Prevalence and antelmintic efficacy studies on gastrointestinal parasites of semi captive orangutans at Orang-Utan Island (OUI), Bukit Merah, Perak
Zary Shariman Yahaya*, Sabapathy A/L Dharmalingam and Noorkhairiah Salleh

Abstract
A total of 338 faecal samples are collected from 16 semi-captive orang utans (5 adults, 5 sub-adults, 6 juveniles) from December 2010 to October 2011. They are screened for gastrointestinal parasites using method of direct smear, faecal flotation, faecal sedimentation, faecal culture and McMaster technique. The aim is to study the gastrointestinal parasites prevalence for semi-captive orang utans and the parasitic infection with the seasonal trend. For the nematodes, *Strongyloides* spp. prevalence was significantly higher throughout the study period compared to trichostrongylids and *Trichuris* spp. One protozoan found and classified as cysts and trophozoites of *Balantidium* spp. Sub-adult orang utans gave the highest prevalence for *Strongyloides* spp. larvae, while juveniles gave the highest for *Strongyloides* spp. eggs. However, the occurrences of trichostrongylids and *Trichuris* spp. were at low prevalence throughout the study. For the protozoa, sub-adults gave the highest prevalence for *Balantidium* spp. cysts and juveniles for the trophozoites. The seasonal difference occurred only in juvenile orang utans where the number of total eggs per gram was significantly higher during the wet season compared to the dry season. Anthelmintics efficacy test was also done to the parasitic infections of the orang utans. The percent efficacy tested that Ivermectin with 98.9%, Albendazole with 99.3% and Mebendazole with 23.2% of percent eggs reduction. However, orang utans tested with Ivermectin had the lowest mean epg at 25 eggs per gram until the fourth week. Also, two species of nematodes are identified until the species level using the 18s rDNA for *Strongyloides* spp. and ITS-2 rDNA for *Oesophagostomum* spp. Sequencing results revealed that the larvae culture had 100% similarity of *Strongyloides fuelleborni* and 99% similarity of *Oesophagostomum cf. aculeatum*.

Key words
Bornean orang utan, parasites, infectious disease, semi-captive orang utan

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1. Introduction
There are many animal species that are unique to our part of Malaysia, but none of them is as endeared as the Orang utan. Many of them are found in the Borneo and Kalimantan forest and they have been known to roam these regions for ages. Orangutan (Pongo pygmaeus) is an endangered mammal species and its population has started to dwindle in recent time, especially in the natural habitats of Borneo, Sumatra and Kalimantan regions. Orang utans are highly arboreal semi-solitary animals. They built nest everyday and their diet is mainly frugivorous. Many aspects of orangutans have been studied in previous years, but not much has been done on the ecto and endo-parasites of orangutans. One of the first reports on orangutan endo-parasites was by Collet et al. (1986), who stated that Strongyloides spp., Balantidium coli, and strongylid nematodes were the most common infestations detected. In addition, a syngamid nematode, Mammomonogamus sp, was also reported for the first time in orangutans. The latest finding by Mulet et al. (2007) who found additional endo-parasite species in orangutan fecal samples such as Chilomastix sp., Giardia sp., Spirurida sp., Ascaris sp., Dicrocoelidae sp., and cestode species. On the one hand, no published report is found on the ecto-parasite of orangutan up to this date. Nevertheless, on the other hand Reid et al. (2006) has reported their findings of Plasmodium spp. in blood samples of orangutans in captivity. Parasites are the most important threat to conservation of endangered species that clearly can cause short term reduction of population size (Collet et al. 1986).

A study on the gastrointestinal parasites of semi-captive Bornean orang utan (Pongo pygmaeus pygmaeus) at the Orang Utan Island (OUI), Bukit Merah, Perak, Malaysia was conducted from December 2010 until December 2011. Sixteen (16) individual orang utans' fecal samples were examined every four (4) weeks for gastrointestinal parasite infection using the method of direct smear, modified McMaster’s technique and faecal culture. The objectives of this study were:

i. To study the prevalence of gastrointestinal parasites infecting semi-captive orang utan in OUI, Bukit Merah.

ii. To study the effect of surrounding parameters towards the prevalence of parasite infecting the animals in OUI.

iii. To determine the common parasite species infecting orang utan in semi-captive conditions.

iv. To determine the efficacy of anthelmintic treatments for gastrointestinal parasite in semi captive orang utan condition.

v. To identify the helminths and protozoan parasites by molecular identification.

