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Diversity and ecological implications of feather lice on wild and captive Grey Parrots in Cameroon

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ABSTRACT

The Grey Parrot is highly prized around the world for its reputation as an intelligent bird species. A good knowledge of parasites of the parrot will be useful in developing possible control measures, which can be used to enhance the survival rate of the parrot in both the wild and captivity. The study identified the diversity of feather lice (Mallophaga) of the Grey Parrot and determined ecological factors that can influence the transmission of these parasites within the bird populations. A total of one hundred and ninety seven (160) wild and captive parrots were sampled from Mebang and Limbe Wildlife Centre (LWC). From the results obtained, five genera of feather lice were identified belonging to two families, one order and two sub-orders. The prevalence and intensities of infestation of ectoparasites within the two parrot populations were influenced by ecological factors such as site, age, sex, seasonality and density of the hosts. It was concluded that the rate of infestation of feather lice in Grey parrots could increase in captive enclosures than in their free ranging counterparts. A maximum enclosure size for a captive parrot population will reduce the probability of ectoparasitic host to host transmission, and will lead to overall health improvement.

Key words: Grey Parrot, Mallophaga, Feather Lice, Ectoparasite, Cameroon

INTRODUCTION

In recent years, the ecology of parasites of birds has received much attention from a conservation perspective as free-ranging wild birds have been discovered to be frequently afflicted with numerous parasites that occasionally cause illness (Loye and Carroll, 1995; Kose, *et al*., 1999; Doyle *et al*., 2005). Similar studies have shown that ectoparasites affect the health and productivity of many bird species, initiates excessive preening which interrupts feeding and as such, these birds spend much time preening rather than involved in other essential life activities such as feeding and playing (Clayton *et al*., 1997; Doyle *et al*., 2004). In addition to being vectors of many diseases of birds, ectoparasites cause illness and sometimes death in many species. For example, a few adult ticks feeding on a chick of the domestic fowl can cause anaemia, reduced growth, weight loss, and contribute to a depressed state of health (Brooke, 1985; Bucher, 1988). Fatal paralysis from bites of tick has been reported in numerous species of small birds (Dumbacher, *et al*., 1996; Kettle, 2000; Doyle *et al*., 2005).

Risk of infection is increased in birds that breed in tree cavities such as parrots and woodpeckers. The parasites can possibly live much longer inside the cavities after the bird has left than in non-cavity nests where they are more exposed to aggressive weather conditions such as wind, sunlight intensity and rain. Most cavity nesting parrots often re-use their cavities for several breeding seasons and as such the probability of re-infection is high (Collar 1997; Juniper & Parr 1998). For example, such behaviour has been observed in neotropical parrots (Wright *et al*., 2001) and the African Grey Parrot (Fry *et al*, 1988; Pain *et al*., 2006; Tamungang & Cheke, 2009;). Related studies show that ecto-parasitic load data of psittacids are known for the Burrowing Parrot *Cyanoliseus patagonus* (Mey & Masello, 2002), and the Monk Parakeet *Myiopsitta monachus* (Aramburú *et al.* 2003). The study of bird ectoparasite associations has provided glaring examples of parasite-mediated ecology and evolution (Noble & Noble, 1971). For example, it is now known that ectoparasites play an important role in the lives of birds with far reaching implications for the ecology and evolution of many species (Loye & Carroll, 1995; Doyle *et al*., 2005). Ornithosis, also called "psittacosis" or "parrot fever," is a well studied and popular parrot disease. It is implicated with *Chlamydia*, a bacterial-like germ found in sick parrots, parakeets and similar birds where symptoms of lung infections dominate (Bucher, 1988; Rae, 1995; Berkunsky *et al*., 2005).

In contrast to neo-tropical parrots, there is a dearth of documented information on parasites of African parrots. This paper is therefore an attempt to provide such basic information on ectoparasites of the African Grey Parrot. The African Grey Parrot is now known to be comprised of two species (Melo & O'Ryan, 2007): the Congo Grey Parrot *Psittacus erithacus* of the Congo Basin, whose distribution ranges from east of River Comoé in Côte d'Ivoire to Angola and the Western form, the Timneh Parrot *Psittacus timneh,* which is endemic and ranges from the west of River Comoé in Côte d'Ivoire to Sierra Leone. This paper is on the Congo Grey Parrot population with Cameroon as part of its range. It will henceforth be referred to as the Grey Par

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rot in this paper.

The Grey Parrot is highly prized around the world for its reputation as an intelligent animal (BirdLife International, 2010): it possesses natural abilities not only to mimic sound and speeches only as in other parrots species, but communicates in human vocabulary (Pepperberg, 1999). The goal of this study was to identify the diversity of feather lice (Mallophaga) of the Grey Parrot and then determine ecological factors that are liable to influence the transmission of these parasites within the bird populations. A good knowledge of the parasites of the parrot will be useful in the development of possible control measures, which can be used to enhance the survival rate of the parrot in the wild and also complement efforts towards captive management of the species.

