan. Despite the presence of water source in Antipas, Cotabato and in one barangay of Midsayap, tabanid flies caught were still few. It was found that there were few tabanids in areas with higher altitude than in Mlang and Aleosan where most number of tabanid flies were caught.

Based on the results, it was found that the higher the elevation or altitude of the study area like in Midsayap and Antipas, the lesser was the number of tabanid flies trapped. This finding was in agreement with the findings of Dargantes (2010) that all five species of tabanids trapped were most common in low than in high altitude areas. The variation in the number of tabanid flies trapped per municipality observed was in agreement with the findings of Bolero (2013) and Sorupia (2014).

But, the threshold altitude and the mountain terrain at which the number of tabanids starts to reduce were not taken.

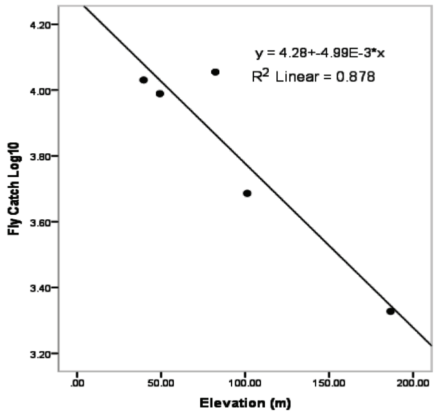
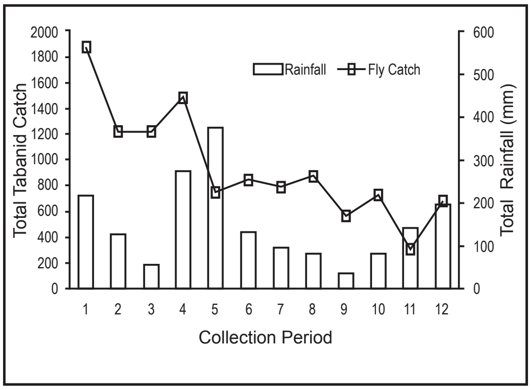


Figure 13 Scatter diagram of the relationship between altitude and number of tabanids caught using Nzi traps in North Cotabato

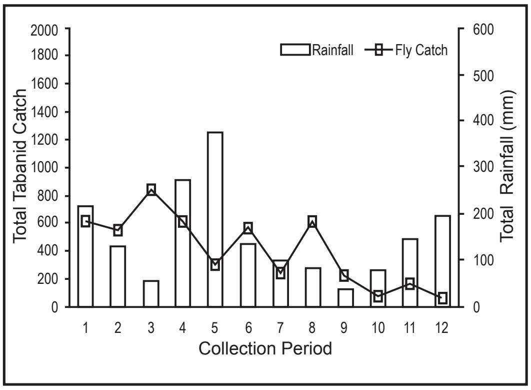
Rainfall pattern and tabanid flies in study sites

The rainfall data (Figure 14 a, b, c, and d) were taken from three Climatological Stations in North Cotabato, Philippines: Midsayap, Kabacan, and Arakan Climatological Stations. Since there is no Weather Bureau stationed in Aleosan, Antipas and Mlang of North Cotabato, rainfall data used were taken from Midsayap for Aleosan; Arakan for Antipas, and none for Mlang since the closest station to Mlang cannot cover the rainfall data.

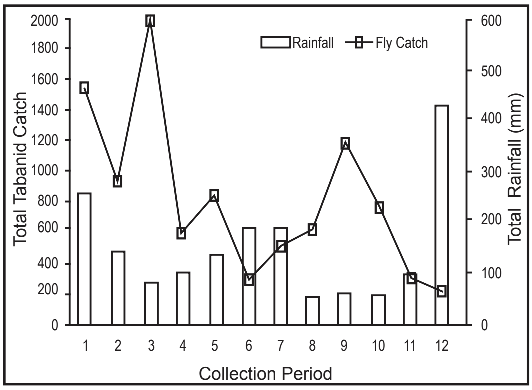
Based on the analysis of data, there was a negative correlation on the relationship between the abundance of tabanid flies and the average amount of rainfall.



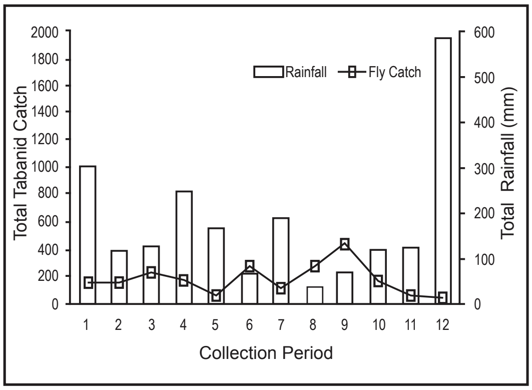
a. Elevation (82.22 m)



b. Elevation (101.22 m)



c. Elevation (49.22 m)



d. Elevation (186.56 m)

Figure 14. Total tabanid caught using NZI traps (n=9 per site) and total rainfall from different Municipalities of North Cotabato (a. Aleosan; b. Midsayap; c. Kabacan; and d. Antipas) courtesy from Garduque, 2014.