2. Prevalence of Gastrointestinal Parasites in Semi-captive Orang utans

2.1 Species Identification by Morphological Observation
The prevalence of helminths and protozoan infections was obtained by the method of direct smear, faecal flotation, faecal sedimentation, McMaster’s technique and faecal culture. Species identification was done by observing the morphology of collected parasite samples and identified them using references provided by Roberts and Janovy (2008). Three types of helminths were found in faecal samples of orang utan. They were eggs and larvae (L1) of Strongyloides spp. (Figure 4), eggs of Trichostrongylids (Figure 5) and eggs of Trichuris spp. (Figure 6). In addition, only one type of parasitic protozoa, Balantidium spp. was identified (Figure 7).
2.2 Prevalence of Helminth Parasites between Age Groups

Table 1 and Figure 1 show the prevalence of helminths parasites recovered from the adult, sub-adult and juvenile orang utans for the 11 months of study period. It shows that the adults had the least number of parasites infections. Sub-adult orang utans showed highest number of parasites infections while the juveniles showed a moderate number of parasites infections from December 2010 to October 2011.

Table 1: Prevalence of Helminths Parasites between Adult, Sub-adult and Juvenile Orang utans

<table>
<thead>
<tr>
<th>Orang utan</th>
<th>N</th>
<th>Stro</th>
<th>Tc</th>
<th>Tri</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>eggs</td>
<td>larvae</td>
<td>eggs</td>
</tr>
<tr>
<td>Adults</td>
<td>110</td>
<td>50.91 ± 12.21</td>
<td>16.36 ± 17.47</td>
<td>13.64 ± 16.29</td>
</tr>
<tr>
<td>Sub-adults</td>
<td>110</td>
<td>82.73 ± 11.91</td>
<td>38.18 ± 21.36</td>
<td>24.55 ± 16.94</td>
</tr>
<tr>
<td>Juveniles</td>
<td>118</td>
<td>86.27 ± 13.34</td>
<td>31.0 ± 24.07</td>
<td>22.82 ± 20.19</td>
</tr>
</tbody>
</table>

Description: Stro: Strongyloides spp.; Tc: Trichostrongylids; Tri: Trichuris spp.

Figure 5: Comparison of Helminths Prevalence between Adult, Sub-adult and Juvenile Orang utans. Stro: Strongyloides spp.; Tc: Trichostrongylids; Tri: Trichuris spp.
2.3 Prevalence of *Balantidium* spp. between Adults, Sub-adults and Juveniles Orang utans

Only one species of protozoan was found during the study period from December 2010 to October 2011. Table 2 and Figure 2 show the prevalence of *Balantidium* spp. recovered from the adult, sub-adult and juvenile orang utans for 11 months of study period. It shows that adults have the least occurrence of trophozoites stage of *Balantidium* spp. compared to sub-adults. However, juvenile orang utans have the highest number of trophozoites stage of *Balantidium* spp. where usually lead them to diarrhoea. However, the study shows that adult and sub-adult orang utans have slightly high occurrence of *Balantidium* cysts compared to the juveniles.

2.4 Total Eggs per Gram (EPG) in Adult, Sub-adult and Juvenile Orang utans

Table 3 and Figure 3 show low total eggs count found in adult orang utans throughout the study period compared to sub-adult and juvenile orang utans. However, sub-adult orang utans show the highest eggs per gram reading for almost every month. Juveniles show significantly high eggs per gram reading for October 2011 compared to other months.

<table>
<thead>
<tr>
<th>Orang utan</th>
<th>N</th>
<th><em>Balantidium</em> spp.</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Trophozoites</td>
<td>Cysts</td>
<td></td>
</tr>
<tr>
<td>Adults</td>
<td>110</td>
<td>0.91 ± 3.02</td>
<td>26.36 ± 9.24</td>
<td></td>
</tr>
<tr>
<td>Sub-adults</td>
<td>110</td>
<td>15.45 ± 12.93</td>
<td>37.27 ± 16.79</td>
<td></td>
</tr>
<tr>
<td>Juveniles</td>
<td>118</td>
<td>34.0 ± 15.13</td>
<td>25.18 ± 18.0</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Prevalence of *Balantidium* spp. between Adults, Sub-adults and Juveniles Orang utans

Figure 6: Prevalence of *Balantidium* spp. between Adults, Sub-adults and Juveniles Orang utans
Table 3: Comparison of Total Eggs per Gram (EPG) in Adult, Sub-adult and Juvenile Orang utans