MATERIALS AND METHODS

Study area background

Cameroon has distinct climatic patterns in major ecological regions of the country. The grand southern part of the country which harbours the humid rainforest is incidentally the endemic region of the Grey Parrot. This part of the country is characterised by two major seasons: a rainy season from March to October and a dry season from November to February. The average amount of rainfall measured in the grand south varies between 1500 and 2000 mm. Rainfall is however greatest on the west of the Cameroon mountain. The mean annual rainfall measured for this mountainous region is 1800 and 2500 mm (March to October) of the year (Djoumessi-Tatsangue, 2003).

The contemporary temperature of the study area varies between 18°C to 35°C and is characterised by a high humidity throughout the year. The mean annual temperature for the south and the western highlands ranges from 22°C to 25°C (Atangana *et al*., 2010). In Mebang area in the South Region, the annual average temperature was 25°C and the rainfall varies between 1500 and 2000mm. There are two types of climate (the Guinea and Cameroon types) with four seasons (two dry and two rainy seasons); the big dry season (December to mid February), the small dry season (June to August); and the big rainy season (from mid February to May), (LaClaviere, 1980).

The vegetation structure of Cameroon varies with the major climatic belts. In the southern part of the country, about 15 to 50 km distant from the Gulf of Guinea delineates the coastal plains and has an average elevation of 90m (AGG, 2013). This coastal plain is characterised by lowland rainforest, mangrove swamps and water bodies that are emptied into the Atlantic Ocean. An equatorial rainforest characterises the Southern Cameroon plateau which reaches a height of 650 metres and projects from the coastal plains (Jagoret *et al.,* 2011). The mid-region of Cameroon is characterised by a range of plateaux which project northwardly and stretch from the western mountainous region and divide the country's south from the north (Schluter, 2008). There is an extensive commercial cultivation of agricultural crops such as oil palm, rubber, tea, bananas and cocoa in the coastal and forested areas in the south. The southern Cameroon plateau supports the cultivation of cash crops such as coffee, sugar and tobacco while the western highlands support coffee production.

On the west coast of Cameroon and bordering the Atlantic Ocean is the Limbe Wildlife Centre (LWC). It lies between 3°30′ and 4°15′N and between 8°15′ and 9° 35′E and has a total surface area of about 3.7ha. The LWC rescues and cares for primates and other orphaned wild animals of the bush-meat trade. In recent years, the sanctuary has become a home to critically endangered species, such as a Cross River Gorilla (*Gorilla gorilla diehli*), Western Lowland Gorillas (*Gorilla gorilla gorilla*), other endangered species, such as the drill monkey (*Mandrillus leucophaeus*) and the Elliot's chimpanzee (Pan troglodytes ellioti). LWC is located at the foot of mount Cameroon where annual precipitation ranges from 2000 mm to 10,000mm in Limbe which is near to Debuncha, the wettest place in Central and West Africa (Djoumessi-Tatsangue, 2003).

Study design

The study was carried out from 2007-2008 and it was designed to sample ecto-parasites of the Grey Parrot in both the wild and captivity. For wild parrot sampling at a specific site, Mebang village in the South Region of Cameroon was selected because of its large parrot population size and remoteness from urban influence.

Sampling of captive parrots was carried out in the Limbe Wildlife Centre (Zoo). This centre was selected because frequently it held the highest Grey Parrot captive population in the country. A few weeks to the planned period for sampling of Grey Parrots in the LWC and precisely in December 2007, some 1220 Grey Parrots were confiscated by government officials from illegal traders who were about to export them through the Douala Airport. The confiscated birds were transferred to the LWC for rehabilitation. The arrival of these birds at the Centre precipitated us to start data collection a few weeks earlier than scheduled. Generally, after trapping the birds in their natural habitats for export trade, they are transported in small wooden cages to villages and towns where they are kept in aviaries for acclimatisation. This process usually lasts for six months or more, depending on market dynamics and acquisition of export permits. Once ready for export, the birds are caught in a random manner in the aviaries and introduced into wooden cages (Figure 8B) with a capacity to contain about 10 - 20 birds, and then transported to the airport for veterinary inspection, document verification and then expedition. Judging from the large number of parrots brought to the LWC in one consignment, it is likely that the birds were trapped in major habitats (East and South Regions) of their endemic range in the country. Analysis of data from a report (Idoiaga *et al*., 2011) from the LWC show that out of the 1220 parrots received (Figure 8A), 21% died (Figure 8D)from stressful conditions before and on arrival at the LWC (It should be noted that there was no enclosure reserve for captive parrots/birds at the centre, at the time of arrival of the birds, hence the birds were temporary lodged in enclosures designed for primates (Figure 8A), 68% of the birds were rehabilitated and then released into the wild while the rest (11%) were being rehabilitated at the close of the study.

Sampling of birds for ectoparasites

In Mebang, parrots were captured in forest clearings during the early hours of the morning (between 6 am to 10 am) using local fishing nets. During trapping, a caller tamed parrot was tied on a twig near the net. The caller bird attracted free-flying parrots nearby which came and perched on the net. A trapper who was hiding nearby and holding a rope attached to the net drew and overturned it and thus covering the birds in the net. The trapped birds were immediately picked and placed individually in small baskets to avoid transfer of parasites from one host to another and transported to the village for examination. A maximum of four birds were carried in individual baskets to the village per trip by four people.