It was found that the abundance of flies depends on the rainfall. Aiello (1998), Bowman (1995) and Soulsby (1982) tabanids have a liking for sunlight but there are stages in their life cycle that they are semi-aquatic in characteristic. It was generally observed that the rainfall was not so heavy during the conduct of the study to cause the washing out of the tabanid larvae. This result was also in agreement with the findings of Mercado et al. (2012) in Compostela Valley and Davao del Norte provinces. Moreover, the amount of water and changes in water availability in study areas during the entire duration of the study were not taken.

The abundance of tabanid flies in study areas could be associated with the altitude, source of water, rainfall pattern and the presence of livestock such as cattle, buffaloes, goats and horses in the area. The higher the elevation or the altitude of the study areas, the lesser the number of tabanid flies trapped. The more sources of stagnant water, the more tabanid flies were trapped and the presence of livestock is a requirement for the female tabanid flies to survive and reproduce since blood is their source of food which is necessary for the maturation of their ovaries (Soulsby, 1982).

The reduction in the number of flies trapped from the first month to the 12th month indicated that trapping of flies can be a potential resource to control the vectors of *Trypanosoma evansi* in livestock.

Conclusion and Recommendations

In summary, there were 38,818 *Tabanidae* found namely: *Tabanus and Chrysops* and there were four species of *Tabanus such as Tabanus partitus* (77.04%), *T. striatus* (11.26%), *T. reduscens* (5.43%), *T. philippinensis* (0.22%) and *Chrysops* (0.12%) and the remaining 5.92% were the unidentified tabanids. It was observed that *Tabanus partitus* flies were the most abundant and the least were of *Chrysops.* The highest number of tabanid flies were trapped in Aleosan (11,349) followed by Mlang (10,733), Kabacan (9,754), Midsayap (4,855) and the least was in Antipas (2,127) all in Cotabato.

The abundance of tabanid flies in the study areas was influenced by the altitude and the presence of water sources. The higher the elevation or altitude of the study area, the lesser was the number of flies trapped. The highest total rainfall data was recorded in Arakan (2,131.90) to include the municipality of Antipas. However, Antipas had the lowest number of tabanid flies caught. A variation and reduction in tabanid flies trapped per month from July 2013 to June 2014 using Nzi fly trap implies that trapping Tabanidae flies, the vector of *T. evansi* (surra) infection, is a good resource to control surra disease in livestock.

The presence of flies in the study areas indicated the availability of animal hosts, and their dependence on them, suitable environment like water source, and climatic conditions that favor the breeding of tabanids that transmit *Trypanosoma evansi.* These results must serve as a basis in formulating strategies to continuously reduce the abundance of tabanid flies to improve animal health and production.

It is recommended that a similar study will be replicated in other high risk areas in nearby provinces. It is also recommended that the use of Nzi traps will be adopted by the Local Government Units (LGU) to reduce the risk of livestock to become infected with *Trypanosoma evansi* brought by bites of tabanids. Furthermore, it is recommended to improve the collection, drying and keeping of flies from the study sites to prevent damage of their morphological structures and eating by ants to reduce unidentified tabanid flies. It is recommended further to make a device to record the actual rainfall concentration in the study areas because of the varied locations of the Agro-climatic meteorological stations. Furthermore, it is recommended to assess the amount of water available in the study sites and to conduct a study to determine the threshold altitude at which reduction in the number of tabanids start to occur at the wet and dry side of the mountain.

Moreover, it is recommended to use other control measures such as the use of herbal medicine extracts, the use of ivermectin against tabanid flies in vitro and in vivo, and the use of Nzi fly traps baited and unbaited with urine to attract tabanids to control the tabanid population and subsequently control surra in livestock in North Cotabato, Philippines.

■ ■ ■

References

Aiello, S. E. (1998). Horse flies and deer flies. In: The Merck Veterinary Manual 8th edition p 642, New York, U.S.A.: Merck & Co., Inc.

Aquino, L., Machado, R., Alessi, A., Marques, L., Castro, M., & Malheiros, E. (1999). Clinical, parasitological and immunological aspects of experimental infection with *Trypanosoma evansi* in dogs. *Mem Inst Oswaldo Cruz, Rio de Janeiro. 94 (2): 225-260*.

Bolero, M. E. (2013). *Identification of common species of tabanids caught in selected municipalities of north Cotabato using NZi fly trap* (Unpublished undergraduate thesis). University of Southern Mindanao College of Veterinary Medicine, Kabacan, Cotabato.

Bowman, D. (1995). Blood Parasites. In: Georgi's Parasitology for Veterinarians 6th edition, Philadelphia: W.B. Saunders Company.