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>Adults</td>
<td>110</td>
<td>65.00 ± 81.82</td>
<td>20.00 ± 42.16</td>
<td>165.00 ± 265.68</td>
<td>120.00 ± 217.56</td>
<td>70.00 ± 133.75</td>
<td>25.00 ± 35.36</td>
<td>125.00 ± 204.46</td>
<td>233.33 ± 422.33</td>
<td>140.00 ± 309.84</td>
<td>60.00 ± 84.33</td>
<td>30.00 ± 59.86</td>
</tr>
<tr>
<td>Sub-adults</td>
<td>110</td>
<td>775.00 ± 862.89</td>
<td>1300.00 ± 2300.12</td>
<td>595.00 ± 1502.67</td>
<td>1225.00 ± 2193.71</td>
<td>900.00 ± 913.48</td>
<td>525.00 ± 784.31</td>
<td>793.00 ± 996.52</td>
<td>1900.00 ± 3616.24</td>
<td>940.00 ± 1094.6</td>
<td>710.00 ± 1051.93</td>
<td>1892.50 ± 1500.47</td>
</tr>
<tr>
<td>Juveniles</td>
<td>118</td>
<td>365.00 ± 423.64</td>
<td>605.00 ± 1001.24</td>
<td>365.00 ± 591.63</td>
<td>355.00 ± 445.00</td>
<td>675.00 ± 910.20</td>
<td>855.00 ± 1256.42</td>
<td>475.00 ± 805.62</td>
<td>495.83 ± 752.71</td>
<td>833.33 ± 1348.62</td>
<td>779.17 ± 1126.03</td>
<td>1950.00 ± 1768.09</td>
</tr>
</tbody>
</table>

Figure 7: Comparison of Total Eggs per Gram (EPG) in Adult, Sub-adult and Juvenile Orang utans
3. Efficacy Studies of Ivermectin, Albendazole and Mebendazole Anthelmintics to the Orang Utans

3.1 Ivermectin
Number of total eggs per gram (epg) of orang utans pre- and post treatment with ivermectin is presented in Figure 8 in the two weeks of pre-treatment and four weeks of post-treatment study. As in the graph, epg of treated orang utans reduced tremendously after the treatment given. Number of eggs found in Adam and Malek remained negative until forth week. However, Nikol maintained an epg below 75 eggs in a gram of faecal until the fourth week.

3.2 Albendazole
Figure 9 shows the total epg before and after the treatment of Albendazole given to Carlos, Harry and Carina who harboured high total epg from 125 to almost 4000. However, after the treatment given (week 1, 2, 3, 4) there was a decrease in total epg for Paulina and April but no changes for Charles Jr.

3.3 Mebendazole
Figure 10 shows the total epg before and after the treatment of Mebendazole given to Paulina, Charles Jr. and April who harboured high total epg from 25 to almost 5000. However, after the treatment given (week 1, 2, 3, 4) there was a decrease in total epg for Paulina and April but no changes for Charles Jr.

3.4 Control
Figure 11 presented the number of total eggs per gram (epg) of non-treated group of orang utans. The study comprised of two weeks of pre-treatment and two weeks of post-treatment analysis. As in the graph, the epg were reduced at the first week and increased drastically at the following weeks.

![Figure 8: Total eggs per gram (epg) of Strongyloides spp. in 6 weeks studies of Ivermectin Group](image)

![Figure 9: Total eggs per gram (epg) of Strongyloides spp. in 6 weeks studies of Albendazole Group](image)
4. DNA Identification of Gastro Parasitic Nematode of Orang utans

4.1 Materials and Methods

4.1.1 Total DNA Extraction

Nematode larvae of Strongyloides spp. and Oesophagostomum spp were cultured from orang utans’ faecal samples at Orang Utan Island, Bukit Merah. It was then preserved in 70% of ethanol and kept at ambient temperature at 4°C. The genomes DNA were extracted using Qiagen DNeasy Blood & Tissue Kit by Spin-Column protocol for Animal Tissue. Approximately one thousand (1000) of infective larvae of L3 were used for optimal DNA extraction and placed in a sterile 1.5 ml microcentrifuge tube. It was then added with 180 µl of Buffer ATL. Then 20 µl of proteinase K were added followed by 5 – 10 s vortexing to mix them well and incubated in the water bath at 56°C for overnight to maximize the lysis of larvae tissue. After the incubation, the mixture was vortexed again and 200 µl of Buffer AL was added and directly homogenized by vortexing. Then the mixture was immediately added with 200 µl of ethanol (96 – 100%) and mixed again by vortexing.