At home in Mebang, the birds were examined for possible symptoms, sexed and classified into stages of development (generally; young or adult) with the assistance of experienced trappers. Body parameters such as length of each bird were taken using a ribbon metre. The weight of each bird was taken using a sensitive scale balance.

Parasites were removed from the birds using the technique described by Clayton and Walther (1997) and modified according to the state of the host. Briefly, live birds were placed and maintained individually in a closed plastic bucket containing light concentrated chloroform soaked in cotton balls. The head and neck of each bird were raised carefully outside through an opening made on the cover of a small plastic bucket. The host was maintained in this condition for ten minutes to permit dislodging of the parasites. After this treatment, each host was removed from the bucket and placed on a board. Feathers of the bird were lightly dishevelled to remove remaining parasites. After this treatment, the birds were put in an aviary for monitoring and rehabilitation for eventual release in to the wild. Ninety seven (97) live parrots were sampled and all of them controlled and released.

The birds used for this study at the LWC were from the 21% (257) that died (Figure 8D), and 63 of them were randomly sampled for ectoparasites. We repeated the same procedures as did in Mebang (South Region) except that dead birds were placed at the bottom of a plastic bucket, covered and allowed for the same ten minutes for immobilisation.

After removal of chloroform treatment, all parasites from individual birds (in both Mebang and the LWC) were collected and introduced into clear penicillin containing ethanol at 70% for fixing according to Furman & Catts (1982). The parasites were later mounted on objects carrying blades containing a drop of Hoyer solution meant to highlight the parasites. Each preparation was further covered with a cover-slip. The blades thus confectioned were examined under a microscope using the objective lens 4x and then 10x. Each parasite was identified according to morphological characteristics described by Noble & Noble, 1971; Soulsby 1982; Kettle 2000; Smith, 2000. All identified parasites were limited at the level of genus with respect to available documents and materials. A total of one hundred and ninety seven (160) wild and captive parrots were sampled; ninety seven (97) from Mebang and sixty three (63) from the Limbe Wildlife Centre (LWC).

Statistical analysis

Comparison of prevalence of infestation, mean intensity, harvest site, season, age, sex and body length of the host were compared using Chi-Square and Student t-test. The significant difference was used at $\alpha = 0.05$.

RESULTS

Diversity of feather lice identified

Out of the 160 Grey Parrots examined during this study, 82 (51.3%) of them were found with ectoparasites (feather lice). Out of the total number of birds with ectoparasites, 48 (30%) of them were from the LWC and 34 (21.3%) were from Mebang. A total of five genera (Table 1) of feather lice were identified belonging to two Families (Menoponidae, Philopteridae) and two Sub-Orders (Amblycera, Ischnocera) as shown in Table 1.

Table 1. Genera diversity and prevalence of infestation of feather lice identified on sampled Grey Parrots in Mebang and in Limbe Wildlife Centre

Genus	Prevalence (%)	Family	Sub-Order
Menacanthus	37.5	Menoponidae	Amblycera
Psittacomenopon	35.6		
Menopon	0.63		
Cuclotogaster	22.5	Philopteridae	Ischnocera
Echinophilopterus	5.62		

The prevalence of each genus ranged from 0.63% in *Menopon* to 37.5% in *Menacanthus* (Table 1). The highest and lowest prevalences were obtained in the Family Menoponidae and the Sub-order Amblycera.

Furthermore, we describe some ecological associations investigated in this study using the following measurable parameters: Prevalence of infestation, the fraction of parasitized lice in a Grey Parrot population; Intensity of infestation, the number of individual lice on an infested Grey Parrot; Mean intensity of infestation, the average number of individual lice across infested Grey Parrots in a population; Parasite distribution, the pattern of occurrence of lice at the sample sites.

Infestation as function of sample site

The prevalence of infestation was evaluated for the two study sites where the birds were sampled. Results show that each site was infested with four types of feather lice (Figure 2), however the level of infestations varied for

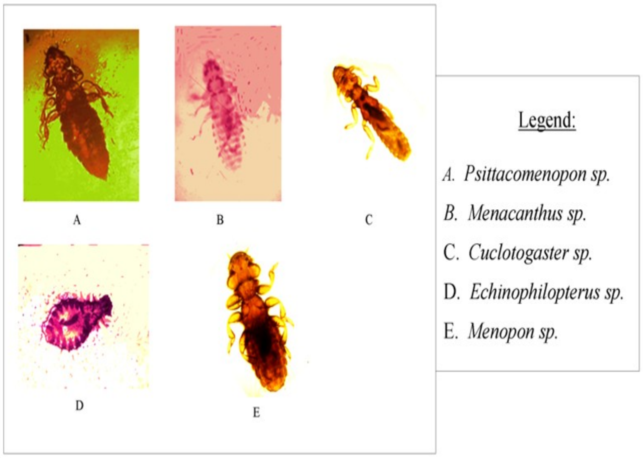

Figure 1. Genera of feather lice found on the Grey Parrot in Mebang and the Limbe Wildlife Centre.

each genus. For example, *Menopon* was 2% in Mebang but completely absent in the LWC. Similarly, the prevalence of *Echinophilopterus* was 15% in the LWC, but was completely absent in Mebang. The highest prevalence of infestation of 68% was from *Menacanthus* in the LWC and but was only 24% in Mebang. Similar trends were observed between *Psittacomenopon* and *Cuclotogaster* at the two sites. Prevalence of infestation in the five types of feather lice was generally higher in the LWC than in Mebang (Figure 2). This conclusion is confirmed by the fact that the prevalence of infestation of the five types of feather lice was significantly different ($p<0.05$) between the sampled sites.