Burger, J. F., & Thompson, F. C. (1981). The *Tabanus striatus* complex (Diptera: *Tabanidae):* a revision of some oriental horsefly vectors of surra. *Proceedings of the Entomological Society of Washington, 83*, 339-358.

Dargantes, A. P. (2010). Epidemiology, control and potential insect vectors of Trypanosoma evansi (surra) in village livestock in southern Philippines. (PhD Dissertation. Murdoch University. Western Australia. Retrieved from http://researchrepository.murdoch.edu.au/id/eprint/4629.

Dargantes, A. P, Campbell, R. S, Copeman, D. B, Reid, S. A. (2005). Experimental *Trypanosoma evansi* infection in the goat. II. *Journal of Comparative Pathology, 133*(4), 267-76.

Damayanti, R. (1993). The pathology of natural *Trypanosoma evansi* infection in buffalo (*Bubalus bubalis*) In: Penyakit Hewan. *25*(45), 34-39. Research Institute of Veterinary Science, Bogor, Indonesia.

Davison, H., Thrusfield, R., Husein, A., Partoutomo, S., Rae, F., & Luckins, A. (1999). Evaluation of antigen and antibody detection tests for *Trypanosoma evansi* infection in buffaloes in Indonesia. In: *Epidemiology Infect.* 123, 149-155.

Dobson, R. J., Dargantes, A. P., Mercado, R. T. & Reid, S. A. (2009). Models for *Trypanosoma evansi (surra),* its control and economic impact on small-hold livestock owners in the Philippines. *International Journal for Parasitology, 39(10). 1115-1123.* http://dx.doi.org/10.1016/j.ijpara.2009.02.013.

Foil, L. D and Hogsette, J. A. (1994). Biology and control of tabanids, stable flies and horn flies *Rev. sci. tech. Off. int. Epiz., 13(4), 1125-1158*. Retrieved from http://www.oie.int/doc/ged/D8938.

Hill, C., & MacDonald, J. (2007). *Horse and deer flies*: *biology and public health risk.* Purdue University Public Health Extension Publication E-246-w. Retrieved from http://extension.entm.purdue.edu/publications/E-246.pdf.

Lang, P. S., My, L. N., Lan, P. D. & Phoung, V. L. (2001.) Studies on the incidence and control of trypanosomiasis in buffaloes caused by *Trypanosoma evansi* Steel 1885 in North Vietnam. *Proceedings of Buffalo Workshop*. National Institute of Veterinary Research.

Luckins, A. G. (1999). Epidemiology of non tse-tse transmitted trypanosomiasis, Center for Tropical Veterinary Medicine. Easter Bush, Roslin, Midlothian, Scotland (Abstract).

Manuel, M. F. (1998). *Sporadic outbreak of surra in the Philippines and its economic impact* (Unpublished undergraduate thesis). College of Veterinary Medicine, University of the Philippines, Los Baños, Laguna, Philippines.

Mercado, R. T., Gonzaga, E. A., Garduque, R. J., Salcedo, N. B., Molina, E. C., Dargantes, A. P., & Alforque J. A. (2012). *Relative abundance of tabanids and prevalance of surra in selected barangays of Davao* *del Norte and Compostela Valley Provinces, Mindanao, Philippines*. (Terminal Report) Davao City: Department of Agriculture, Region XI.

My, L. N. (2000). Comparison of serological tests for *Trypanosoma evansi* natural infection in water buffaloes in north Vietnam. National Institutue of Veterinary Research, Troung China 61, Dong Da, Hanoi, Vietnam. Internet access: http://www.elsevier.com

Philip, C. B. (1959). The Philippine expedition 1946-1947: *Tabanida*e (Diptera). *Feldiana Zoology, 33*, 543-625.

Roberts L. S. and Janovy, J. (1996). Blood Parasites. In: Foundation of Parasitology 5th edition, pp. 253-257, USA: WBC.

Sorupia, F. J. R. (2014). *Identification of common species of tabanids caught in selected Municipalities of North Cotabato using Nzi fly trap* (Unpublished undergraduate thesis). College of Veterinary Medicine, University of Southern Mindanao, Kabacan, Cotabato.

Soulsby, E. J. L. (1982). *Helminths, arthropods, and protozoa of domesticated animals* (7th ed.). Philadelphia: Lea & Febiger.

Squitier, J. M (2014). Common name: deer flies, yellow flies and horse flies scientific name: *Chrysops, Diachlorus, and Tabanus* spp. (Insecta: Diptera: Tabanidae) http://entnemdept.ufl.edu/creatures/livestock/deer_fly.htm.

Wilson, A. J. (1983). The non tse-tse-borne Trypanosmiases. *The Kenya Veterinarian 9*(2), 15. Research Institute for Animal Disease, Bogor, Indonesia.