All the mixture was pipetted out into the DNeasy Mini spin column placed in a 2 ml collection tube and centrifuged at 8000 rpm for 1 minute. The flow - through and collection tube were discarded and placed the DNeasy Mini spin column into a new 2 ml collection tube. Then 500 µl of Buffer AW1 were added and centrifuged at 8000 rpm for 1 minute. The flow - through and collection tube were discarded and placed the spin column into a new 2 ml collection tube. Next 500 µl of Buffer AW2 were added and centrifuged for 3 minutes at 14000 rpm to ensure no carried over of residual ethanol that might interfered with subsequent reactions. The DNeasy Mini spin column was placed in a sterile 1.5 ml microcentrifuge tube and instead of 200 µl of elution buffer, 50 µl of Buffer AE were directly pipetted onto the DNeasy membrane to increased final DNA concentration followed by incubation at room temperature for 1 minute.
prior centrifuged at 8000 rpm for 1 minute. The extracted DNA was kept at –20°C until used. The quality of the yielded DNA was analyzed by agarose gel electrophoresis.

4.1.2 Electrophoresis by Agarose Gel
The DNA was analyzed on 1.0 % agarose gel in 0.5X TAE (Tris-acetate-EDTA) buffer. 0.5 g Agarose powder (Promega) was weighed and boiled with 50 ml 0.5X TAE buffer. Once the slurry cooled down, it was poured into a mini gel casting tray with a comb provided. After the gel was solidified, the samples was prepared by mixing 5 µl of the DNA sample with 1 µl of 6X loading dye (Vivantis) and it was then loaded into each well. For comparison of DNA fragment, 1 µl of 1 kb DNA Ladder (Fermentas) was loaded into the gel as a reference. The gel was processed at 65 V for 30 minutes. Finally, the gel was stained with ethidium bromide solution and observed the band under UV light using gel documentation system (FluorChem HD2, Cell Biosciences).

4.1.3 Molecular Identification using 18S rDNA Sequence
Purified DNA isolated from the L3 Strongyloides spp. larvae were amplified using primers of Nem18SF (5’- CGCGAAATRGCTCATTACAACAGC-3’) and 18SPCR (5’-ACGGGCGGTGTGTRC-3’). The reaction mixture consisted of 1X Taq buffer (Promega), 2 mM MgCl₂ (Promega), 0.2 mM dNTP mix (Promega), 1 µM of each primer, 0.05 U of Taq DNA polymerase (Promega) and 10 – 50 ng/µl of DNA as the template in a total volume of 25 µl. The amplification was performed using MyCycler™-Thermal Cycler (BIO RAD, U.S.A) with the following cycle condition consisted of pre-denaturation at 94°C for 1 min, followed by 25 cycles of denaturation at 94°C for 30 seconds, annealing at 55°C for 30 seconds and extension at 72°C for 30 seconds for PCR1 while 10 cycles was added in PCR2. The final extension at 72°C for 5 minutes was also included.

4.1.4 Molecular Identification using ITS-2 rDNA Sequence
A semi – nested PCR assay was applied to detect ITS-2 rDNA sequence using purified DNA isolated from the L3 Oesophagostomum spp. larvae. Three primers were used namely NC1F (5’-AGCTTGTCTTCAGGGTTT-3’), NC2R (5’-TTAGTTTTCTCCCGTCTCT-3’) and OBF (5’-TATATTGCAACAGTTTTGTTGCT-3’). The first PCR (PCR1) used primer pairs of NC1F and NC2R while the second PCR (PCR2) used primers pairs of OBF and NC2R. Reaction mixture for both PCR1 and PCR2 were similar which contained 1X Taq buffer (Promega), 3 mM MgCl₂ (Promega), 0.2 mM dNTP mix (Promega), 1 µM of each primer, 0.05 U of Taq DNA polymerase (Promega) and 10 – 50 ng/µl of DNA as the template in a total volume of 25 µl. Subsequent to successful PCR1, the products was subjected to PCR2. The amplification was performed using MyCycler™-Thermal Cycler (BIO RAD, U.S.A) with the following cycle condition consisted of pre-denaturation at 94°C for 5 minutes, followed by 25 cycles of denaturation at 94°C for 30 seconds, annealing at 55°C for 30 seconds and extension at 72°C for 30 seconds for PCR1 while 10 cycles was added in PCR2. The final extension at 72°C for 5 minutes was also included.