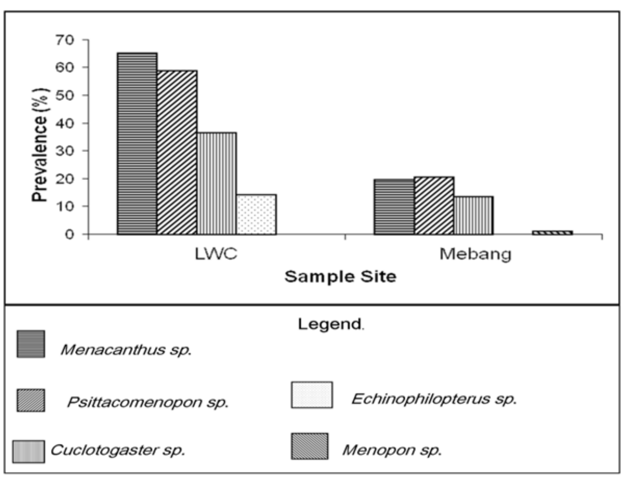

Figure 2. Comparison of the prevalence of infestation of feather Lice in Grey Parrots in the Limbe Wildlife Centre (LWC) and Mebang.

The data was further analysed to elucidate trends of parasitic associations in relation to sample sites. Four types of parasitic associations were identified in the two parrot populations. The LWC had three parasitic associations whereas Mebang had four. The highest prevalence of infestation was registered in the double-parasitic association (12%) in Mebang was against 7.8% in the LWC. This was closely followed by the triple-parasitic association in the LWC with 11% and only 2% in Mebang. A reversed trend was observed for the mono-parasitic association which was much higher in Mebang (11.8%) than in the LWC (4.8%). Quadruple parasitic association was less observed in Mebang (2.5%) but was much higher at the LWC (10.6%). Generally, the parasitic association trends did not differ significantly ($p>0.05$) between the two sites.

The mean infestation intensities of the types of feather lice are presented in Figure 3 with respect to sample sites. It was generally noted that mean infestation intensities were weaker at Mebang compared to those obtained in the LWC.

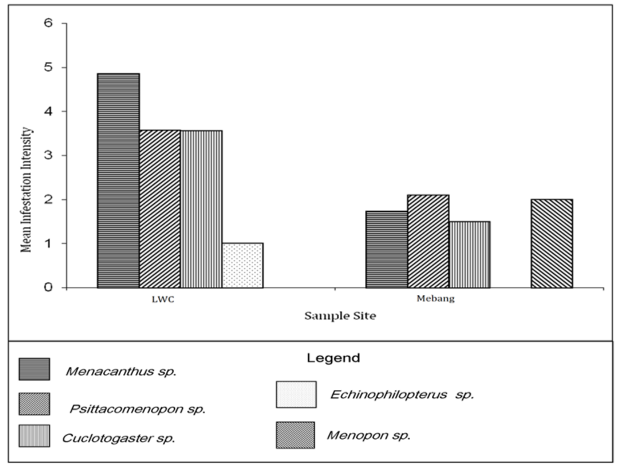

Figure 3. Mean intensity of infestation of feather lice with respect to sampled sites.

The mean infestation intensities were generally higher at the LWC than in Mebang except for *Echinophilopterus* which was about 1.2 in the LWC and was completely absent in Mebang. Similarly, *Menopon* was completely absent in the LWC, but had a mean intensity of 2.4 in Menbang (Figure 3). The overall highest mean infestation intensity of 4.8 was observed in *Menacanthus* in the LWC whereas in Mebang, it was only1.8.

Infestation in relation to sex of host

The prevalence of infestation with respect to sex of host was investigated at the sample sites (Figure 4). Results show that males were more infested than females except for *Psittacomenopon* whose prevalence of infestation (10.2%) was same in both sexes (Figure 4).

The prevalence of infestation of *Menacanthus, Psittacomenopon* and *Cuclotogaster* was about the same (10.2%) in males but fluctuated in the females with *Cuclotogaster* being the least (2.8%). However, the prevalence of infestation of *Menopon* was 2% in the males but was completely absent in the females (Figure 4). *Menopon* was the only ectoparasite present on the male host and it had a mean infestation intensity of 2.2. Male hosts generally had higher mean infestations than their female counterparts. For female birds, mean infestation intensities ranged from a low value of 1.4 in *Cuclotogaster*, thorough a median value of 2.3 in *Menacanthus* culminating in a high value of 2.3 in

Menacanthus culminating in a high value of 2.3 in *Psittacomenopon*. Furthermore, trends were compared for mean infestation intensity of feather lice as a function of sex of the host (Figure 5).

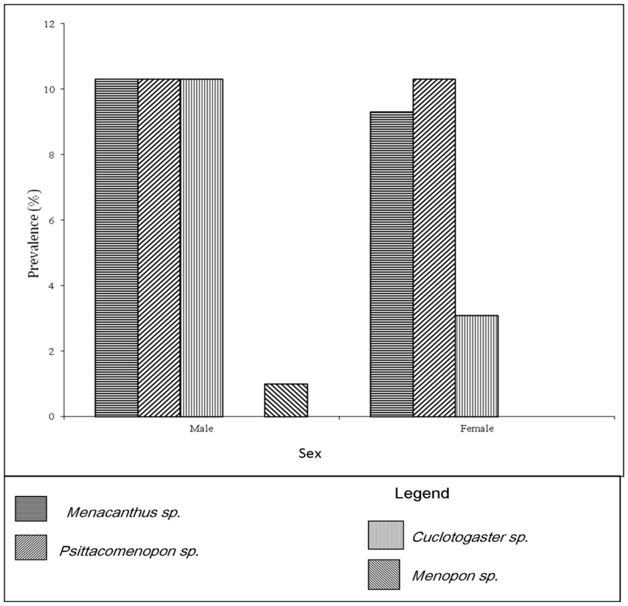

Figure 4. Prevalence of infestation of feather lice in relation to sex of the Grey Parrot.

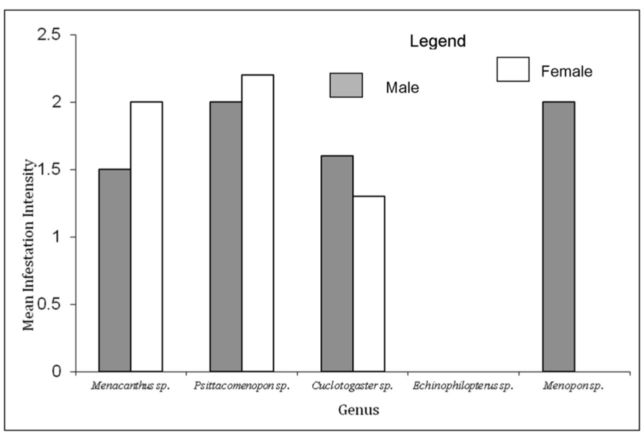

Figure 5. Mean infestation intensity of feather lice as with respect to the sex of host.

Results show that the birds were infested by the *Menacanthus, Psittacomenopon, Cuclotogaster* and *Menopon* with mean intensities of 1.5±0.97, 2±2.82, 1.6±1.4, and 2±0 in males as against 2±0.7, 2.2±1.3, 1.3±0.57 and 0±0 in females respectively. In all, the difference between these means was not significant (p>0.05).

Infestation as a function of age of host

The prevalence of infestation as a function of age (young or adult) was investigated only in Mebang since ages of the birds were more distinct than in the LWC (Figure 6). Results show that the two classes had varying degrees of infestation. In the two classes, the genera *Menacanthus* and *Psittacomenopon* ranked very high, with the prevalence of 8.2% in young and 10.8% in adult birds. *Menopon* was limited to adult birds though with a low prevalence rate of 2%. Lastly, the difference between the prevalence of infestation was not significant (p>0.05) between these two age classes.

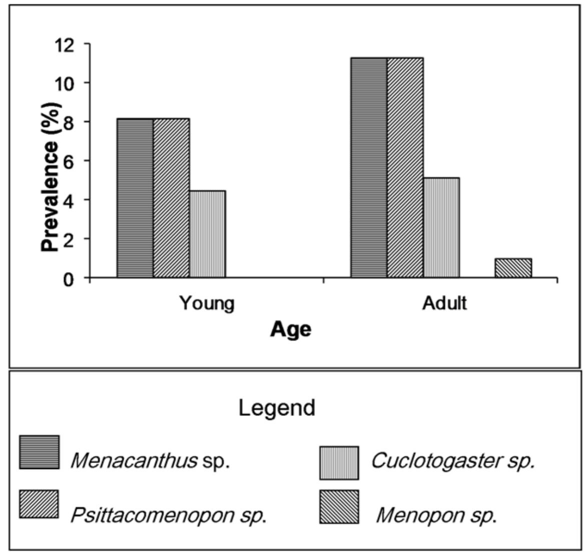

Figure 6. Infestation of feather lice as a function of age of host in Mebang.

Infestation with respect to body length of host

The body length of each Grey Parrot was measured as a representation of the size of host. The prevalence of infestation of feather lice as a function of size is presented on Figure 6. The class length of 34-36cm was the most infested by *Menacanthus* and *Psittacomenopon* with prevalence of 6%. In the LWC (A), all the class sizes were infested by three types of lice (*Menacanthus*, *Psittacomenopon* and *Cuclogaster*) except for the class length of 38 – 42cm with four types of lice were recorded.