4.1.5 Extraction and Purification of DNA
Extraction and purification of the DNA were done using QIAquick Gel Extraction Kit by Spin Protocol. The DNA fragment viewed from the agarose gel was cut with a clean, sharp scalpel and put into the 1.5 ml microcentrifuge tube. The microcentrifuge tube was weighed before and after putting the excised gel to get the weight of the gel. 3 volumes of Buffer QG were added to 1 volume of gel (100 mg ~ 100 µl). Then, the tube was incubated at 50°C for 10 minutes by vortexing them every 2 – 3 minutes during incubation to help the gel dissolved. Next, 1 gel volume of isopropanol was added to the sample and mixed before transferred the sample into the QIAquick spin column placed in a 2 ml collection tube. Then for the DNA binding, the tube was centrifuged at 13 000 rpm for 1 minute and the flow – through was discarded. 0.5 ml of Buffer QG was added as recommended to the QIAquick spin column placed in a new collection tube and centrifuged for 1 minute at 13 000 rpm. After that, 0.75 ml of Buffer PE was added for DNA washing and centrifuged for 1 minute at 13 000 rpm. The flow – through was discarded and the column was centrifuged for another 1
minute at 13,000 rpm in addition. Finally, QIAquick column was placed in a clean 1.5 ml centrifuge tube. Elution was done by added 30 µl of Buffer PE to the centre of the column and let it stands for 1 minute before centrifuge at 13,000 rpm for again 1 minute.

4.1.6 Sequencing
The 18s rDNA and ITS-2 rDNA gene sequence were analyzed for the identification of the helminths species. The sequencing was performed by 1st BASE Laboratories Sdn. Bhd with the primer set of Nem18SF and 18SPCR for Strongyloides spp. and primer set of OBF and NC2R for Oesophagostomum spp. The sequences obtained were aligned with those in the GenBank by using Basic Local alignment Search Tool (BLAST) to determine the species.

4.2 Results

4.2.1 Total DNA Extraction from helminths
The total genomic DNA from six samples was extracted using the recommended protocol of DNeasy Tissue Kit (Qiagen, USA). The samples showed a smeared band when analyzed on 1% agarose gel (Figure 12). Each sample represented species at different age groups.

4.2.2 Molecular Identification Products of Genomic DNA

4.2.2.1 Molecular Identification using 18s rDNA Sequence
The extracted DNA from the L₃ of Strongyloides spp. larvae was amplified using Nem18SF and 18SPCR primers. Figure 13 shows a gel picture from a successful of 18s rDNA amplification with the size of band at approximately 1,500 bp.

4.2.2.2 Molecular Identification using ITS-2 rDNA Sequence
The extracted DNA from the L₃ of Oesophagostomum spp. larvae was amplified using semi-nested PCR assay. NC1F and NC2R primers were used for the PCR1 and followed by OBF and NC2R primers for the PCR2. ITS-2 rDNA gene was amplified at approximately 220 bp (Figure 14).
Table 4: Blast results for S. fuelleborni that shows high similarity in certain host.

<table>
<thead>
<tr>
<th>Accession No.</th>
<th>Host</th>
<th>Similarity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB272235</td>
<td>Macaca fuscata</td>
<td>99</td>
</tr>
</tbody>
</table>

Figure 15: The 18s rDNA nucleotide sequences of S. Fuelleborni from orang utan isolate.

4.2.3 DNA Purification and Sequencing

The amplified target genes were purified and sent for sequencing. The sequences obtained were aligning with those in the GenBank using Basic Local alignment Search Tool (BLAST) to determine the species. It shows 99 - 100 % similarity of Strongyloides spp. to Strongyloides fuelleborni.

Meanwhile, it shows 93 % similarity of Oesophagostomum spp. to Oesophagostomum bifurcum.

Table 5: Blast results for O. bifurcum that had shown high similarity in certain host.

<table>
<thead>
<tr>
<th>Accession No.</th>
<th>Host</th>
<th>Similarity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AF136575</td>
<td>Non-human primates</td>
<td>93</td>
</tr>
</tbody>
</table>

Figure 16: The ITS-2 rDNA nucleotide sequences of O. bifurcum from orang utan isolate.