In Mebang (B), prevalence was much higher than in the LWC. All body length classes were infested by four types of feather lice except for the biggest class (38-42cm) which was not represented by any type of louse. Therefore 26-38cm body length represents the range in which feather lice were recorded in Mebang sample site. In this range, *Menacanthus* had the highest prevalence of infestation of 17%, compared to the LWC with only 6%. *Menopon* was observed in varying amounts but had the lowest prevalence in all the length classes at Mebang and was completely absent in all the classes in the LWC. The mean intensity of infestation as a function of body length of the host was significantly different (p<0.05) between the harvest sites. The mean infestation intensity as a function of body length was also investigated for body length of male and female birds. In general, three to four genera were represented in most body length classes except for *Echinophilopterus* which was absent in some classes.

As a whole, Ectoparasites of five genera of Mallophaga were found, with varying degree prevalence of infestation in *Menacanthus* (37%), *Psittacomenopon* (36 %) *Cuclotogaster* (22 %), *Echinophilopterus* (6 %) and *Menopon* (1 %).

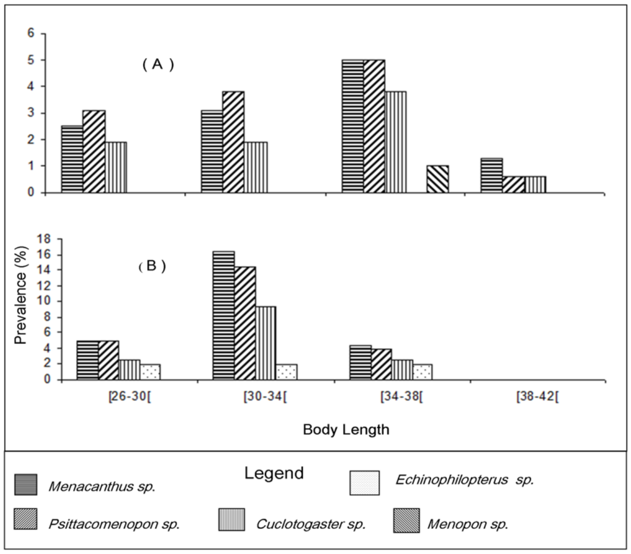

Figure 7. Prevalence of infestation of feather lice in relation to body length of the Grey Parrot in the Limbe Wildlife Centre (A) and Mebang (B).

Prevalence of infestation was significantly higher in the captive birds than in the wild-caught birds. Bird sex did not have any influence on parasitism but prevalence rates were higher in the dry season than in the rainy season. Mean infestation intensities of the genera *Menacanthus*, *Psittacomenopon* and *Cuclotogaster* were 1.7 ± 0.9, 2.1 ± 2.1 and 1.5 ± 1.1 parasites in the wild-caught birds, and in the captive birds were 4.8 ± 4.8, 3.6 ± 3.9 and 3.6 ± 2.9 respectively. *Echinophilopterus* and *Menopon* had mean intensities of 1 ± 0 and 2 ± 0 respectively. The mean intensity of infection was significantly higher in the captive birds than in the wild-caught.

DISCUSSION

Ecological implications of feather lice of the Grey parrot

Specifically, five Genera of feather lice were identified on the Grey Parrot and three of them (*Menacanthus, Cuclotogaster, Menopon*) have been described as ectoparasites of domesticate birds (Soulsby, 1982; Kettle, 2000). In general, higher prevalence of infestation registered in the LWC than in Mebang can be explained by the fact that the birds examined in the LWC were confined in small cages and rooms. The process of confinement started immediately when the birds were trapped in the wild and transported in small cages to urban centres and acclimatised in aviaries in preparation for export. They were finally put into export cages (Figure 8B) and then carried to the airport. It is estimated that birds were in confinement for a minimum of six months depending on export market dynamics and exporting conditions. The temperature of the rooms in which the birds were confined increased due to overcrowding, poor ventilation and consequently, this increase in temperature favours the fecundity and proliferation of parasites. Usually, newly trapped parrots are often stressed by their new environment, strange feeding and handling conditions. In such conditions, the birds rarely have time and space to carryout body maintenance behaviours such as preening, sunning and shake off of useless feathers. Such a physical environment and conditions (such as in Figure 8A) favour rapid multiplication and transfer of lice from one host to another.

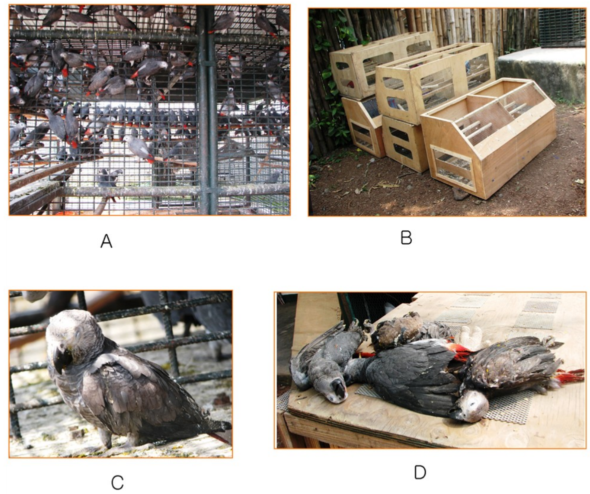

Figure 8. Fate of some confiscated Grey Parrots in the Limbe Wildlife Centre during the study period: (A) Parrots were temporary housed in a primate enclosure on arrival at the centre due to lack of s specialised enclosure for birds. (B) Sample transit cages from which the parrots were removed. (C) A stressed and sick parrot in the large enclosure with other birds. (D) Dead parrots removed from the enclosure kept for post-mortem analyses. (Photos by S. A. Tamungang).

Feather lice are ectoparasitic flightless insects which infect the feathered areas of their host and feed on the feathers. There are several different varieties of these lice that have preference fo bird species (Noble & Noble, 1971). Lice are obligatory and permanent parasites of many bird species (Aramburú, 2003; Berkunsky, 2005). They cannot jump or fly or move very well and therefore spend their entire life on the body of the host birds (Smith, 2000). For these reasons, transfer of ectoparasite from host to host is easier in captivity than in the wild. In the wild, most parasites can be transmitted when two bodies of the hosts are in close contact such as during communal roosting, copulation and feeding of young. It is therefore expected that the death of an individual parrot will inevitably mean the death of the entire parasitic population on its body. This assertion is confirmed by the fact that sampling for feather lice in the LWC was successfully carried out on dead parrots.
The *Menopon* parasite was observed only in the LWC while the *Echinophilopterus* was found in Mebang. This observation could be attributed to the manner in which the birds were handled. For example, stocking many parrots in the same cage can enhance interspecific competition thereby giving rise to the exclusive competition principle (Hardin, 2005). This principle works well in the following instances: (a), if the two ectoparasites occupy the same ecological niche or (b), if they are sympatric, or (c) if the population of

one of the ectoparasites multiplies faster than the other, and as such, the larger population will displace the smaller population and it will eventually become extinct (Hardin, 2005).

All age classes of the birds were infested with lice in Mebang. This observation could be associated to the fact that young and old birds alike displaced themselves in the same milieu and therefore had equal opportunities to the same environmental conditions. Whatever is the size class of the birds, the infestation intensities were almost the same and no correlation was observed between parasitism and the size of the host. On the other hand, seasonality did not have clear influence on infestation despite the fact that infestations were higher in the dry season than in the rainy season. The parasites thus have a higher probability of finding more favourable conditions in the dry season for their multiplication than the rainy season. It has been observed that home ranges of the Grey Parrot are longer in the dry season than the rainy season whereby the birds displace themselves in large numbers to feeding sites around villages and forest clearings (Tamungang *et al*., 2003). This behaviour allows for contact between different bird hosts. Mean infestation intensities were generally higher in the LWC than in Mebang. In effect, the higher probability of body contact of birds in captive cages (Figure 8A & B) thus favours the multiplication of parasites as well as their transfer from one host to another.

Some lice were found restricted to an individual parrot's body and others restricted to a particular sampling site (Fowler, 1985; Kettle, 2000). These restrictions can be explained by the concept of host /parasite specificity. A high degree of host specificity observed on the Grey Parrot may mean that the adaptation between the host and the parasite is so weak that the parasite is unable to successfully thrive on the body of the host. The parasite can therefore move from host to host in search of favourable habitat conditions. Since feather lice cannot fly, the only means of transmission is by body to body contact (Figure 8A & D). Body to body contact can occur in free-living birds at roosting, feeding and nesting sites. In captive birds, body to body contact is more common depending on the size of the enclosure (cage or aviary) and the population size under consideration (Figure 8A & B). If the size of the enclosure is larger in contrast to the bird population size, then the lesser the probability of transmission of ectoparasites from host to host, and the vice versa. Therefore, probability and degree of transmission of feather lice is determined by both size of the enclosure and population of the birds. This rule can only work for relatively well tamed Grey Parrots. Untamed Grey Parrots will invariably be frightened by the appearance of a human person and will tend to clump together thereby enabling body to body contact. In such a case the probability of transmission of ectoparasites is increased. At the site specific level, it could mean that environmental factors responsible for survival of ectoparasites were removed and the parasites were now unable to survive on that particular host (Fowler, 1985). The Grey Parrot like any other wild bird species is generally affected by the surrounding environment of the free-living lifestyle (as in Mebang) and it is constantly developing specific responses and adaptations to combat feather lice on its body. Such an ectoparasite then makes best of a body to body contact opportunity to transfer itself from an old host with depleting food resources to a new host having abundant food resources. This method can be used to transmit ectoparasites in a large population of Grey Parrots. It is generally accepted that bird lice are exclusive to birds, and will not infest human hair (Clayton & Walther, 1997; Kettle, 2000). However, this does not mean that lice cannot harm a bird. Indeed, lice can be vectors to other diseases in addition to having the ability to cause painful and itchy bites on birds. It is advised to limit physical contact with an infested bird until proper veterinary treatment for the parrot is sought as they can cause painful and itchy bites on humans (Marshall, 1981).