5. Discussion

The study of gastro parasites of orang utans especially in Malaysia has not been done thoroughly for a very long time. Although that is the case, many would agree that there is an urgent need for this kind of research in order to set up an effective disease management program for captive and semi-captive orang utans. In this study, we have successfully determined the prevalence and identified the species of three main gastrointestinal nematodea parasites of orang utans including a parasitic protozoa species.

All in all, the epg data pattern collected in this study showed unpredictable pattern of infection that could be due to exposure of the orang utan to the fecal contaminated with parasitic eggs in the animal living areas, rather than to the environmental factors. In addition, behavior observations were done for every orangutan sampled in order to observe any pathological affect of gastrointestinal parasitic infection on the animals. Due to high standard of animal disease management practice in OUI, we found that none of the orang utan that were carrying the parasites showed any serious symptoms of diseases.
Even though while being infected with the parasites (Table 1, 2 and 3), the adults (Figure 17) showed no symptoms at all with active behavior, good appetite and having solid faecal. This was because of the fully developed body immune system of these adult animals that limits the disease severity (Nunn et al., 2003). Same goes to the sub-adult (Table 1, 2 and 3) orangutans who also showed almost no symptoms at all with active behavior, good appetite and having solid faecal. This was because high parasites exposure in sub-adults may have evolved their immune defense system to limit parasites transmission or physiological resistance to infection upon exposure (Nunn et al., 2003).

Figure 17: Adult orangutans

However, juvenile orangutans (Table 1, 2 and 3) with somehow low parasites prevalence and eggs found compared to the sub-adults orangutan (Figure 18), showed pathological changes with inactive behaviour, appetite lost and watery diarrhoea faecal. This was because of the Juveniles’ undeveloped immunity resistance towards gastrointestinal parasitic infection and therefore, obvious clinical symptoms were observed on them (Lilly et al., 2002).

There were possible factors of parasitic infections; huge number of infective stage of parasites within the exhibit release, overlapping habitat with other primates, humans and ruminants, faecal oral route infections due to coprophagy habits and contaminated food and water.

Figure 18: Sub-adult and juvenile orangutans

Prevention steps have been taken to reduce the number of parasites infections in orangutan include effective hygiene environmental management, clean water supply, routine fecal examination and treatment with sensitive de-wormers and anti-protozoa drug when infections are detected. However, hygienic environmental care for infant orangutans such as wearing diapers have made the parasites infections uncommon in captive (Levecke et al., 2007).

Other than that, individuals infected with respiratory disease and skin diseases are also given treatment. Orangutans can also get infected with other illnesses that could contribute to the higher number of parasitic infection. When illness or other disease infects them, their immunity system becomes weaker and thus parasitic load increased. Thus, as the solution, the infected individuals were given tetracycline, vitamin B complex, hercoff, hosolvon and ventoline. On the other hand, cotrim, neo cortisone cream and trimazole were given to treat any skin infection found on orangutan.

Moreover, it was found that the injured individual could also harboured higher parasitic infection. Orangutans sometimes fight with each other and cause cuts and bruises, and the individual orangutan carrying injuries is highly susceptible to parasitic infection. According to Semple et al. (2002), intraspecific aggressive interactions and attacks by the predators can cause serious injury and consequently high risk of parasitic infection.

All three anthelmintics were given orally to selected number of orangutans. In the end, Ivermectin showed the highest effectiveness compared to albendazole and mebendazole. This is expected as ivermectin is the least
anthelmintic used in animal disease management as it is expensive and due to this, anthelmintic resistant cases from this drug is much less than the other two. Therefore, the effectiveness of Ivermectin is better in treating gastrointestinal parasite infection in these orang utans. Control group showed the highest reading and increased number of eggs during the rainfall in the studies.

6. Conclusion
Further research is needed to identify and understand the transmission method of parasitic species of orangutan in order to better assess the health risk of these parasitic infections, parasites intensities in orang utans and other sources of pathogen affecting orangutan health and survival (Huffman et al., 1997; Mul et al., 2007). These steps are necessary to ensure that no parasite species present can cause adverse effect to the orangutan population especially in captive and semi-captive conditions. Hopefully, when all these measures are taken, we can avoid these beautiful and warm animal from becoming extinct and save them for our future generations.

We would like to thank and say our gratitude to Dr. Kalyana Sundram and Malaysian Palm Oil Council (MPOC) for the research grant given for this research.

References