Possible ways of combating ectoparasites by the Grey parrot

This study has shown that both wild and captive Grey Parrots harbour feather lice and this can be a cause for the management of parrots in both wild and captive environments. As gregarious birds, especially at feeding and roosting sites, the probability that individuals in a population can transmit ectoparasites to one another is plausibly high. Ectoparasites play an important role in the life of birds as they have negative effects on the fitness of hosts (Brooke, 1985; Clayton, *et al*., 2010). When present in large numbers, lice may cause intolerable itches, morbidity and reduced fecundity or mortality of the host (Pulparampil, 1988; Fukatsu, *et al*., 2007).

The Grey Parrot is a busy bird in the wild and its activity patterns vary with changing months and seasons so as to improve its inclusive fitness. Apart from its busy schedules, the bird usually finds time to take care of itself in many ways. Some of these activities may be implicated in reducing ectoparasitic load on the body. Such ways include anti-parasite features of the plumage as well as various forms of anti-parasite behaviour. The Grey Parrot like some bird species attempt to rid of feather lice through some seasonal rhythmic activities such as molting. The wild Grey Parrot molts at least once a year and usually in the rainy season. Molting can reduce arthropod ectoparasitic load since lice stick to feather and hardly walk around and can fall off with dislodge feathers from the body of the parrot.

The bird may also perform Body maintenance behaviour such as grooming**.** Grooming behaviour consist of preening and scratching and is implicated with protection against ectoparasites (Marshall, 1981). In preening behaviour, the bird pulls its feathers between the two mandibles and nibbles the feathers with the bill tips from bottom to top. The Grey performs two types of preening: self-preening and allo-preening. Self-Preening is the most common defensive behaviour used by the Parrot. Both wild and captive Grey Parrots spend a significant amount of time in the day preening especially in the afternoon in the canopies of shaded trees during a feeding recess (*Tamungang and Ajayi, 2003*). In addition to preening themselves, Grey Parrots also "allo-preen" one another. This behaviour is frequently observed between courting and mating pairs, and between parents and their offspring. Allopreening can help to reduce ectoparasites on the head and neck of the parrot which are difficult parts of the body to self-preen. During and after every preening session, the parrot shakes the whole body vigorously to get rid of the ectoparasites that have been killed or dislodged from the body. The advantage with allopreen to self preening is that all parts of the body of the partner can be preened with the beak.

The Grey Parrot usually uses the feet to scratch an important part of the body (such as the head) thereby controlling ectoparasites on that important part of the body. Other possible functions associated with scratching include the removal of stale powder down from the plumage, or straightening of rectal bristles (Brooke, 1985). In captive parrots, a strong lice infestation manifestation results in thin plumage growth since many lice have fed on the feathers. Affected birds suffer from itches and restlessness as a result. There are many other ways by which the Grey Parrot can get rid of ectoparasites and they remain to be tested and described. A more generalised account on how birds control ectoparasites is treated by Clayton, *et al.,* 2010. Furthermore, Moyer and Clayton, 2004 provided a review of defence methods involving plumage as a barrier, and antiparasitic behaviours of some birds. Other studies have attempted to show that some ectoparasites are potent agents of selection on birds as they affect both the survival and reproductive success many species.

CONCLUSION

Five genera of feather lice were identified belonging to two Families (Menoponidae and Philopteridae), one Order (Mallophaga) and two Sub-Orders (Amblycera and Ischnocera). The five genera had the following prevalence of infestation*:* *Menacanthus*, 37.5 %; *Psittacomenopon*, 35.6 %; *Cuclotogaster*, 22.5 %; *Echinophilopterus*, 5.62 %; and *Menopon*, 0,63 %. Although there was a significant difference ($p<0.05$) observed between prevalence of infestation of ectoparasites in the LWC and Membang, there was no significant difference ($p>0.05$) between sex classes of parrots from the two study sites. The prevalence of infestation was higher in the dry season than the rainy season in Mebang. The mean infestation intensities of feather lice were: *Menacanthus,* 1.73 ± 0.87; *Psittacomenopon*, 2.1 ± 2.1; *Cuclotogaster*, 1.5 ± 1.1 in Mebang and in the LWC were: *Menacanthus*, 4.85 ± 4.8; *Psittacomenopon*, 3.6 ± 3.9 and *Cuclotogaster*, 3.6 ± 2.9. The mean infestation intensities for the genera *Echinophilopterus* and *Menopon* were 1 ± 0 and 2 ± 0 respectively. The overall mean infestation intensity was significantly higher ($p<0.05$) in the LWC than in Mebang. The higher prevalence of infestation in the LWC than in Mebang could be explained by the fact that the birds in the LWC were confined in small cages thereby creating favourable conditions for ectoparasite transmission from host to host. Generally, in captive enclosures, the probability of transmission of feather lice from host to host is determined by the size of enclosure and the population size of birds there-in. It therefore follows that the rate of infestation of feather lice in Grey parrots can increase in captive enclosures when compared to the rate in free ranging parrots. A maximum enclosure size for a captive parrot population hereby advocated will reduce the probability of ectoparasite host to host transmission, enable the birds to exercise freely and lead to general health improvement.

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